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Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation (Review)

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[Intervention Review]

Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

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ABSTRACT

Background

Successful tracheal intubation during general anaesthesia traditionally requires a line of sight to the larynx attained by positioning the head and neck and using a laryngoscope to retract the tongue and soft tissues of the floor of the mouth. Difficulties with intubation commonly arise, and alternative laryngoscopes that use digital and/or fibreoptic technology have been designed to improve visibility when airway difficulty is predicted or encountered. Among these devices, a rigid videolaryngoscope (VLS) uses a blade to retract the soft tissues and transmits a lighted video image to a screen.

Objectives

Our primary objective was to assess whether use of videolaryngoscopy for tracheal intubation in adults requiring general anaesthesia reduces risks of complications and failure compared with direct laryngoscopy. Our secondary aim was to assess the benefits and risks of these devices in selected population groups, such as adults with obesity and those with a known or predicted difficult airway.

Search methods

We searched the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE and Embase on 10 February 2015. Our search terms were relevant to the review question and were not limited by outcomes. We carried out clinical trials register searches and forward and backward citation tracking. We reran the search on 12 January 2016; we added potential new studies of interest from the 2016 search to a list of 'Studies awaiting classification', and we will incorporate these studies into the formal review during the review update.

Selection criteria

We considered all randomized controlled trials and quasi-randomized studies with adult patients undergoing laryngoscopy performed with a VLS or a Macintosh laryngoscope in a clinical, emergency or out-of-hospital setting. We included parallel and cross-over study designs.

Data collection and analysis

Two review authors independently assessed trial quality and extracted data, consulting a third review author to resolve disagreements. We used standard Cochrane methodological procedures, including assessment of risk of bias.

Main results

We included 64 studies identified during the 2015 search that enrolled 7044 adult participants and compared a VLS of one or more designs with a Macintosh laryngoscope. We identified 38 studies awaiting classification and seven ongoing studies. Of the 64 included studies, 61 included elective surgical patients, and three were conducted in an emergency setting. Among 48 studies that included participants without a predicted difficult airway, 15 used techniques to simulate a difficult airway. Seven recruited participants with a known or predicted difficult airway, and the remaining studies did not specify or included both predicted and not predicted difficult airways. Only two studies specifically recruited obese participants. It was not possible to blind the intubator to the device, and we noted a high level of inevitable heterogeneity, given the large number of studies.

Statistically significantly fewer failed intubations were reported when a VLS was used (Mantel-Haenszel (M-H) odds ratio (OR), random-effects 0.35, 95% confidence Interval (CI) 0.19 to 0.65; 38 studies; 4127 participants), and fewer failed intubations occurred when a VLS was used in participants with an anticipated difficult airway (M-H OR, random-effects 0.28, 95% CI 0.15 to 0.55; six studies; 830 participants). We graded the quality of this evidence as moderate on the basis of the GRADE system. Failed intubations were fewer when a VLS was used in participants with a simulated difficult airway (M-H OR, random-effects 0.18, 95% CI 0.04 to 0.77; nine studies; 810 participants), but groups with no predicted difficult airway provided no significant results (M-H OR, random-effects 0.61, 95% CI 0.22 to 1.67; 19 studies; 1743 participants).

Eight studies reported on hypoxia, and only three of these described any events; results showed no differences between devices for this outcome (M-H OR, random-effects 0.39, 95% CI 0.10 to 1.44; 1319 participants). Similarly, few studies reported on mortality, noting no differences between devices (M-H OR, fixed-effect 1.09, 95% CI 0.65 to 1.82; two studies; 663 participants), and only one study reporting on the occurrence of respiratory complications (78 participants); we graded these three outcomes as very low quality owing to lack of data. We found no statistically significant differences between devices in the proportion of successful first attempts (M-H OR, random-effects 1.27, 95% CI 0.77 to 2.09; 36 studies; 4731 participants) nor in those needing more than one attempt. We graded the quality of this evidence as moderate. Studies reported no statistically significant differences in the incidence of sore throat in the postanaesthesia care unit (PACU) (M-H OR, random-effects 1.00 (95% CI 0.73 to 1.38); 10 studies; 1548 participants) nor at 24 hours postoperatively (M-H OR random-effects 0.54, 95% CI 0.27 to 1.07; eight studies; 844 participants); we graded the quality of this evidence as moderate. Data combined to include studies of cross-over design revealed statistically significantly fewer laryngeal or airway traumas (M-H OR, random-effects 0.68, 95% CI 0.48 to 0.96; 29 studies; 3110 participants) and fewer incidences of postoperative hoarseness (M-H OR, fixed-effect 0.57, 95% CI 0.36 to 0.88; six studies; 527 participants) when a VLS was used. A greater number of laryngoscopies performed with a VLS achieved a view of most of the glottis (M-H OR, random-effects 6.77, 95% CI 4.17 to 10.98; 22 studies; 2240 participants), fewer laryngoscopies performed with a VLS achieved no view of the glottis (M-H OR, random-effects 0.18, 95% CI 0.13 to 0.27; 22 studies; 2240 participants) and the VLS was easier to use (M-H OR, random-effects 7.13, 95% CI 3.12 to 16.31; seven studies; 568 participants).

Although a large number of studies reported time required for tracheal intubation (55 studies; 6249 participants), we did not present an effects estimate for this outcome owing to the extremely high level of statistical heterogeneity (I^2 = 96%).

Authors' conclusions

Videolaryngoscopes may reduce the number of failed intubations, particularly among patients presenting with a difficult airway. They improve the glottic view and may reduce laryngeal/airway trauma. Currently, no evidence indicates that use of a VLS reduces the number of intubation attempts or the incidence of hypoxia or respiratory complications, and no evidence indicates that use of a VLS affects time required for intubation.

PLAIN LANGUAGE SUMMARY

Videolaryngoscopes to guide the insertion of breathing tubes in adult surgical patients

Background

Patients requiring general anaesthesia need assistance with breathing during the operation. To provide this assistance, the anaesthetist may insert a tube through the mouth or nose and down the trachea (windpipe) into the lungs. For this procedure, which is known as tracheal intubation, the anaesthetist usually uses a metal instrument called a laryngoscope to move the tongue and soft tissues of the mouth so s/he can see the vocal cords directly before intubation. However, seeing the vocal cords may be difficult, for example, when the patient has restrictions on neck movement, and any difficulty in intubation may lead to complications for the patient. Other laryngoscopes, called videolaryngoscopes, use video technology and may improve the anaesthetist's view before intubation. This technology allows the anaesthetist to actually see the position of the tube on a video screen while it is being inserted. This review aimed to assess whether videolaryngoscopes reduce the risks of complications and intubation failure.

Study characteristics

Evidence is current up to 10 February 2015. We found 64 studies with 6895 participants. Studies compared anaesthetists using different types of videolaryngoscopes with anaesthetists using a standard Macintosh laryngoscope without the video feature. We reran the search on 12 January 2016 and will deal with new studies of interest when we update the review.

Key results

We combined the results of studies using statistical tests and found fewer failed intubations requiring intubation with the alternative device when a videolaryngoscope was used with patients, including those with a difficult airway, than when a standard laryngoscope was used. Participants were also less likely to have minor injuries to their mouth/throat or to experience hoarseness after surgery. Anaesthetists had an improved view before intubation and assessed the videolaryngoscope as easier to use than a standard laryngoscope. Researchers reported no differences in the number of adult participants with a sore throat and no differences in the number of successful first attempts or in the overall number of attempts. We were unable to combine data to compare studies statistically for the time taken to use a videolaryngoscope owing to the number of differences in measured time points. We identified 38 studies for possible inclusion and will assess these studies during the review update.

Quality of the evidence

Although we noted good methods in some of the studies, it was not possible for researchers to mask the anaesthetist to the type of laryngoscope used, and we believe that this could have compromised the quality of the evidence in favour of either type of laryngoscope.

Conclusions

Evidence suggests that videolaryngoscopes may improve the success of tracheal intubation, particularly when the patient has a difficult airway.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [Explanation]

Videolaryngoscopy compared with direct laryngoscopy for tracheal intubation

Patient or population: patients requiring tracheal intubation
Settings: clinical, emergency or out-of-hospital, worldwide
Intervention: videolaryngoscopy
Comparison: direct laryngoscopy

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Direct laryngoscopy	Videolaryngoscopy				
Failed intubation	**Study population**		**OR 0.35** (0.19 to 0.65)	4127 (38 studies)	⊕⊕⊕○ **moderate**[a]	Downgraded by 1 level. See footnote.
	94 per 1000	**35 per 1000** (19 to 63)				
	Moderate					
Hypoxia	**Study population**		**OR 0.39** (0.1 to 1.44)	1319 (8 studies)	⊕○○○ **very low**[a,b,c]	Downgraded by 3 levels. See footnotes.
	58 per 1000	**23 per 1000** (6 to 81)				
	Moderate					
Serious respiratory complications	See comment	See comment	Not estimable	78 (1 study)	⊕○○○ **very low**[a,d]	Insufficient data to complete meta-analysis. Downgraded by 2 levels. See footnotes

Mortality	**Study population**		**OR 1.09** (0.65 to 1.82)	663 (2 studies)	⊕○○○ **very low**[a,e,f,g]	Downgraded by 3 levels. See footnotes.
	106 per 1000	**114 per 1000** (71 to 177)				
	Very low					
Proportion of successful first attempts	**Study population**		**OR 0.79** (0.48 to 1.3)	4731 (36 studies)	⊕⊕⊕○ **moderate**[a,h]	Downgraded by 1 level. See footnotes.
	831 per 1000	**795 per 1000** (702 to 865)				
	Moderate					
Sore throat	**Study population**		**OR 1.00** (0.73 to 1.38)	1548 (10 studies)	⊕⊕⊕○ **moderate**[a,i]	Downgraded by 1 level. See footnotes.
	250 per 1000	**289 per 1000** (211 to 385)				
	Moderate					
Time for tracheal intubation	See comment	See comment	Not estimable	4488 (37 studies)	⊕○○○ **very low**[a,j]	High level of statistical heterogeneity between studies; therefore meta-analysis not completed. Downgraded by 3 levels. See footnotes

*The basis for the **assumed risk** (e.g. median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI = confidence interval; OR = odds ratio.

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[a] Not possible to blind intubator to device. Downgraded for study limitations.
[b] I^2 statistic shows high level of heterogeneity at 70%. Downgraded for inconsistency.
[c] Only three studies with event data. Downgraded for imprecision.
[d] Only one study. Downgraded for imprecision.
[e] Only two studies with event data. Downgraded for imprecision.
[f] Both studies include only trauma patients.
[g] No assessment of publication bias made for this outcome.
[h] I^2 statistic shows high level of heterogeneity at 79%. Downgraded for inconsistency.
[i] I^2 statistic shows moderate level of heterogeneity at 55%. Downgraded for inconsistency.
[j] I^2 statistic shows very high level of heterogeneity at 96%. Downgraded for inconsistency.

BACKGROUND

Description of the condition

Securing the patient's airway is a critical step in providing general anaesthesia. Recent data from the Fourth National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) in the UK suggest that tracheal intubation is used for airway management in 38.4% of general anaesthetics, estimated at 1.1 million procedures per year (Woodall 2011). A cuffed tracheal tube, which is considered the most reliable device for securing the airway, is inserted through the mouth and larynx and into the trachea to enable oxygenation and ventilation, and to prevent aspiration, during general anaesthesia.

A clear view may be achieved by flexing the lower cervical spine and extending the upper cervical spine (a 'sniffing the morning air' position), enabling the intubator to create 'line of sight' to the larynx to pass the tracheal tube. Retractor type laryngoscopes, typically a detachable metal blade with handle (e.g. the Macintosh curved blade), are used to retract the tongue and soft tissue in the floor of the mouth during this procedure, which is termed 'direct laryngoscopy'. However, although these laryngoscopes may be adequate for moving soft tissue, the intubator still requires line of sight to the larynx, provided by correct head and neck positioning of the patient.

Failed or difficult intubation is associated with complications, such as increased risk of hypertension, desaturation, unexpected admission to the intensive care unit (ICU) and death (Caplan 1990; King 1990; Rose 1994). Such difficulties during intubation are estimated to occur in 1% to 6% of cases, whereas failed intubation occurs in only 0.1% to 0.3% (Crosby 1998; Shiga 2005).

Airway management difficulties are increased when patients are obese (Juvin 2003; Lundstrom 2009). In the UK, NAP4 showed that obese patients accounted for 42% of patients who experienced a major airway complication during anaesthesia (Cook 2011). Functional residual capacity (FRC), which is the volume of air left in the lungs at the end of normal expiration, is reduced in obese patients; this, along with other factors, reduces respiratory reserve and makes these patients vulnerable to hypoxia if an airway is lost, making airway management more time critical and increasing the risk of postoperative chest infection and other complications (Adams 2000; Malhotra 2008; Marley 2005).

In addition to obesity, intubation may prove difficult for other reasons, for example, restrictions in neck flexion, a narrow jaw opening, an enlarged tongue, poor tissue mobility and cervical instability. Predictive tests, for example, the Mallampati or Wilson index test (Mallampati 1985; Wilson 1988), are used before anaesthesia is given. The Mallampati score, which is based on the view of the soft palate when the patient opens his mouth, is the most widely used predictor of difficult intubation, but this and other prediction tests have been shown to have low positive predictive value for difficult intubation (Shiga 2005).

Patients who are admitted to the ICU and to the emergency department may differ from elective patients scheduled for general anaesthesia. Many patients are admitted to the ICU or the emergency department because they have vulnerable airways, which may be due to major trauma requiring cervical spine protection, airway swelling, direct airway trauma or lung injury, major head and neck surgery or infection. Critical care teams may need to provide airway management in the emergency department at very short notice without the presence of an anaesthetist (Cook 2011).

Description of the intervention and how it might work

Alternative devices, such as a videolaryngoscope (VLS), rely on fibreoptic or digital technology to transmit an image from the tip of the laryngoscope to an eyepiece or monitor, where it is viewed by the intubator. These devices may be flexible or rigid in design for the purpose of assisting in difficult intubations and reducing difficulty, failure, trauma and other complications. For this review, we are interested in the rigid videolaryngoscope, which uses a blade to retract the soft tissues and transmits a video image to a screen attached to the end of the handle or to a monitor. This design enables a lighted view of the larynx without direct 'line of sight' and therefore can assist when difficulty is encountered (or predicted) with direct laryngoscopy.

The Cormack and Lehane classification system describes the intubator's view of the larynx during laryngoscopy (Cormack 1984), with a score or 4 indicating a poor view and a score of 1 indicating a good view. Studies suggest that the use of videolaryngoscopes improves these visualization scores (e.g. a Storz V-Mac videolaryngoscope compared with a Macintosh laryngoscope in Kaplan 2006). Videolarngoscopes may therefore provide the possibility of more successful intubation for patients in whom direct laryngoscopy may be difficult. They also may be used after unsuccessful attempts to intubate with direct laryngoscopy.

Why it is important to do this review

Use of a videolaryngoscope may aid visualization, but evidence is required to establish whether this equates with increased success of intubation with reduced complications. Recent non-Cochrane reviews of VLS models have concentrated on their impact on process measures, such as the view of the larynx, first-time and overall intubation success rates and intubation time, and have concluded that there is limited evidence to support their use in tracheal intubation in unselected populations and in those with a known or anticipated difficult direct laryngoscopy (Griesdale 2012b; Healy 2012; Niforopoulou 2010). A systematic review and meta-analysis of 17 studies of the GlideScope reported advantages for non-expert intubators (Griesdale 2012b).

No reviews have considered the use of VLS specifically in obese patients. The prevalence of obesity is increasing in both developed and developing countries (current figures: http://www.oecd.org/),

as is the number of obese patients requiring anaesthesia. It is important to establish whether videolaryngoscopy is a more effective technique for this patient group, as well as for other selected and unselected groups.

We wish to update the non-Cochrane reviews above by focusing only on evidence derived from randomized controlled trials (RCTs) and by considering, when possible, patient relevant outcomes such as complications. We aimed to consider studies in both unselected and selected populations, and to include studies of obese participants. This review will continue the work of the current review authors in published reviews such as "Supraglottic airway devices versus tracheal intubation for airway management during general anaesthesia in obese patients" (Nicholson 2013a) and "Tracheal intubation with a flexible intubation scope for obese patients requiring general anaesthesia" (Nicholson 2013b). This review does not focus on videolaryngoscopy in children, as this topic is the focus of another Cochrane review (Abdelgadir 2014).

OBJECTIVES

Our primary objective was to assess whether use of videolaryngoscopy for tracheal intubation in adults requiring general anaesthesia reduces risks of complications and failure compared with direct laryngoscopy. Our secondary aim was to assess the benefits and risks of these devices in selected population groups, such as adults with obesity and those with a known or predicted difficult airway.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomized controlled trials (RCTs) of both parallel and cross-over design. We did not include simulation or mannequin studies.

Types of participants

We included trials of participants aged 16 years and older who required tracheal intubation during general anaesthesia. We included participants scheduled for surgery, as well as participants requiring tracheal intubation in the emergency department or the ICU under general anaesthesia. We included trials with unselected patient populations, those restricted to participants with known or predicted difficult laryngoscopy (e.g. Mallampati score III or IV (Mallampati 1985) or previous Cormack and Lehane score III or IV (Cormack 1984) with direct laryngoscopy) and those restricted to participants with a body mass index (BMI) > 30 kg/m^2.

Types of interventions

We included studies that compared the use of a videolaryngoscope of any model versus direct laryngoscopy with a Macintosh blade. We provide a list of example models and manufacturers in Appendix 1. We excluded optical stylets.

Types of outcome measures

Our primary outcomes were serious complications that may arise from difficulties with intubation. We included failed intubation with the first choice of device as a primary outcome. This is an important indicator of the success of an intubation technique. Failed intubation with the first device may not always result in an adverse consequence for the patient, but it increases the risk of serious complications, especially in obese patients (Cook 2012). The other primary outcome was hypoxia. Our secondary outcomes included mortality and serious airway complications, as well as surrogate process markers for airway problems, such as the number of attempts at intubation. We also assessed the impact of sore throat or hoarseness after surgery on patient-reported measures as surrogate measures of airway trauma.

We did not include outcomes as part of the study eligibility assessment. We included studies that reported on any of the relevant outcomes even if they were not primary study outcomes.

Primary outcomes

1. Failed intubation or change of device required
2. Hypoxia between start of intubation and recovery from anaesthesia, with dichotomous data (episodes of arterial oxygen saturation < 90%) or continuous data (lowest or mean arterial oxygen saturation)

Secondary outcomes

1. Mortality within 30 days of anaesthesia
2. Serious respiratory complications (including aspiration) within 30 days of anaesthesia
3. Laryngeal or airway trauma - including any one of damage to vocal cords, bleeding or dental injury
4. Patient-reported sore throat or hoarseness - both early (within two hours of anaesthesia) and late (within 48 hours of anaesthesia)
5. Proportion of successful first attempts at tracheal intubation
6. Number of attempts at tracheal intubation
7. Total time for tracheal intubation and commencement of ventilation
8. Difficulty of tracheal intubation - assessed by intubator or observer, using a locally derived or validated difficulty scale

9. Improved visualization of the larynx as measured on a validated scale (such as the Cormack and Lehane classification system (Cormack 1984); the POGO (percentage of glottic opening) score (Levitan 1998); or classification system by (Cook 2000).

Search methods for identification of studies

Electronic searches

We searched for eligible trials on 10 February 2015 in the following databases: Cochrane Central Register of Controlled Trials (CENTRAL; 2015, Issue 2) in the Cochrane Library (searched 10 February 2015), MEDLINE via Ovid (1970 to 10 February 2015) and Embase via Ovid (1980 to 10 February 2015). We applied the Cochrane highly sensitive filter for randomized controlled trials in MEDLINE and Embase. We searched the trial register www.clinicaltrials.gov for ongoing trials. We have presented our search strategies for MEDLINE, Embase and CENTRAL in Appendix 2, Appendix 3 and Appendix 4. We searched using both medical subject headings (MeSH) (or equivalent structured vocabulary in other databases) and free text.

We included publications that reported study data, including abstracts. We applied no restrictions on language of publication.

We reran the searches in the databases above (CENTRAL, MEDLINE and Embase) on 12 January 2016. We have added potential new studies identified during the 2016 search to Characteristics of studies awaiting classification and will incorporate these into the formal review during the review update.

Searching other resources

We undertook forward and backward citation tracking for key review articles and eligible articles identified through the electronic resources.

Data collection and analysis

Selection of studies

We collated results of the searches and removed duplicates.

Two review authors (Sharon Lewis (SL) and Andrew Butler (AB)) screened all titles and abstracts to remove studies that were ineligible. If no abstract was available but the title was possibly relevant, we obtained the full text of the article.

We (SL and AB) reviewed the full texts of potentially relevant titles. Each review author used software (www.covidence.org) to record decisions and reach consensus at each stage. We reported in a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) flow chart the numbers of full-text papers assessed and exclusions at each stage, along with reasons for those reviewed in full text.

Data extraction and management

Two of three review authors (SL, AB and Joshua Parker (JP)) extracted data from eligible studies using Covidence software (Covidence).

We successfully contacted the authors of Ahmad 2013, Cordovani 2013 and Suzuki 2008 for additional information. We resolved disagreements by discussion and, if necessary, by consultation with Tim Cook (TC) or Andrew Smith (AS).

Assessment of risk of bias in included studies

We used the Cochrane risk of bias tool to assess the quality of study design and the extent of potential bias (Higgins 2011) by considering the following domains.

1. Sequence generation.
2. Allocation concealment.
3. Blinding of participants, personnel and outcomes assessors.
4. Incomplete outcome data.
5. Selective outcomes reporting.

It was not possible for the anaesthetist or the intubator to be blinded to the intervention for this research question and, similarly, it was difficult for assessors of outcomes during intubation to be unaware of the allocation of the participant. Outcomes assessed during or after the operation, such as airway trauma or respiratory complications, could be assessed by staff other than the intubator who were unaware of the laryngoscopy device. It is feasible that the asleep participant may not know the device used, which may be important for patient-reported outcomes, such as sore throat.

Other sources of bias

We paid particular attention to sources of funding and the role of manufacturers and also considered the potential for selective reporting bias. We reviewed the original protocol of the trial, if this was available, to identify any changes to procedure or missing outcome data that may indicate bias.

We considered baseline characteristics of participants as well as the expertise of the anaesthetist, which has the potential to be an important confounder in this review.

We included cross-over trials, but we conducted sensitivity analyses to determine whether they had introduced bias into the results.

Measures of treatment effect

The outcomes in this review are mainly dichotomous outcomes (mortality, complications, successful first attempt, failed intubation). For dichotomous outcomes, we entered totals and numbers of events within each randomization group into RevMan 5.3 and calculated odds ratios with 95% confidence intervals. For continuous measures (e.g. time for intubation), we calculated mean

differences. We recorded some outcomes on short ordinal scales (e.g. number of attempts, intubation difficulty scores, scales of improved visualization). We converted these to dichotomous data when appropriate.

Unit of analysis issues

As well as including studies of cross-over design, we included studies that reported more than one comparison, for example, groups allocated to two designs of videolaryngoscopes compared with a direct laryngoscopy group. We compared an amalgamated comparison group (combining each type of videolaryngoscope) with the control group, initially at least, to create a single pair-wise comparison (Section 16.5.4 of Higgins 2011). In subgroup analyses, we presented the data for each device separately. When it was not possible to amalgamate data without unit of analysis error, we chose to include data from the VLS group that would be closest to a result of 'no effect' - we then addressed these decisions in a sensitivity analysis.

Dealing with missing data

We attempted to contact study authors to request missing data and included results only when study authors confirmed data. We did not include results reported in abstracts in which denominator figures were not explicitly stated and for which we were unable to reach study authors.

Assessment of heterogeneity

We expected that the findings for any given outcome may differ between the studies included in the review. This heterogeneity may be due to:

1. BMI > 30 kg/m^2 and degree of obesity;
2. anticipated degree of difficulty of airway, with measures such as Mallampati score;
3. expertise of intubator, VLS device used (e.g. GlideScope or Pentax);
4. urgency of intubation (emergency vs elective); or
5. site of intubation (operating theatre, emergency department, ICU).

We assessed heterogeneity by using Chi^2 and I^2 statistics. We investigated important heterogeneity (Chi^2 test with $P < 0.1$ or $I^2 > 50\%$) by performing subgroup analyses.

Assessment of reporting biases

We examined a funnel plot to assess the potential for publication bias for our primary outcome.

Data synthesis

We carried out meta-analysis for outcomes for which we had comparable effect measures from more than one study, and when measures of heterogeneity indicated that pooling of results was appropriate. An I^2 statistical value > 80% would argue against presentation of an overall estimate. Our choice of a fixed-effect or random-effects statistical model for any meta-analysis was influenced by study characteristics, in particular, the extent of methodological or clinical differences between studies. We used Mantel-Haenszel models for all dichotomous outcomes. For our continuous outcome (i.e. time for tracheal intubation) we used the inverse variance method.

We initially combined all designs of VLS and all population types, when appropriate, before dividing data by VLS design and by unselected and selected participant groups.

Subgroup analysis and investigation of heterogeneity

We considered whether the results of meta-analysis for the outcome of failed intubation differed for:

1. different designs of VLS;
2. obese and non-obese participants;
3. anticipated or known difficult laryngoscopy;
4. different sites of intubation (operating theatre, emergency department, ICU); and
5. experienced and inexperienced intubator.

We defined experienced intubators as those who had equivalent experience in the clinical setting of at least 20 uses with each device, and inexperienced intubators as those with fewer than 20 uses of a VLS.

Sensitivity analysis

We undertook sensitivity analyses to explore the potential impact of missing data in our risk of bias assessment. We also considered the potential impact of data analysis decisions on the results.

Summary of findings

We used the principles of the GRADE system to give an overall assessment of evidence related to each of the following outcomes (Guyatt 2008).

1. Failed intubation or change of laryngoscopy device required.
2. Hypoxia between start of intubation and recovery from anaesthesia.
3. Mortality within 30 days of anaesthesia.
4. Serious respiratory complications (including pulmonary aspiration of gastric contents and lower respiratory tract infection) within 30 days of anaesthesia.
5. Sore throat.
6. Proportion of successful first attempts.

7. Total time for tracheal intubation and commencement of ventilation.

The GRADE approach incorporates risk of bias, directness of evidence, heterogeneity of data, precision of effect estimates and risk of publication bias to give an overall measure of how confident we can be that our estimate of effect is correct. SL used GRADEpro software to create a 'Summary of findings' table for each outcome and discussed discrepancies with AS.

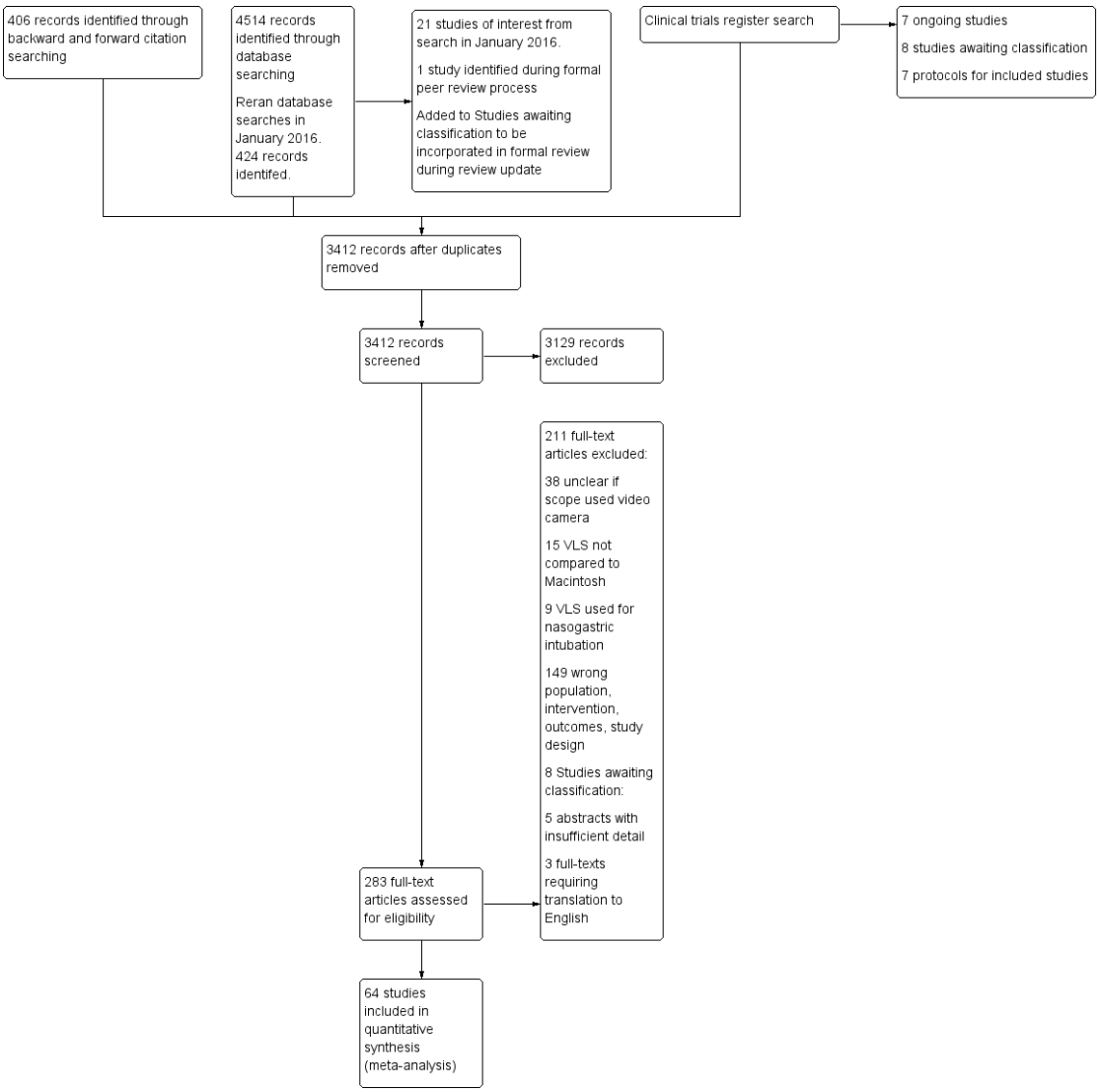
RESULTS

Description of studies

Results of the search

We screened 3412 titles and abstracts, of which we identified 406 through forward and backward citation searching. We also screened titles from clinical trials register searches. We assessed 283 full texts for eligibility. See Figure 1.

Figure 1. Study flow diagram.



We reran the search in January 2016 and screened an additional 424 titles and abstracts, following removal of duplicates. See Characteristics of studies awaiting classification.

Included studies

From the search in February 2015, we identified 64 studies that we included in the review (Abdallah 2011; Ahmad 2013; Andersen 2011; Aoi 2010; Arici 2014; Arima 2014; Aziz 2012; Bensghir 2010; Bensghir 2013; Bilehjani 2009; Carassiti 2013; Cavus 2011; Choi 2011; Cordovani 2013; Dashti 2014; Enomoto 2008; Frohlich 2011; Griesdale 2012; Gupta 2013; Hirabayashi 2007a; Hirabayashi 2009; Hindman 2014; Hsu 2012; Ilyas 2014; Ithnin 2009; Jungbauer 2009; Kanchi 2011; Kill 2013; Kim 2013; Komatsu 2010; Lee 2009; Lee 2012; Lee 2013; Lim 2005; Lin 2012; Maassen 2012; Malik 2008; Malik 2009a; Malik 2009b; Maruyama 2008a; Maruyama 2008b; McElwain 2011; Najafi 2014; Nishikawa 2009; Peck 2009; Pournajafian 2014; Robitaille 2008; Russell 2012; Russell 2013; Sandhu 2014; Serocki 2010; Serocki 2013; Shippey 2013; Siddiqui 2009; Sun 2005; Suzuki 2008; Takenaka 2011; Taylor 2013; Teoh 2010; Turkstra 2005; Walker 2009; Woo 2012; Xue 2007; Yeatts 2013). All identified studies were RCTs. We identified no quasi-randomized studies and no cluster trials. We have summarized details of the individual studies, including countries in which studies were conducted, in the Characteristics of included studies section. See Characteristics of studies awaiting classification for potentially relevant studies identified in the search conducted in January 2016.

A total of 7044 participants were included in the 64 studies. One study took place in the intensive care unit (Griesdale 2012), one at a trauma centre (Yeatts 2013) and one in an out-of-hospital setting (Arima 2014), all with participants requiring emergency treatment. The remaining 61 studies took place in the hospital theatre setting with elective surgical participants. Two studies specified inclusion of only obese participants (Abdallah 2011; Andersen 2011), one study included only obstetrical participants (Arici 2014), one study only participants with untreated hypertension (Dashti 2014) and one study only participants from the burns unit (Woo 2012).

We identified 17 studies conducted by a cross-over design (Carassiti 2013; Cavus 2011; Cordovani 2013; Enomoto 2008; Hindman 2014; Ilyas 2014; Lee 2009; Lee 2012; Maassen 2012; Maruyama 2008a; Peck 2009; Robitaille 2008; Russell 2012; Serocki 2010; Serocki 2013; Taylor 2013; Turkstra 2005) and 47 studies with a parallel design. Those studies described by study authors as cross-over designs used one type of laryngoscope initially to assess glottic view, followed by the other type of laryngoscope to assess glottic view and perform intubation. The exception to this was Hindman 2014, which intubated participants after laryngoscopy with each device. Participants in both cross-over designs were randomized by different orders of laryngoscope.

We included nine different types of VLS in our analysis; data showed comparisons with GlideScope (29 studies: Ahmad 2013; Andersen 2011; Bilehjani 2009; Carassiti 2013; Choi 2011; Cordovani 2013; Dashti 2014; Griesdale 2012; Hsu 2012; Ithnin 2009; Kill 2013; Lee 2012; Lim 2005; Malik 2008; Malik 2009b; Najafi 2014; Pournajafian 2014; Robitaille 2008; Russell 2012; Russell 2013; Sandhu 2014; Serocki 2010; Serocki 2013; Siddiqui 2009; Sun 2005; Teoh 2010; Turkstra 2005; Xue 2007; Yeatts 2013), Pentax AWS (20 studies: Abdallah 2011; Aoi 2010; Arima 2014; Enomoto 2008; Hirabayashi 2007a; Hirabayashi 2009; Kanchi 2011; Kim 2013; Komatsu 2010; Lee 2013; Malik 2008; Malik 2009a; Malik 2009b; Maruyama 2008a; Maruyama 2008b; Nishikawa 2009; Suzuki 2008; Takenaka 2011; Teoh 2010; Woo 2012), C-MAC (C-MAC - nine studies: Aziz 2012; Cavus 2011; Gupta 2013; Jungbauer 2009; Lee 2009; Lee 2012; Maassen 2012; McElwain 2011; Teoh 2010; DCI - one study: Serocki 2010) and McGrath (McGrath Series 5 - six studies: Arici 2014; Frohlich 2011; Ilyas 2014; Lee 2012; Taylor 2013; Walker 2009; McGrath with unspecified design - two studies: Peck 2009; Shippey 2013). The remaining VLS comparisons included X-lite for only two studies (Bensghir 2010; Bensghir 2013) or individual studies; C-MAC D-blade (Serocki 2013); Airtraq (with video) (Hindman 2014; McElwain 2011); Truview EVO2 (Malik 2008); and CEL-100 (Lin 2012). Most studies used a two-arm design, comparing one type of VLS with a Macintosh blade. However, eight studies (Cavus 2011; Lee 2012; Malik 2008; Malik 2009b; McElwain 2011; Serocki 2010; Serocki 2013; Teoh 2010) conducted multi-arm comparisons with two or three types of VLS versus a Macintosh blade. Gupta 2013 used a multi-arm design but compared a C-MAC blade and a Macintosh blade, both with and without the use of a stylet, to aid intubation. We have provided further details of included VLS designs in Appendix 5.

Four of the multi-arm studies (Cavus 2011; Lee 2012; Serocki 2010; Serocki 2013) used a cross-over design.

We included three studies that used a double-lumen tracheal tube for intubation (Bensghir 2010; Cordovani 2013; Russell 2013). All remaining studies used a single-lumen tube.

Forty-eight studies recruited patients without predicted difficult airways (Andersen 2011; Aoi 2010; Arici 2014; Bensghir 2010; Bensghir 2013; Bilehjani 2009; Carassiti 2013; Choi 2011; Dashti 2014; Enomoto 2008; Griesdale 2012; Gupta 2013; Hirabayashi 2007a; Hirabayashi 2009; Hindman 2014; Hsu 2012; Ilyas 2014; Ithnin 2009; Kanchi 2011; Kill 2013; Kim 2013; Komatsu 2010; Lee 2012; Lee 2013; Lim 2005; Lin 2012; Maassen 2012; Malik 2008; Malik 2009a; Maruyama 2008a; Maruyama 2008b; McElwain 2011; Najafi 2014; Nishikawa 2009; Peck 2009; Pournajafian 2014; Robitaille 2008; Russell 2012; Russell 2013; Shippey 2013; Siddiqui 2009; Sun 2005; Takenaka 2011; Taylor 2013; Turkstra 2005; Walker 2009; Woo 2012; Xue 2007). Six studies recruited patients with a known or predicted difficult airway (Aziz 2012; Cordovani 2013; Jungbauer 2009; Malik 2009b; Serocki 2010; Serocki 2013); of these, two studies specified inclusion of patients with restricted cervical mobility (Aziz 2012; Serocki 2013). Two studies specified recruitment of participants

both with and without predicted airway difficulties (Cavus 2011; Teoh 2010). Eight did not specify airway difficulties in the inclusion or exclusion criteria (Abdallah 2011; Ahmad 2013; Arima 2014; Frohlich 2011; Lee 2009; Sandhu 2014; Suzuki 2008; Yeatts 2013). For those participants recruited without predicted difficult airways, 15 studies used techniques (such as manual in-line stabilization) to simulate a difficult airway (Aoi 2010; Enomoto 2008; Gupta 2013; Ilyas 2014; Komatsu 2010; Lim 2005; Malik 2008; Malik 2009a; Maruyama 2008a; McElwain 2011; Peck 2009; Robitaille 2008; Shippey 2013; Taylor 2013; Turkstra 2005).

Most studies specified the use of experienced anaesthetists to perform laryngoscopies (47 studies: Abdallah 2011; Ahmad 2013; Andersen 2011; Aoi 2010; Arici 2014; Arima 2014; Aziz 2012; Bensghir 2013; Bilehjani 2009; Carassiti 2013; Cavus 2011; Choi 2011; Cordovani 2013; Dashti 2014; Frohlich 2011; Gupta 2013; Hindman 2014; Hsu 2012; Ilyas 2014; Ithnin 2009; Jungbauer 2009; Kanchi 2011; Kim 2013; Komatsu 2010; Lee 2009; Lee 2012; Lee 2013; Lin 2012; Malik 2008; Malik 2009a; Malik 2009b; Maruyama 2008a; McElwain 2011; Najafi 2014; Nishikawa 2009; Pournajafian 2014; Robitaille 2008; Russell 2013; Serocki 2010; Serocki 2013; Siddiqui 2009; Sun 2005; Takenaka 2011; Teoh 2010; Turkstra 2005; Woo 2012; Xue 2007). Five studies used anaesthetists who were described as novices or who were trained with mannequins but had no patient experience (Griesdale 2012; Hirabayashi 2007a; Hirabayashi 2009; Taylor 2013; Walker 2009). Five studies used both novice and experienced anaesthetists (Bensghir 2010; Kill 2013; Lim 2005; Russell 2012; Yeatts 2013). Seven studies did not specify the experience of anaesthetists (Enomoto 2008; Maassen 2012; Maruyama 2008b; Peck 2009; Sandhu 2014; Shippey 2013; Suzuki 2008).

Ten study authors declared that they had received one or more of the intervention devices from the manufacturers for the purpose of the study (Abdallah 2011; Frohlich 2011; Komatsu 2010; Malik 2008; Malik 2009a; Malik 2009b; Maruyama 2008a; Maruyama 2008b; McElwain 2011; Serocki 2010). Five study authors declared that one of their study team had an interest in the company that manufactured the intervention devices (Storz manufacturers: Aziz 2012; Cavus 2011; Serocki 2013. Pentax AWS manufacturers: Enomoto 2008. McGrath manufacturers: Taylor 2013). Other studies reported department or government grant sources or did not report on this.

Excluded studies

We excluded 211 studies at the full text review stage; we have listed 70 of these under Characteristics of excluded studies. A large number of studies had used an Airtraq laryngoscope, which can be used with or without a video camera attachment. We excluded those studies in which it was unclear whether the laryngoscope had been used with the camera device. We also excluded studies of other devices in which it was not clear whether a video camera had been used. Thus we excluded from this review 30 studies comparing an Airtraq scope with a Macintosh blade (Ali 2012; Amor 2013; Chalkeidis 2010; Corso 2010; DiMarco 2011; Erden 2010; Ferrando 2011; Gaszynski 2009; Hayes 2011; Hayes 2012; Hirabayashi 2008a; Koh 2010; Maharaj 2006; Maharaj 2007; Maharaj 2008; Marco 2011; Ndoko 2008a; Park 2010; Ranieri 2012; Ranieri 2014; Sansone 2012; Saxena 2013; Stumpner 2011; Terradillos 2009; Tolon 2012; Trimmel 2011; Turkstra 2009a; Turkstra 2009b; Wang 2009; Wasem 2013) and eight studies that used other devices (Bullard, Truview, WuScope and Optiscope) (Araki 2002; Arora 2013; Barak 2007; Carlino 2009; Hastings 1995; Smith 1999; Watts 1997; Yang 2013). We excluded other studies because they lacked comparison with a Macintosh blade, used nasotracheal intubation, included patients not undergoing general anaesthesia, provided abstracts with insufficient details, did not report relevant outcomes or used the wrong study design. See Characteristics of excluded studies.

Ongoing studies

We identified seven studies through a clinical trials register search (NCT01914523; NCT01914601; NCT02088801; NCT02167477; NCT02292901; NCT02297113; NCT02305667). All studies were potentially eligible and were listed as at the stage of recruiting participants. See Characteristics of ongoing studies.

Studies awaiting classification

We identified a total of 38 studies that required further assessment for inclusion and have listed these under Characteristics of studies awaiting classification.

We identified eight studies through a clinical trials register search (NCT00178555; NCT00602979; NCT00664612; NCT01029756; NCT01114945; NCT01488695; NCT01516164; NCT02190201). All were potentially eligible and were listed as complete. However, study results were not published on the register, and we were unable to establish whether these studies had been published.

We found five additional studies that were reported in abstract form only, with insufficient detail, and we were unable to contact study authors (Ahmadi 2014; Eto 2014; Gharehbaghi 2012; Ishida 2011; Morello 2009). We will await the publication of full texts for these studies. We identified three studies that are awaiting translation before they can be assessed for inclusion (Kita 2014; Liu 2010; Wang 2008).

We identified 21 new studies for potential inclusion through screening of titles and abstracts during the search conducted in January 2016 (Ahmad 2015; Ahmadi 2015; Akbar 2015; Amini 2015; Bakshi 2015; Bhandari 2013; Bhat 2015; Colak 2015; Hamp 2015; Janz 2015; Kido 2015; Laosuwan 2015; Nakayama 2010; Pieters 2015; Postaci 2015; Rovsing 2010; Silverberg 2015; Wallace 2015; Yao 2015; Yousef 2012; Zhao 2014) and one study

during the peer review process that we had excluded at an earlier stage (Cattano 2013). We will incorporate these studies into the formal review during the review update.

Risk of bias in included studies

We have included a summary of risk of bias assessments in Figure 2 and Figure 3.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

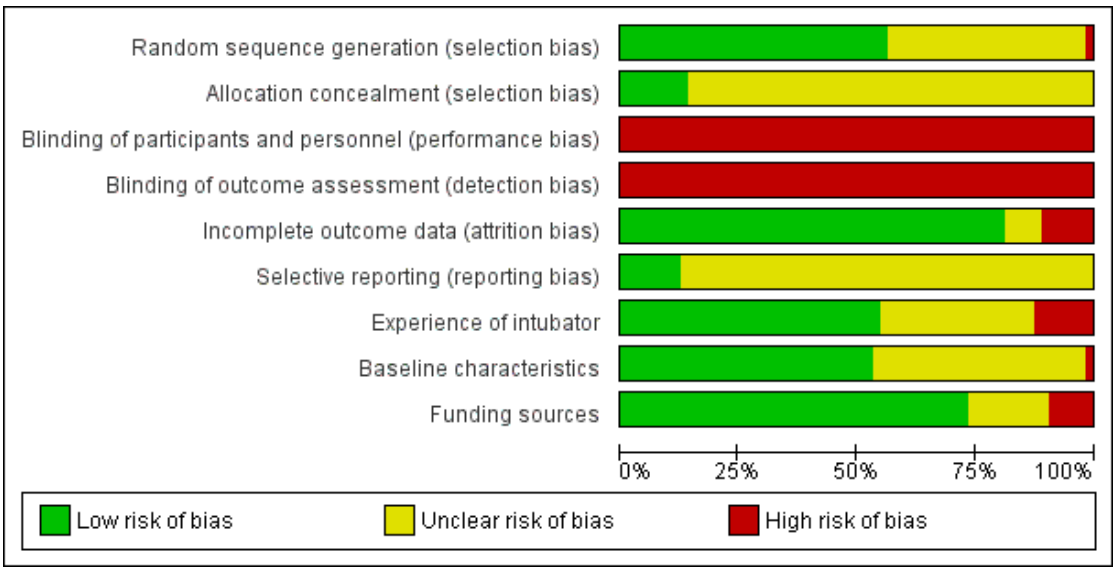
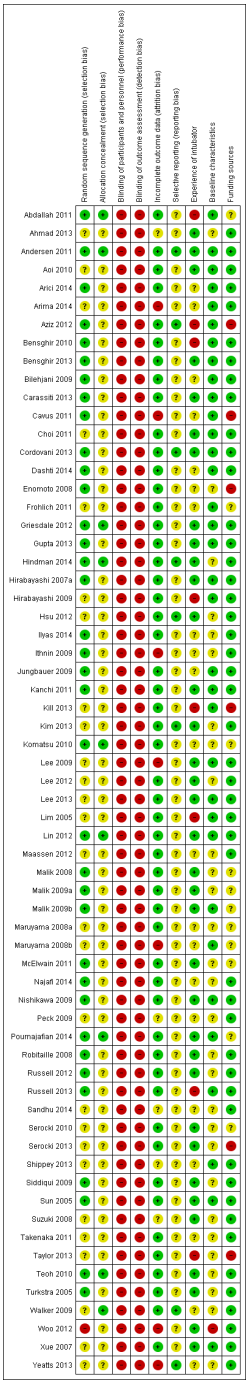


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Allocation

All studies were described as randomized, and 36 studies provided sufficient details on the method of randomization (Abdallah 2011; Andersen 2011; Arici 2014; Aziz 2012; Bensghir 2010; Bensghir 2013; Bilehjani 2009; Carassiti 2013; Cavus 2011; Cordovani 2013; Dashti 2014; Enomoto 2008; Griesdale 2012; Gupta 2013; Hirabayashi 2007a; Hindman 2014; Ilyas 2014; Ithnin 2009; Jungbauer 2009; Kanchi 2011; Komatsu 2010; Lin 2012; Malik 2008; Malik 2009a; Malik 2009b; McElwain 2011; Najafi 2014; Nishikawa 2009; Pournajafian 2014; Robitaille 2008; Russell 2012; Russell 2013; Siddiqui 2009; Sun 2005; Teoh 2010; Turkstra 2005). Other studies failed to provide details, or review authors determined that it was unclear if the method described would be adequate to reveal whether bias had been introduced. We judged only one study (Woo 2012) to be at high risk of selection bias regarding methods of randomization.

Only nine studies provided sufficient detail about methods used to conceal allocation from personnel (Abdallah 2011; Andersen 2011; Griesdale 2012; Hindman 2014; Komatsu 2010; Lin 2012; Pournajafian 2014; Teoh 2010; Walker 2009), and we were unable to make judgements other than 'unclear' for all remaining studies.

Blinding

We judged all studies to be at high risk of performance bias, as it was not possible to blind the anaesthetist from the type of scope used.

Similarly, it was not possible for outcome assessors of the primary outcomes of failed intubation and hypoxia to be blinded, and so again we judged all studies to be at high risk of detection bias. However, seven studies reported that researchers had made attempts to blind assessors to particular outcomes such as assessment of sore throat (Abdallah 2011; Kill 2013; Lee 2013; Lin 2012; Najafi 2014; Nishikawa 2009; Siddiqui 2009). In all, 15 studies described observers as 'independent' for some outcomes (Aoi 2010; Bensghir 2013; Enomoto 2008; Gupta 2013; Hirabayashi 2007a; Hsu 2012; Kanchi 2011; Kim 2013; Lee 2012; Lim 2005; Malik 2008; Malik 2009a; Malik 2009b; McElwain 2011; Teoh 2010); although this does not equate to being blinded to group allocation, these study authors made attempts to reduce detection bias in their studies.

Incomplete outcome data

Most studies reported no participant losses during the trial or only a small number of losses that were unlikely to affect results. We obtained insufficient data for some studies reported in abstract format only (Ahmad 2013; Sandhu 2014; Shippey 2013; Suzuki 2008), and so we were unable to make judgements of bias for these. We judged seven studies as having high risk of bias (Arima 2014; Cavus 2011; Ithnin 2009; Lee 2009; Maruyama 2008b; Woo 2012; Yeatts 2013) because they reported large numbers of losses, used exclusion criteria that introduced bias to the results or made changes to the protocol during the trial.

Selective reporting

We were able to source published protocols for eight of the studies and could adequately judge these as having low risk of bias because study authors had reported on all outcomes as stated in the protocol (Andersen 2011; Aziz 2012; Cordovani 2013; Hindman 2014; Hsu 2012; Kim 2013; Walker 2009; Yeatts 2013). We did not seek protocols for all other studies and therefore could not adequately judge the risk of bias for this domain.

Other potential sources of bias

Experience of intubator

We considered the experience of the intubator to be a potential source of bias in this review, in particular whether the intubator had equivalent experience with the VLS as with the Macintosh blade. It was often not possible to judge from the information presented by study authors whether bias had been introduced by intubators' experience.

Several studies adequately described anaesthetists as having equivalent experience with both devices, and we judged these to be at low risk of bias. Some studies described experience in terms of the number of intubations performed with each device.

If anaesthetists had carried out more than 20 intubations with the VLS device in the clinical setting, or had spent a considerable length of time using the device and at least this much time with the Macintosh device, we judged these studies to be at low risk of bias (Ahmad 2013; Andersen 2011; Bensghir 2013; Carassiti 2013; Choi 2011; Cordovani 2013; Gupta 2013; Hindman 2014; Hsu 2012; Kanchi 2011; Kim 2013; Lee 2012; Lee 2013; Lin 2012; Malik 2008; Malik 2009a; Malik 2009b; Nishikawa 2009; Pournajafian 2014; Robitaille 2008; Russell 2012; Serocki 2010; Serocki 2013; Siddiqui 2009; Sun 2005; Suzuki 2008;Teoh 2010; Turkstra 2005; Woo 2012). Two studies described personnel as experienced in the use of both devices; we assumed this to be equivalent experience and judged these studies as having low risk of bias (Aoi 2010; Xue 2007). Frohlich 2011 described operators as having used the devices on at least five occasions, but we believed this information was insufficient for us to judge whether bias was introduced here.

If however anaesthetists had carried out fewer than 20 intubations with the VLS device in the clinical setting, we assumed, unless

otherwise stated, that the balance of experience would favour the Macintosh group and therefore judged these studies as having high risk of bias (Abdallah 2011; Taylor 2013).

Some studies used novice personnel only, and if it was implied that the level of experience between all personnel was equivalent, we judged these studies as having low risk of bias (Griesdale 2012; Hirabayashi 2007a). Hirabayashi 2009 described personnel as novices with less experience with the videolaryngoscope compared to the Macintosh; we judged this study to be at higher risk of bias.

Some studies used both novice and experienced personnel; if study authors did not adequately explain whether the balance of experience was equivalent between groups, we judged these studies to be at high risk of bias (Aziz 2012; Kill 2013; Lim 2005). Enomoto 2008 and Lee 2009 provided adequate descriptions of equivalent experience between novice and experienced personnel for review authors to judge these studies as having low risk of bias.

In two studies, anaesthetists had equivalent experience with the devices but not with use of a double-lumen tube; therefore, we determined that a higher level of bias had been introduced (Bensghir 2010; Russell 2013). Similarly, in studies designed to assess devices at ground level and in the lateral position, operators had less experience with devices in the simulated position; it was not clear if this experience was equivalent between devices and whether bias had been introduced (Komatsu 2010 and Takenaka 2011, respectively).

Nineteen studies did not specify the experience of the anaesthetist at all, or described the anaesthetist as experienced but did not state whether the experience was equivalent in both devices; we were unable to judge the risk of bias for these (Arici 2014; Arima 2014; Bilehjani 2009; Cavus 2011; Dashti 2014; Ilyas 2014; Ithnin 2009; Jungbauer 2009; Maassen 2012; Maruyama 2008a; Maruyama 2008b; McElwain 2011; Najafi 2014; Peck 2009; Russell 2012; Sandhu 2014; Shippey 2013; Walker 2009; Yeatts 2013).

Baseline characteristics

Four abstracts did not present sufficient information on baseline characteristics, and we were unable to make a sufficient judgement of the risk of bias for this domain (Ahmad 2013; Peck 2009; Sandhu 2014; Suzuki 2008). One full study report provided no information on baseline characteristics, and we were unable to make a decision on bias for this (Robitaille 2008). Eight of the cross-over design studies had presented baseline characteristics for the whole group of randomized patients and not by order of scope; therefore, it was not possible to judge bias for these studies (Enomoto 2008; Hindman 2014; Maassen 2012; Maruyama 2008a; Serocki 2010; Serocki 2013; Turkstra 2005; Walker 2009).

Sixteen studies had presented baseline characteristics for which we noted some differences between study groups (Hsu 2012; Ilyas 2014; Ithnin 2009; Kim 2013; Komatsu 2010; Lee 2012; Malik 2008; Malik 2009a; McElwain 2011; Najafi 2014; Russell 2012; Siddiqui 2009; Takenaka 2011; Taylor 2013; Teoh 2010; Yeatts 2013). However, it was unclear how these differences may have affected the results. We noted significant differences in the numbers of participants reported throughout Woo 2012, leading to concerns about the randomization process and adequate reporting of baseline characteristics; therefore, we judged this study as having high risk of bias.

Funding

We judged studies reporting that they had received no funding or department funding only as having low risk of bias; when studies did not report any funding source, we assumed that no funding had been received and judged these studies to be at low risk of bias (in total, 48 studies: Ahmad 2013; Andersen 2011; Aoi 2010; Arici 2014; Arima 2014; Bensghir 2010; Bensghir 2013; Bilehjani 2009; Carassiti 2013; Choi 2011; Cordovani 2013; Dashti 2014; Griesdale 2012; Gupta 2013; Hindman 2014; Hirabayashi 2007a; Hirabayashi 2009; Hsu 2012; Ilyas 2014; Ithnin 2009; Jungbauer 2009; Kanchi 2011; Kim 2013; Lee 2009; Lee 2012; Lee 2013; Lim 2005; Lin 2012; Maassen 2012; Najafi 2014; Nishikawa 2009; Peck 2009; Pournajafian 2014; Robitaille 2008; Russell 2012; Russell 2013; Sandhu 2014; Shippey 2013; Siddiqui 2009; Sun 2005; Suzuki 2008; Takenaka 2011; Teoh 2010; Turkstra 2005; Walker 2009; Woo 2012; Xue 2007; Yeatts 2013).

Ten study authors declared that they had received one or more of the intervention devices from the manufacturers for the purpose of the study (Abdallah 2011; Frohlich 2011; Komatsu 2010; Malik 2008; Malik 2009a; Malik 2009b; Maruyama 2008a; Maruyama 2008b; McElwain 2011; Serocki 2010). It was unclear if this in itself was sufficient to introduce bias, and we reported these studies as having unclear risk of bias.

Six study authors declared that one member of their study team had an interest in the manufacturing company of the intervention devices (Storz manufacturers: Aziz 2012; Cavus 2011; Serocki 2013. Pentax AWS manufacturers: Enomoto 2008. McGrath manufactures: Taylor 2013. GlideScope manufacturers: Kill 2013). We believe that this connection would present increased risk of bias towards the study results, and we therefore judged these studies to be at high risk of bias.

Effects of interventions

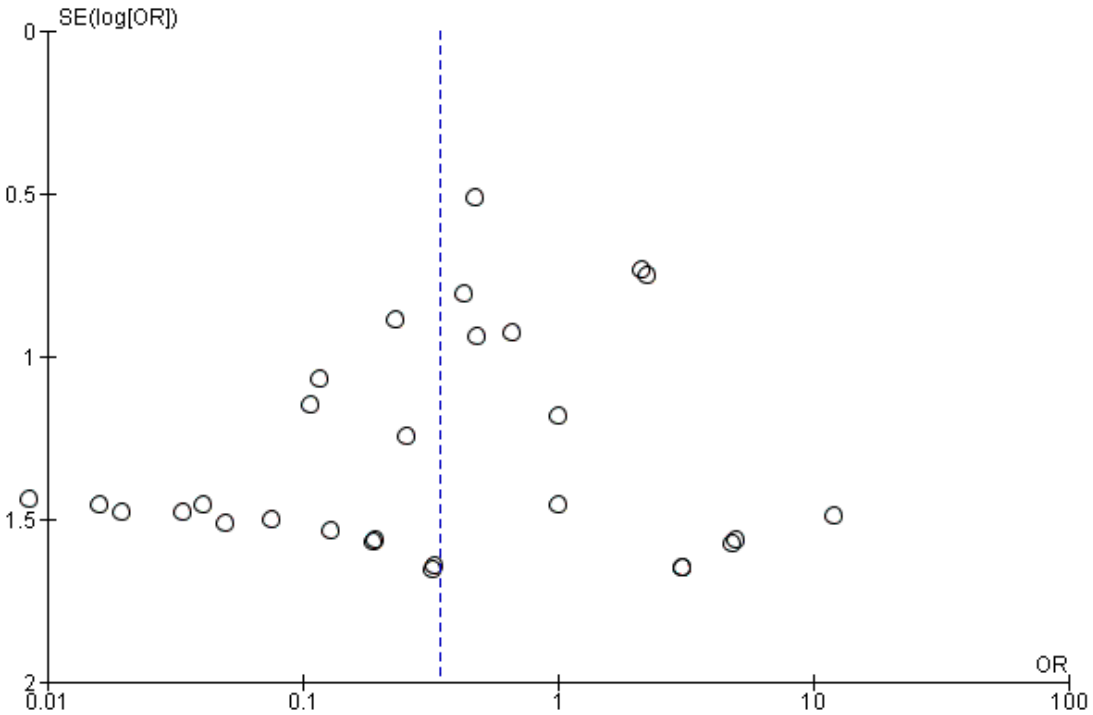
See: **Summary of findings for the main comparison** Videolaryngoscopy compared with direct laryngoscopy for tracheal intubation

Primary outcomes

Failed intubation

Thirty-nine studies with 4141 participants reported the number of failed intubations. Of these, eight were multi-arm studies that presented data for more than one comparison arm (Cavus 2011; Lee 2012; Malik 2008; Malik 2009b; McElwain 2011; Serocki 2010; Serocki 2013; Teoh 2010). We combined the data from these studies for all videolaryngoscope groups and compared them with data for the Macintosh group. We did not include Hindman 2014 in the meta-analysis, as this cross-over design included the intubation of participants with both devices; therefore we believed this study introduced too much performance bias to be equivalent to the others. Analysis demonstrated fewer failed intubations when a VLS was used (Mantel-Haenszel (M-H) odds ratio (OR), random-effects 0.35, 95% confidence interval (CI) 0.19 to 0.65; I^2 = 52%; 4127 participants). See Analysis 1.1. In our 'Summary of findings' table, we downgraded this outcome owing to risk of performance bias introduced by lack of blinding, grading the quality of the evidence as moderate. See Summary of findings for the main comparison. A funnel plot did not suggest evidence of reporting bias for this outcome. See Figure 4.

Figure 4. Funnel plot of comparison: 1 Failed intubation, outcome: 1.1 Failed intubation.



Hypoxia

Eight studies reported the number of participants who had hypoxia (Andersen 2011; Aziz 2012; Bensghir 2010; Bensghir 2013; Komatsu 2010; Lin 2012; Serocki 2010; Teoh 2010). The multi-arm studies Serocki 2010 and Teoh 2010 reported no hypoxia in any group, and Andersen 2011, Komatsu 2010 and Lin 2012 reported no events. Only Aziz 2012, Bensghir 2010 and Bensghir 2013 reported participants with hypoxia, and analysis of combined data showed no differences between groups (M-H OR, random-effects 0.39, 95% CI 0.10 to 1.44; I^2 = 70%; 1319 participants). See Analysis 2.1. Owing to the few studies with data to combine, we downgraded this evidence to very low quality. See Summary of findings for the main comparison.

Secondary outcomes

Mortality

Only two studies with 663 participants reported mortality rates. Griesdale 2012 included a patient group requiring urgent tracheal intubation in the ICU and reported nine deaths in the videolaryngoscope group and 12 deaths in the Macintosh group, with 20 participants in each group. Yeatts 2013 included a patient group in the trauma resuscitation unit and reported 28 out of 303 deaths in the videolaryngoscope group and 24 out of 320 deaths in the Macintosh group (M-H OR, fixed-effect 1.09, 95% CI 0.65 to 1.82; I^2 = 29%; 663 participants). See Analysis 3.1. Again owing to lack of data, we downgraded the evidence for this outcome to very low quality. See Summary of findings for the main comparison.

Serious airway complications

One study with 78 participants (Bilehjani 2009) reported respiratory complications as an outcome, with one recorded event of pneumothorax in the Macintosh group and none in the videolaryngoscope group. Again owing to lack of data, we downgraded the evidence for this outcome to very low quality. See Summary of findings for the main comparison.

Laryngeal/airway trauma

In all, 29 studies with a total of 41 comparisons reported data for laryngeal or airway trauma, or both. Of these, seven were multi-arm studies (Cavus 2011; Gupta 2013; Lee 2012; Malik 2008; Malik 2009b; McElwain 2011; Teoh 2010), and to avoid unit of analysis issues, we combined data for all of the intervention arms of each multi-arm study. We noted no events in either intervention or comparison group in seven studies (Andersen 2011; Arici 2014; Carassiti 2013; Cavus 2011; Frohlich 2011; Lee 2009; Maassen 2012). A total of 22 comparisons yielded event data in analysis for this outcome (Abdallah 2011; Aoi 2010; Aziz 2012; Bensghir 2010; Bensghir 2013; Bilehjani 2009; Gupta 2013; Hsu 2012; Ilyas 2014; Kim 2013; Komatsu 2010; Lee 2012; Lim 2005; Lin 2012; Malik 2008; Malik 2009a; Malik 2009b; McElwain 2011; Russell 2013; Taylor 2013; Teoh 2010; Walker 2009). Results showed fewer trauma events when a videolaryngoscope was used (M-H OR, random-effects 0.68, 95% CI 0.48 to 0.96; I^2 = 25%; 3110 participants). See Analysis 4.1.

Sore throat or hoarseness

A total of 18 studies with 2238 participants reported on sore throat and/or hoarseness. Maassen 2012 did not provide data by intervention or comparison group; therefore, we did not include this study in the analysis. We had intended to measure sore throat at the time points of two hours and 48 hours postoperatively, but results did not concur with study reports. Five studies (Andersen 2011; Najafi 2014; Siddiqui 2009; Taylor 2013; Teoh 2010) stated that sore throat was assessed in the postanaesthesia care unit (PACU), and eight studies, including two that had reported data for the PACU (Abdallah 2011; Hsu 2012; Lee 2013; Lin 2012; Najafi 2014; Nishikawa 2009; Siddiqui 2009; Woo 2012), gave data obtained at assessment 24 hours postoperatively. We constructed our analysis by using two time points: in the PACU and at 24 hours. To avoid a unit of analysis issue, we included data for Siddiqui 2009 only at the 24-hour time point. Six studies (Aoi 2010; Aziz 2012; Bilehjani 2009; Ilyas 2014; Peck 2009; Russell 2013) did not state when sore throat was assessed, and for the purpose of this analysis, we included these data in the PACU group. Analysis revealed no difference in incidences of sore throat in the PACU (M-H OR, random-effects 1.00, 95% CI 0.73 to 1.38; I^2 = 24%;1548 participants) nor at postoperative day one, regardless of which laryngoscope was used (M-H OR, random-effects 0.54, 95% CI 0.27 to 1.07; I^2 = 74%; 844 participants). See Analysis 5.1. We considered the high level of performance bias to be an important consideration in this outcome and downgraded the evidence to moderate quality. See Summary of findings for the main comparison.

Six studies reported data on hoarseness (Andersen 2011; Aoi 2010; Bilehjani 2009; Hsu 2012; Ilyas 2014; Siddiqui 2009). For the purpose of analysis, we combined data regardless of the time of measurement, including data from the PACU for Siddiqui 2009 rather than at 24 hours postoperatively. Analysis showed fewer incidences of hoarseness for those with whom the VLS had been used (M-H OR, fixed-effect 0.57, 95% CI 0.36 to 0.88; I^2 = 28%; 527 participants). See Analysis 6.1.

Proportion of successful first attempts

Data from 36 studies on successful first attempt could be combined. For studies with multi-arm comparisons (Cavus 2011; Gupta 2013; Lee 2012; Malik 2008; Malik 2009b; McElwain 2011; Serocki 2010; Serocki 2013; Teoh 2010), we combined data for all VLS groups, with the exception of Gupta 2013, for which we combined the comparison group of VLS (with and without stylet) versus Macintosh (with and without stylet). Our analysis showed no differences between groups (M-H OR, random-effects 1.27, 95% CI 0.77 to 2.09; I^2 = 79%; 4731 participants). See Analysis 7.1. Again, we considered the high level of performance bias to be an important consideration in this outcome and downgraded the quality of evidence to moderate. See Summary of findings for the main comparison.

Number of attempts

Thirty studies with 3504 participants reported number of attempts as an outcome. Of these, one study did not report number of attempts clearly for each group (Arima 2014) and data could not be used; another study reported the number of attempts as a mean, and therefore data could not be combined with data from other studies (Siddiqui 2009 - this study reported no statistically significant differences between groups requiring only one attempt

at intubation; P = 0.144). We included the remaining 28 studies in our meta-analysis for requiring only one attempt at intubation with either device (Abdallah 2011; Andersen 2011; Aoi 2010; Bensghir 2010; Bilehjani 2009; Cavus 2011; Frohlich 2011; Griesdale 2012; Gupta 2013; Hirabayashi 2009; Hsu 2012; Kim 2013; Komatsu 2010; Lee 2012; Lim 2005; Lin 2012; Malik 2008; Malik 2009a; Malik 2009b; McElwain 2011; Serocki 2010; Serocki 2013; Shippey 2013; Sun 2005; Teoh 2010; Walker 2009; Woo 2012; Xue 2007). For multi-arm studies, we combined data for all VLS groups. Our analysis revealed no differences between types of devices for participants intubated in one attempt (M-H OR, random-effects 1.25, 95% CI 0.68 to 2.31; I^2 = 79%; 3346 participants). See Analysis 8.1. We did not include outcome data from studies that reported 'successful first attempt' but did not also report data on additional attempts.

We combined the data from studies reporting two, three or four attempts. We also included studies that reported data on 'more than two attempts' or 'more than three attempts'. For multi-arm studies, we combined data for all VLS groups. Results of our analysis showed no difference in types of laryngoscopes with additional attempts (M-H OR, random-effects 0.89, 95% CI 0.47 to 1.70; I^2 = 79%; 3346 participants). See Analysis 8.1.

Time for tracheal intubation

A total of 55 studies with 6249 participants reported data on time for tracheal intubation. Of these, one did not provide denominator figures (Ahmad 2013), one did not provide a standard deviation or range (Frohlich 2011), one differed from the other studies in time scales of measurement used for this outcome (Lee 2012) and 14 reported data as medians and interquartile ranges (Abdallah 2011; Andersen 2011; Cordovani 2013; Griesdale 2012; Gupta 2013; Kill 2013; Lin 2012; Malik 2009a; Malik 2009b; McElwain 2011; Russell 2012; Serocki 2010; Takenaka 2011; Walker 2009). Therefore, it was not possible to combine these data in our meta-analysis, nor did we include Hindman 2014, as we believed that this cross-over design introduced too much performance bias. The remaining 37 studies included multi-arm studies with a total of 44 comparisons (Aoi 2010; Arici 2014; Aziz 2012; Bensghir 2010; Bensghir 2013; Bilehjani 2009; Carassiti 2013; Cavus 2011; Choi 2011; Dashti 2014; Enomoto 2008; Hirabayashi 2009; Hsu 2012; Ilyas 2014; Kanchi 2011; Kim 2013; Komatsu 2010; Lee 2013; Lim 2005; Malik 2008; Maruyama 2008b; Najafi 2014; Nishikawa 2009; Peck 2009; Pournajafian 2014; Sandhu 2014; Serocki 2013; Shippey 2013; Siddiqui 2009; Sun 2005; Suzuki 2008; Taylor 2013; Teoh 2010; Turkstra 2005; Woo 2012; Xue 2007; Yeatts 2013). From the multi-arm studies, we included only one comparison in the analysis, using data that showed the most time in the videolaryngoscope group; for Cavus 2011, we used data from the C-MAC4 group; for Malik 2008, the Truview EVO2 group; for Serocki 2013, the GlideScope group; and for Teoh 2010, the C-MAC group. When these 37 studies were combined, we identified an extremely high level of statistical heterogeneity (I^2 = 96%), which could possibly be explained by the various time points at which individual studies measured time for intubation. Therefore, we have not presented an effects estimate for this outcome. See Included studies above and Analysis 9.1.

Difficulty of intubation

Nineteen studies with 1765 participants reported data on difficulty of tracheal intubation (Abdallah 2011; Andersen 2011; Aoi 2010; Arima 2014; Bensghir 2013; Choi 2011; Frohlich 2011; Gupta 2013; Ilyas 2014; Ithnin 2009; Lim 2005; Lin 2012; Maassen 2012; Malik 2008; Malik 2009a; Malik 2009b; McElwain 2011; Sandhu 2014; Takenaka 2011). Fourteen of these studies used the same validated scale of measurement (Intubation Difficulty Score (IDS)) (Andersen 2011; Aoi 2010; Arima 2014; Bensghir 2010; Frohlich 2011; Gupta 2013; Ilyas 2014; Lin 2012; Malik 2008; Malik 2009a; Malik 2009b; McElwain 2011; Sandhu 2014; Takenaka 2011). Only seven of these 14 studies reported data that could be combined (Aoi 2010; Bensghir 2013; Gupta 2013; Malik 2008; Malik 2009a; Malik 2009b; McElwain 2011), whilst the others reported IDS scores as median and interquartile ratio (IQR) or as an overall mean. For the purpose of this analysis, we combined the videolaryngoscope intervention results of multi-arm studies and presented the data for all seven studies as dichotomous for those with no difficulty (achieving an IDS of 0). Our analysis showed that the videolaryngoscope was easier to use when compared with the Macintosh, with 165 out of 340 cases given the lowest IDS score of 0 in the videolaryngoscope group versus 31 out of 228 cases in the Macintosh group (M-H OR, random-effects 7.13, 95% CI 3.12 to 16.31; P < 0.00001; I^2 = 62%; 568 participants). See Analysis 10.1.

Of the remaining studies that used an IDS scoring system, four reported a statistically significant result in favour of the videolaryngoscope (Ilyas 2014 - P = 0.0024, 128 participants; Lin 2012 - P < 0.001, 170 participants; Sandhu 2014 - P < 0.05, 200 participants; and Takenaka 2011 - P < 0.01, 69 participants), one reported a higher IDS score in the videolaryngoscope group (Frohlich 2011 - P < 0.05, 60 participants) and one reported no differences between groups (Arima 2014 - P = 0.66, 109 participants). Andersen 2011 reported results on a graph, from which it was not possible to extract data.

Five studies used an alternative scale to IDS (Abdallah 2011; Choi 2011; Ithnin 2009; Lim 2005; Russell 2013). Abdallah 2011 used a Likert scale measuring ease of intubation (from 0 = extremely easy to 100 = extremely difficult), Choi 2011 and Lim 2005 described a visual analogue scale for recording difficulty of intubation (a 10-point scale and a 100-mm scale, respectively), Russell 2013 used a numerical rating scale from 1 (none) to 10 (severe) and Ithnin 2009 used an intubation scoring system to assess jaw relaxation, laryngoscopy, vocal cords, coughing and movement. In Abdallah 2011, study authors reported more difficult intubation

in the Pentax AWS group (P = 0.02; 99 participants), in Choi 2011 study authors reported less difficult intubation in the GlideScope group (P < 0.05; 60 participants), Russell 2013 described intubation as easier in the Macintosh group and Ithnin 2009 and Lim 2005 reported no differences between groups.

Improved visualization

A total of 36 studies with 3869 participants assessed visualization using the Cormack and Lehane (CL) scoring system to assign grades of 1 to 4 (1 indicated that > 50% of cords were visible; 4 meant that neither glottis nor epiglottis was seen). Four studies presented data in graphs from which it was not possible to extract precise data (Cavus 2011; Jungbauer 2009; Lee 2009; Serocki 2013). Abdallah 2011 collected data but reported no results in the paper, Ilyas 2014 combined data for each patient between first and second laryngoscope attempts and Sun 2005 collected data between laryngoscopy comparisons that could not be pooled. Sandhu 2014 reported a statistically significant difference between groups for this outcome but presented no figures and no direction of significance.

Six studies used a cross-over design and recorded the CL grade for all participants for each laryngoscope (Enomoto 2008; Maruyama 2008a; Peck 2009; Robitaille 2008; Serocki 2010; Taylor 2013). We excluded these studies to avoid a unit of analysis issue. Lee 2012 used a cross-over design but had reported CL scores for each laryngoscope so that the data could be reported separately. We included this study in our analysis by using the lowest CL 1 score, which was provided by the Storz group. For multi-arm studies, we combined data for each of the VLS groups. Thus we carried out meta-analysis for 22 studies (Andersen 2011; Aoi 2010; Arici 2014; Aziz 2012; Bensghir 2010; Bensghir 2013; Frohlich 2011; Griesdale 2012; Gupta 2013; Kim 2013; Komatsu 2010; Lee 2012; Lim 2005; Lin 2012; Malik 2008; Malik 2009a; Malik 2009b; Maruyama 2008b; McElwain 2011; Takenaka 2011; Teoh 2010; Walker 2009), which showed a higher number of laryngoscopies achieving a grade 1 CL view when a videolaryngoscope was used (M-H OR, random-effects 6.77, 95% CI 4.17 to 10.98; P < 0.00001; I^2 = 74%; 2240 participants). See Analysis 11.1.

We combined data for CL grades 1 to 2 and for CL grades 3 to 4, again excluding cross-over designs with the exception of Lee 2012, for which we used data from the Storz group, and combining the data for multi-arm studies. This approach revealed more laryngoscopies achieving CL grade 1 or 2 with a VLS (M-H OR, random-effects 5.42, 95% CI 3.70 to 7.95) and fewer VLS laryngoscopies achieving CL grade 3 or 4 (M-H OR, random-effects 0.18, 95% CI .013 to 0.27; I^2 = 5%; 2240 participants). See Analysis 12.1.

Only five studies used the POGO scoring method (percentage of glottic opening) (Choi 2011; Hindman 2014; Peck 2009; Sandhu 2014; Woo 2012). Hindman 2014 did not report mean scores and was not included in the meta-analysis. Combined results for the other studies showed an extremely high level of heterogeneity (I^2 = 96%); therefore, we did not pool the data. See Analysis 13.1.

Subgroup analysis

Different designs of VLS

We included nine different types of VLS in our analysis; most comparisons included GlideScope (29 studies), Pentax AWS (20 studies), C-MAC (10 studies) and McGrath (eight studies). Remaining VLS comparisons were reported by only two studies (X-lite) or by individual studies (C-MAC D-blade, Airtraq (with video), Truview EVO2 and CEL-100).

We carried out subgroup analysis on four VLS designs (GlideScope, Pentax AWS, McGrath and C-MAC) for the outcome of failed intubation. Results showed no statistically significant differences when GlideScope, Pentax or McGrath was compared with the Macintosh blade (GlideScope: M-H OR, random-effects 0.57, 95% CI 0.25 to 1.32; 1306 participants; Pentax: M-H OR, random-effects 0.24, 0.05 to 1.20; 1086 participants; and McGrath: M-H OR, random-effects 1.18, 95% CI 0.06 to 23.92; 466 participants). Separation of GlideScope studies from studies of the other VLS devices revealed a lower level of statistical heterogeneity for this result (I^2 = 24%), whereas heterogeneity for the Pentax and McGrath comparisons remained moderate to high (I^2 = 59%, I^2 = 78%, respectively). The comparison for the C-MAC device demonstrated statistically significant differences and fewer failures with the C-MAC (M-H OR, random-effects 0.32, 95% CI 0.15 to 0.68; 1058 participants). We found no heterogeneity (I^2 = 0%) for this result. See Analysis 14.1.

We did not carry out subgroup analysis on hyoxia by design of VLS because only three studies reported event data for this outcome.

Obese or non-obese patients

Only two studies with 199 participants included individuals who were obese (Abdallah 2011; Andersen 2011). It was not possible for review authors to carry out meaningful subgroup analysis for this patient group for our prespecified outcomes of failed intubation, time for tracheal intubation and hypoxia, as Abdallah 2011 reported on none of these outcomes, and Andersen 2011 reported only failed intubation and hypoxia.

Anticipated or known difficult airways

A total of 19 studies that included only participants without a predicted difficult airway reported data on failed intubation (Andersen 2011; Arici 2014; Bensghir 2010; Bensghir 2013; Bilehjani 2009; Carassiti 2013; Ilyas 2014; Kill 2013; Lee 2012; Lin 2012; Nishikawa 2009; Pournajafian 2014; Russell 2013; Siddiqui 2009; Sun 2005; Takenaka 2011; Walker 2009; Woo 2012; Xue 2007). Six studies included only participants with a

predicted difficult airway (Aziz 2012; Cordovani 2013; Jungbauer 2009; Malik 2009b; Serocki 2010; Serocki 2013), and nine studies included participants whose airway was manipulated to simulate a difficult laryngoscopy (Aoi 2010; Enomoto 2008; Komatsu 2010; Lim 2005; Malik 2008; Malik 2009a; McElwain 2011; Peck 2009; Taylor 2013). Subgroup analysis for the failed intubation outcome showed fewer failures when a VLS was used with participants who had a predicted difficult airway (M-H OR, random-effects 0.28, 95% CI 0.15 to 0.55; I^2 = 0%; 830 participants). This effect was also evident for those with a simulated difficult airway (M-H OR, random-effects 0.18, 95% CI 0.04 to 0.77; I^2 = 53%; 810 participants). However, studies with no predicted difficult airway reported no difference in failed intubation by type of device (M-H OR, random-effects 0.61, 95% CI 0.22 to 1.67; I^2 = 56%; 1743 participants). See Analysis 15.1.

Different sites of intubation

Three studies with 772 participants did not include elective surgical patients (Arima 2014 - prehospital setting; Griesdale 2012 - urgent tracheal intubation by critical care team; Yeatts 2013 - emergency airway management in trauma resuscitation unit).
Only one of these studies reported on the outcome of failed intubation (Arima 2014); therefore it was not possible for review authors to carry out subgroup analysis, although this study described a greater number of failures in the VLS group than in the Macintosh group. None of these studies reported on hypoxia.

Experienced or inexperienced intubator

We compared studies that included personnel with equivalent experience in the clinical setting (≥ 20 intubations) with the VLS and Macintosh devices against studies in which investigators stated that included personnel had less experience in the clinical setting with the VLS device (fewer than 20 intubations; or unfamiliar with using double-lumen tubes for intubation). We found no statistical differences between subgroups (P = 0.75) for the outcome of failed intubation. However, whilst studies with personnel experienced in both devices reported fewer failed intubations when a VLS was used (M-H OR, random-effects 0.32, 95% CI 0.13 to 0.75; I^2 = 47%; 1927 participants), there was no evidence of a difference in the number of failed intubations when personnel were less experienced with a VLS (M-H OR, random-effects 0.20, 95% CI 0.02 to 2.56; I^2 = 75%; 346 participants). See Analysis 16.1.

Sensitivity analysis

Missing data

We considered the effect of missing data on our results. We excluded studies for which we had been unable to judge whether data were complete because only abstracts were available, as well as studies that had high or unexplained participant loss for all outcomes in which these studies were included. For the analysis of sore throat on postoperative day 1, we removed one study (Woo 2012), and results demonstrated fewer sore throats when a VLS was used (M-H OR, random-effects 0.45, 95% CI 0.22 to 0.90). Other analyses remained unchanged.

Cross-over studies

The inclusion of cross-over studies in our review had the potential to introduce bias, and in sensitivity analysis we reconsidered the results for each of our outcomes, eliminating these studies when relevant. For the outcomes failed intubation, sore throat (in PACU), hoarseness, successful first attempt and number of attempts, results showed no differences. For the outcomes hypoxia, sore throat (postoperative day 1) and intubation difficulty scores, either no cross-over studies were included in the analysis, or study results revealed no events in either group. However, for laryngeal/airway trauma, although fewer traumas were reported in the VLS group, results were no longer statistically significant (M-H OR, random-effects 0.75, 95% CI 0.51 to 1.11; I^2 = 26%; 22 studies; 2369 participants).

Multi-arm studies

To avoid unit of analysis errors, we made decisions regarding the inclusion or exclusion of data for our multi-arm studies. In sensitivity analysis, we re-considered these decisions. We altered the data by including only the lowest event scores for each of our multi-arm studies, and then only the highest event scores for each of these studies. For our primary outcome of failed intubation, this revealed no differences in results. Similarly, this sensitivity analysis revealed no differences in patient-reported sore throat and successful first attempt. We deemed it unnecessary to perform multi-arm sensitivity analysis for hypoxia, as included relevant studies provided no event data. For laryngeal trauma, we found no significant differences in results between VLS and Macintosh groups when we included the highest event scores for each of these studies (M-H OR, random-effects 0.73, 95% CI 0.52 to 1.03; I^2 = 20%; 29 studies; 3110 participants). We did not carry out any further analysis on this result.

Risk of bias

For sensitivity analysis of our risk of bias assessments, we considered only our primary outcome of failed intubation.
We removed studies with unclear or high risk of selection bias (Aoi 2010; Arima 2014; Kill 2013; Lee 2009; Lee 2012; Lim 2005; Peck 2009; Pournajafian 2014; Serocki 2010; Serocki 2013; Takenaka 2011; Taylor 2013; Walker 2009; Woo 2012; Xue 2007). A statistically significant effect remained, with fewer failed intubations when a videolaryngoscope was used (M-H OR, fixed-effect 0.41,

95% CI 0.26 to 0.63; 23 studies; 2811 participants). Similarly, we noted no differences in results when we removed those with a high level of attrition bias (Arima 2014; Cavus 2011; Lee 2009; Woo 2012) (M-H OR, fixed-effect 0.36, 95% CI 0.26 to 0.51; 34 studies; 3624 participants).

We removed studies that we had judged to be at high risk of bias regarding reporting of intubator experience (Aziz 2012; Bensghir 2010; Kill 2013; Lim 2005; Russell 2013); we found no difference in results when we removed these studies, nor when we combined removal of those that we had recorded as having unclear risk of bias for this domain (Arici 2014; Arima 2014; Bilehjani 2009; Cavus 2011; Enomoto 2008; Ilyas 2014; Jungbauer 2009; Komatsu 2010; Peck 2009; Takenaka 2011; Walker 2009).

Similarly, we noted no differences in results when we removed from analysis those with high risk of funding bias (Aziz 2012; Cavus 2011; Enomoto 2008; Kill 2013; Serocki 2013; Taylor 2013).

DISCUSSION

Summary of main results

We included 64 studies comparing videolaryngoscopy with direct laryngoscopy in patients requiring tracheal intubation for general anaesthesia. In addition, we identified 38 studies awaiting classification and seven ongoing studies.

Nine types of videolaryngoscope (VLS) design were used in the 64 included studies: GlideScope, Pentax AWS, C-MAC (to include DCI laryngoscope), McGrath, X-lite, C-MAC D-blade, Airtraq, Truview EVO2 and CEL-100. Most studies compared the use of GlideScope, Pentax AWS, C-MAC and McGrath. Some designs of Airtraq and Truview EVO2 could be used with and without a camera attachment, and we included only those studies in which it was clear from the report that the devices had been used with a camera. Forty-eight studies included participants without a predicted difficult airway, and 15 of these used techniques to simulate a difficult airway for the purpose of the study. Six studies recruited participants with a known or predicted difficult airway, but others did not specify or included both predicted and not predicted difficult airways.

Most studies used an experienced anaesthetist to perform laryngoscopies. However, it was not always clear from the paper whether anaesthetists had equivalent experience with both devices.

Studies measured our primary outcomes of failed intubation and hypoxia, as well as our secondary outcomes of mortality, serious respiratory complications, laryngeal or airway trauma, patient-reported sore throat or hoarseness, number of successful first attempts, number of attempts, time for tracheal intubation, difficulty of tracheal intubation and improved visualization of the larynx.

Analysis of 38 studies, which included all types of VLS, revealed statistically significantly fewer failed intubations when a VLS was used. However, when analysis was carried out by type of scope, we noted no significant difference in the number of failed intubations when the GlideScope, Pentax or McGrath was compared with the Macintosh blade. The result for failed intubation remained statistically significantly in favour of the C-MAC device in this analysis. We also carried out analysis according to assessed difficulty of the participant airway. We found statistically fewer failed intubations when a VLS was used in participants who presented with an anticipated difficult airway or a simulated difficult airway, but no difference in the number of failed intubations for participants who presented without an anticipated difficult airway. We also considered whether the experience of the intubator with the VLS device affected the number of failed intubations. We found fewer failed intubations with a VLS when the intubator had equivalent experience with both devices (we defined this as having used a VLS on at least 20 occasions in the clinical setting, with at least equivalent experience with a Macintosh, although the Macintosh experience was often substantially greater). However, when the intubator was experienced with the Macintosh but had used the VLS device on fewer than 20 occasions in the clinical setting, we found no evidence of a difference in the number of failed intubations.

Analysis of other outcomes demonstrated statistically significantly fewer laryngeal/airway traumas (in 22 studies) and fewer incidences of postoperative hoarseness (in six studies) when a VLS device was used. However, the result for laryngeal/airway trauma was dependent on our decision regarding inclusion of cross-over designs and which data to use for included multi-arm studies. A statistically significantly higher number of laryngoscopies achieved a CL grade 1 view, with most of the cords visible, when a VLS was used (in 22 studies), and statistically significantly fewer laryngoscopies with a VLS achieving a grade 3 or 4 CL view (in 22 studies); also, the VLS was easier to use than the Macintosh (in seven studies). Only three studies reported results that we were able to combine for hypoxia, and for this outcome, we noted no differences between types of scopes used. Similarly, few studies reported on mortality and respiratory complications. We found no statistically significant difference in the incidence of sore throat in the postanaesthesia care unit (PACU) nor at 24 hours postoperatively, and no statistically significant differences between scopes in the proportion of successful first attempts nor in the proportion of those needing more than one attempt.

We noted an extremely high level of heterogeneity when studies reporting time for tracheal intubation were combined, possibly explained by the various time points used to measure this outcome. We did not present an effects estimate for this outcome.

Overall completeness and applicability of evidence

We carried out a thorough search and identified 7044 participants in a large number of studies. We included comparisons of currently available videolaryngoscopes with a Macintosh blade. Included

studies were published from 2005 to 2014; most were published since 2010, reflecting the introduction and potential availability of such devices. Many of our included studies measured our primary outcome of failed intubation, as well as our secondary outcomes. We included studies that enrolled both participants who were anticipated to have a difficult intubation and participants who were not. We included studies with both experienced and inexperienced personnel performed in different settings, both in-hospital and out-of-hospital.

Quality of the evidence

It was not possible to blind personnel to the type of laryngoscope used with each participant; because of the likely potential for user preference, we believed that all studies were subject to a high level of performance bias. However, we considered other types of bias in our sensitivity analysis, and despite varied levels of bias across studies, results for our primary outcome of failed intubation were not affected by the quality of the evidence when combined in meta-analysis. When using GRADE to assess quality across the included studies, we believed that the unavoidable high level of performance bias in all studies should take preference when the risk of bias for this review was summarized. As a result, we downgraded evidence for each of our outcomes by one level for study limitations. We assessed the outcomes failed intubation, proportion of successful first attempts, and sore throat, to be moderate quality evidence. We included few studies that reported hypoxia, serious respiratory complications, or mortality, which introduced imprecision and downgraded these outcomes to very low quality evidence. There was a large number of studies with substantial heterogeneity that reported time for tracheal intubation and we graded the evidence for this outcome to be very low quality. Summary of findings for the main comparison.

Potential biases in the review process

We made the decision to exclude studies that had used particular devices (Airtraq, Truview EVO2, Bullard, Wuscope and Optiscope) and had not described whether these were used with a video/camera attachment. We did not contact any of the study authors to clarify the intervention, leading to exclusion of 38 studies from this review.

We encountered difficulty establishing the actual level of experience of personnel, either by the number of years of anaesthetic experience or by the number of experiences with each device. Although we attempted to measure our outcomes by level of experience, our results are applicable only according to our own interpretation of this.

Agreements and disagreements with other studies or reviews

The review of Mihai et al (Mihai 2008) concluded that evidence obtained by examination of rigid videolaryngoscopes was of poor quality, and review authors did not provide strong evidence that use of these devices should supersede direct laryngoscopy for straightforward or difficult intubation. The Mihai review included many observational studies, as well as randomized controlled trials (RCTs). Other more recent reviews concluded that videolaryngoscopes can improve the glottic view as measured on a Cormack and Lehane scale (Griesdale 2012b; Hoshijima 2014; Su 2011). Review authors indicated that this improvement is more pronounced in patients with a difficult airway (Griesdale 2012) and recommended the use of videolaryngoscopes to achieve successful intubation in patients with higher risk of a difficult laryngoscopy (Healy 2012). Our findings in this systematic review are consistent with the findings of these recent reviews, and whilst these reviews considered many of the same studies that we have included, none were as large and none included all of our review outcomes.

AUTHORS' CONCLUSIONS

Implications for practice

Our evidence suggests that videolaryngoscopes may aid intubation, particularly in patients presenting with a predicted or known difficult airway. Their use is likely to improve the glottic view and reduce the number of laryngoscopies in which the glottis cannot be seen, irrespective of predicted or known difficulty, and may reduce the incidence of laryngeal/airway trauma. We found no evidence to indicate that use of a VLS would result in fewer attempts to intubate. We were not able to establish whether intubation is likely to take less or more time with a VLS, nor whether this would result in fewer incidences of hypoxia or respiratory complications. However, we are aware of relevant ongoing studies that compare different videolaryngoscopes with direct laryngoscopy, and a large number of studies were identified in searches run in January 2016, along with completed studies identified from clinical trials registers. This demonstrates continued research interest in this field, and incorporation of data from these studies may lead to changes in the results of this review.

Implications for research

This review has not sufficiently explored the use of VLS devices in particular clinical scenarios, for example, VLS intubation in the emergency setting during anaesthesia, and in the intensive care unit and emergency department and outside hospitals. Further research is needed on the effect of intubator experience on potential benefits of VLS. We would recommend that studies incorporate useful data on respiratory complications, hypoxia and

time to intubate. Finally, we were not able to usefully distinguish performance differences between different types of VLS, but it is unlikely that devices of differing designs would perform equally; research is needed to elucidate the differential effects of different types of VLS.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Abdallah 2011

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 99 **Inclusion criteria:** body mass index between 30 and 50 kg/m^2; orotracheal intubation required for elective surgery **Exclusion criteria:** no details **Baseline characteristics:** **Pentax AWS** *Age:* 50 (SD ± 12) *Gender M/F:* 11/39 *BMI:* 41.2 (SD ± 4.4) *ASA II:* 15 *ASA III:* 32 *ASA IV:* 3 *Mallampati 1:* 21 *Mallampati 2:* 18 *Mallampati 3:* 7 *Mallampati 4:* 4 **Macintosh** *Age:* 49 (SD ± 14) *Gender M/F:* 10/39 *BMI:* 42.5 (SD ± 5.9) *ASA II:* 7 *ASA III:* 40 *ASA IV:* 2 *Mallampati 1:* 14 *Mallampati 2:* 21 *Mallampati 3:*13 *Mallampati 4:* 0 **Country:** USA **Setting:** hospital
Interventions	Pentax AWS (n = 50) vs Macintosh blade (n = 49) Macintosh laryngoscope with a #4 blade
Outcomes	*Continuous outcomes:* Time to intubation: defined as time from start of first attempt of insertion of laryngoscope until a capnogram signal was obtained. Median (Q1, Q3) time: Pentax 38 (31, 50) seconds vs Macintosh 26 (22, 29) seconds. Adjusted for Mallampati and ASA status: hazard ratio 0.35, 95% confidence interval 0.23 to 0.55, P < 0.001. No evidence of a learning curve on time to intubation with the Pentax AWS based on analysis of sequence quartiles Ease of intubation on a scale of 0 to 100 (0 as easiest): VLS 52 (SD ± 31), Mac 40 (SD

	± 28); P = 0.02 CL glottic view reported with CL 1 and 2: grouped as good; CL 3 and 4: grouped as poor. Data not reported for this outcome *Dichotomous outcomes*: Laryngeal/airway trauma Sore throat Successful first attempt No. of attempts: 1 to 3
Notes	*Baseline characteristics:* more women than men in each group. More ASA II in Pentax group, more ASA III in Macintosh group. More Mallampati scores of 1 in Pentax group, more Mallampati scores of 2 in Macintosh group *Conclusions of study authors:* Although Pentax AWS often provided a superb glottic view, time required for intubation was longer than for Macintosh. Success was better with Mactinosh blade. AWS should not be substituted routinely for a conventional Macintosh #4 blade in morbidly obese patients *Funding/declarations of interest:* supported by internal funds; Pentax on loan from manufacturers for duration of the study

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "Randomization was based on computer-generated, random-block codes"
Allocation concealment (selection bias)	Low risk	Quote: "sequentially numbered opaque envelopes" Comment: assumed envelope was sealed
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "it was impossible to blind the operator to the device being used" Comment: this will affect all outcomes for this domain.
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: Observers who looked at blood staining and postoperative sore throat were blinded to group allocation. However, it was not possible to blind outcome assessors to primary outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Of 105 randomized patients, 4 did not complete the study because of cancellation of surgery or because the laryngoscopist could not arrive to the operating room on time, and 2 patients in the Pentax group had missing primary outcomes" Comment: few losses, unlikely to introduce any bias

Abdallah 2011 (*Continued*)

Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	High risk	Quote: "All patients' tracheas were intubated by 1 of 2 attending anesthesiologists, each of whom had previously used the Pentax AWS 5 to 10 times before the study began" Comment: it is likely that the balance of experience will favour the Macintosh group
Baseline characteristics	Low risk	Quote: "patients in the Pentax group were more likely to have better ASA physical status and better Mallampati scores (absolute standardized difference 0.25)" Comment: small difference unlikely to be clinically relevant
Funding sources	Unclear risk	Comment: supported by internal funds; Pentax on loan from manufacturers for duration of study

Ahmad 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 50 **Inclusion criteria:** normal intraocular pressure, scheduled for ophthalmic surgery requiring tracheal intubation **Exclusion criteria:** no details **Baseline characteristics:** described as comparable but no details given; abstract only **Country:** Saudi Arabia **Setting:** hospital
Interventions	GlideScope vs Macintosh blade
Outcomes	*Continuous outcomes*: Duration of intubation *Other outcomes:* MAP and HR, plus intraocular pressure
Notes	*Additional:* email sent to authors to request additional details; additions made to risk of bias tables following study author response *Funding/declarations of interest:* none (confirmed by study authors in email)
Risk of bias	

Ahmad 2013 (*Continued*)

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "randomly assigned" Comment: Email information from study authors states use of sealed envelopes
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: abstract only; insufficient details but no blinding assumed
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Comment: abstract only; insufficient details
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Comment: Email information from study authors states intubators had 5 years' experience with GlideScope and up to 20 years' experience with Macintosh blade
Baseline characteristics	Unclear risk	Comment: no details
Funding sources	Low risk	Comment: Email information from study authors states no additional funding used for study

Andersen 2011

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 100 **Inclusion criteria:** all patients scheduled for elective bariatric surgery, BMI > 35 kg/m^2 and age > 18 and < 60 years **Exclusion criteria:** severe mental illness, ongoing alcohol or substance abuse, previous difficult intubation, patient considered by the anaesthesiologist to require a different procedure of anaesthesia or intubation (e.g. fibreoptic intubation) than prescribed by the study protocol **Baseline characteristics:** **GlideScope** *Age:* 42 SD ± 10 (range 21-60) *Gender M/F:* 15/35

Andersen 2011 (*Continued*)

	BMI: 42 SD ± 6 (range 35-62) *Mallampati ≥ 3*: 11 *Height (cm)*: 171 SD ± 10 (range 150-195) *Weight (kg)*: 125 SD ± 10 (range 92-190) **Macintosh** *Age*: 41 SD ± 8 (range 28-59) *Gender M/F*: 9/31 *BMI*: 41 SD ± 5 (range 35-56) *Mallampati 3*: 16 *Height (cm)*: 172 SD ± 7 (range 157-194) *Weight (kg)*: 122 SD ± 18 (range 90-167) **Country:** Denmark **Setting:** hospital
Interventions	GlideScope (n = 50) vs Macintosh blade (n = 50) GlideScope participants in ramped position; #4 blade used; stylet bent at 90 degrees, as per manufacturer guidelines Macintosh participants in ramped position; #3 or #4 blade at the intubator's discretion; hockey-stick-shaped stylets
Outcomes	*Continuous outcomes:* Time to intubation (time from gripping the laryngoscope until registration of expired CO_2): GlideScope (median (range)): 48 (22-148); Mac 32 (17-209) Difficulty of intubation: no difference in subjective difficulty of intubation, but IDS scores significantly lower in GlideScope group; median IDS score: GlideScope group 1 (0-4); Mac 2 (0-7) (P = 0.01) *Dichotomous outcomes*: Failed intubation: defined as not achieving intubation in maximum 2 attempts Hypoxia: defined as oxygen desaturation < 93% Laryngeal/airway trauma: defined as mucosal injury, airway bleeding, dental trauma Sore throat/hoarseness (assessed at 1 hour post extubation on a VAS): sore throat present in 40% in GlideScope group vs 42% in Macintosh group No. of attempts: 4 participants in Macintosh group required more than 1 attempt at intubation vs 1 in GlideScope group (P = 0.36). Two of the 4 participants in the Macintosh group proved impossible to intubate within 2 attempts with direct laryngoscopy (i.e. failed intubation) and were subsequently intubated with the GlideScope with no problem CL glottic view: 1 to 4
Notes	*Experience of intubator*: all intubations performed by 1 of 5 certified nurse anaesthetists or 2 anaesthesiologists, all with prior experience with at least 20 GlideScope intubations and with wide experience in anaesthetizing obese patients *Funding/declarations of interest:* departmental funding only

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Andersen 2011 (*Continued*)

Random sequence generation (selection bias)	Low risk	Quote: "computer-generated random numbers"
Allocation concealment (selection bias)	Low risk	Quote: "sealed opaque envelopes packed by an outside investigator" Comment: does not state that envelopes are sequentially numbered, but low risk of bias assumed with use of outside investigator
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: no attempt to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "One hundred consecutive patients were enrolled after which the trial was ended as planned. All eligible patients gave consent to participate, none were excluded or failed to complete, and all were included in the nal analysis"
Selective reporting (reporting bias)	Low risk	Comment: copy of protocol on clinicaltrials. gov sought and compared with published trial (clinical trials ID NCT00917033); all outcomes reported
Experience of intubator	Low risk	Quote: "All intubations were performed by one of five certified nurse anaesthetists or two anaesthesiologists all with prior experience from at least 20 GS (*GlideScope)* intubations and with wide experience in anesthetizing obese patients"
Baseline characteristics	Low risk	Quote: "The patients in the two groups were comparable with regards to demographic and airway characteristics"
Funding sources	Low risk	Comment: departmental funding only

Aoi 2010

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 36 **Inclusion criteria:** patients between 20 and 80 years of age, ASA I or II, scheduled to undergo elective surgery requiring intubation **Exclusion criteria:** risk factors for cardiopulmonary disease, predicted or history of difficult intubation (cervical spine abnormality, restricted neck mobility), gastric aspiration **Baseline characteristics:** **Pentax AWS** *Age*: 61.7 (SD ± 8.8) *Gender M/F*: 8/10 *Height (m)*: 160.0 (SD ± 8.6) *Weight (kg)*: 59.7 (SD ± 14.1) *Mallampati 1*: 10 *Mallampati 2*: 8 *Mallampati 3*: 0 **Macintosh** *Age*: 56.7 (SD ± 17.3) *Gender M/F*: 13/5 *Height (m)*: 163.9 (SD ± 7.1) *Weight (kg)*: 63.5 (SD ± 11.3) *Mallampati 1*: 8 *Mallampati 2*: 9 *Mallampati 3*: 1 **Country:** Japan **Setting:** hospital
Interventions	Pentax AWS (n = 18) vs Macintosh (n = 18) A pillow was placed under the participant's head, and an appropriately sized semirigid cervical collar was fitted around the neck to simulate limited neck movements Macintosh blade #3 or #4
Outcomes	*Continuous outcomes*: Time for tracheal intubation: defined as time when the airway device was handed to the anaesthesiologist to time when the presence of carbon dioxide was confirmed in the exhaled breath on the vital sign monitor Difficulty of intubation: IDS score distribution: AWS score of 0 in 14 participants, score of 1 in 3 participants; Mac score of 0 in 1 participant, score of 1 in 5 participants, score of 2 in 3 participants, 3 in 4 participants, 4 in 3 participants, 5 in 1 participant *Dichotomous outcomes*: Failed intubation (1 failure in AWS group due to insufficient interincisor space compared with thickness of the blade; 1 failure in Mac group due to tooth injury; failures excluded from CL data) Laryngeal/airway trauma (lip injury, blood on device) Participant reported sore throat (pharyngeal pain) Hoarseness No. of attempts: 1 to 4 CL glottic view: 1 to 4

Aoi 2010 (*Continued*)

Notes	*Experience of intubator*: In all cases, laryngoscopy was performed by 1 anaesthesiologist experienced in the use of both devices *Funding/declarations of interest:* none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Comment: described as randomized but no additional details given
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: time measured by independent observer, but not possible to blind observer for other outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: one participant from each group had failed intubation, and subsequent analyses of outcomes did not include these missing participants. However, losses were few
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Comment: all laryngoscopies performed by 1 anaesthetist experienced with both devices
Baseline characteristics	Low risk	Comment: baseline characteristics equivalent
Funding sources	Low risk	Comment: none

Arici 2014

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 80 **Inclusion criteria:** pregnant patients undergoing caesarean section surgery under general anaesthesia **Exclusion criteria:** presence of cardiovascular, hepatic, renal or neuromuscular disease, non-co-operation, restricted neck movements, retrognathia, ASA score of III or IV,

Arici 2014 (*Continued*)

	Mallampati score of 4, history of airway-related surgery, emergency surgery. Additionally, patients who had more than 2 of the following criteria were excluded: Mallampati score of 3, maximal mouth-opening capacity < 35 mm, thyromental distance < 65 mm **Baseline characteristics:** **McGrath** *Age*: 27.55 (SD ± 3.82) *Height (cm)*: 162.9 (SD ± 6.15) *Weight (kg)*: 77.90 (SD ± 13.71) *BMI*: 29.45 (SD ± 5.6) *ASA I*: 28 *ASA II*: 12 *Mallampati 1*: 19 *Mallampati 2*: 19 *Mallampati 3*: 2 **Macintosh** *Age*: 29.25 (SD ± 4.41) *Height (cm)*: 160.8 (SD ± 6.0) *Weight (kg)*: 72.32 (SD ± 9.82) *BMI*: 27.98 (SD ± 3.22) *ASA I*: 24 *ASA II*: 16 *Mallampati 1*: 21 *Mallampati 2*: 19 *Mallampati 3*: 0 **Country:** Turkey **Setting:** hospital
Interventions	McGrath series 5 (n = 40) vs Macintosh (n = 40) McGrath blade: use of stylet to guide tube during videolaryngoscopy Macintosh blade #3 or #4
Outcomes	*Continuous outcomes*: Time for tracheal intubation: defined as time from anaesthesiologist taking the laryngoscope in his hand until first upward deflection on the capnograph after connection of the anaesthetic ventilation system to the tracheal tube POGO *Dichotomous outcomes*: Failed intubation Laryngeal/airway trauma: no palatoglossal arch nor dental injuries in either group Successful first attempt CL glottic view: 1 to 4 Other outcomes: haemodynamic outcomes
Notes	*Funding/declarations of interest:* none apparent

Risk of bias

Bias	Authors' judgement	Support for judgement

Arici 2014 (*Continued*)

Random sequence generation (selection bias)	Low risk	Quote: "computer-generated random numbers"
Allocation concealment (selection bias)	Unclear risk	Quote: "sealed-envelope technique" Comment: no additional details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: assumed no attempts made to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Quote: "All intubations were performed by an experienced anesthesiologist"
Baseline characteristics	Low risk	Quote: "There was no significant difference in the demographic data and preprocedural intubation conditions between the groups"
Funding sources	Low risk	Comment: none apparent

Arima 2014

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 109 **Inclusion criteria:** age ≥ 18 years and requiring emergency tracheal intubation in the prehospital setting only during the day shift **Exclusion criteria:** none given **Baseline characteristics:** **Pentax AWS** *Age*: 74.4 (SD ± 13.6) *Gender M/F*: 34/22 Cardiac arrest participants: 54/56 **Macintosh** *Age*: 74.1 (SD ± 13.0) *Gender M/F*: 38/15 Cardiac arrest participants: 47/53 **Country:** Japan **Setting:** prehospital; paramedics/physicians travel together in ambulance to calls

Arima 2014 (*Continued*)

Interventions	Pentax AWS (n = 56) vs Macintosh (n = 53) A suction device and Magill forceps were available for use at any time
Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation(measured on IDS): median IDS (IQR): Pentax 0 (0-1) ; Mac 1 (0-2) Number of attempts (before switching from AWS to Macintosh): 0 in 3 cases, 1 in 14 cases, 2 in 1 case, 3 in 2 cases; data not reported for switching from Macintosh to AWS (Note: In 3 cases, the alternative device was used before the procedure was even started) Time for tracheal intubation (measured from insertion of the blade between the teeth to confirmation of endotracheal tube placement by capnograph. If intubation failed and the device for intubation was changed, time was measured from insertion on the first attempt to success on the second or successive attempts): median time (IQR) seconds: Pentax 155 (71-216); Mac 120 (60-170) *Dichotomous outcomes*: Failed intubation Successful first attempt Other: ultimate success of intubation (if intubation achieved within 600 seconds, even if change of device had taken place): Pentax 54/56; Mac 53/53
Notes	*Experience of intubator:* 6 physicians had previously worked as anaesthetists with an estimated range of 15 to 30 AWS intubations or > 100 Macintosh intubations per year. The remaining 5 had at least 50 Macintosh experiences but relatively fewer experiences with AWS intubation (but had received manikin training sessions) *Funding/declarations of interest:* none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "allocation was changed in a serial manner and was controlled by personnel at the physician car system center"
Allocation concealment (selection bias)	Unclear risk	Quote: "The operators were told which of the two devices had been allocated to them to use only when en route to the incident in the ambulance"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind physician
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: all outcomes assessed by physician who was not blinded. Some potential for bias in the outcomes as operators were encouraged to complete intubation as quickly as possible, even if it

Arima 2014 (*Continued*)

		was achieved by switching devices. Operators could be biased to familiar equipment; therefore change to an alternative device made frequently
Incomplete outcome data (attrition bias) All outcomes	High risk	Quote: "Of 121 patients enrolled in this study, 12 were excluded due to missing data, age < 18 years, or problems with the device used, leaving 109 for final analysis" Comment: high level of losses; no explanation about what problems with the device led to the exclusion of some patients
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Quote: "6 physicians had generally performed N 100 intubations per year as they had previously worked as anesthetists. The number of AWS intubations they have performed is not precisely known, but is estimated to be in the range of 15 to 30 AWS intubations per physician per year. The remaining 5 physicians had done an anesthesia rotation and had performed at least 50 intubations, but with relatively fewer experiences with AWS intubation" Comment: some variety of experience among personnel; unclear if these personnel were balanced between intervention and comparison groups
Baseline characteristics	Low risk	Comment: most baseline characteristics equivalent, except for differences in types of cases
Funding sources	Low risk	Comment: none

Aziz 2012

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 296 **Inclusion criteria:** patients with objective predictors of potentially difficult tracheal intubation: reduced cervical motion from pathological condition or cervical spine precautions (limited capacity to flex or extend the neck or managed with a cervical collar, but with negative imaging), Mallampati classification score of 3 or 4, reduced mouth opening (< 3 cm), history of difficult direct laryngoscopy

Aziz 2012 (*Continued*)

	Exclusion criteria: a documented easy tracheal intubation (success on first attempt), history of failed intubation and failed bag-mask ventilation, known unstable cervical spine injury, age < 18 years, presentation for an emergency surgical procedure **Baseline characteristics:** **C-MAC** *Age*: 54 (SD ± 14) *Gender M/F*: 74/75 *BMI*: 34 (SD ± 10) *ASA I*: 3 *ASA II*: 60 *ASA III*: 80 *ASA IV*: 6 **Macintosh** *Age*: 55 (SD ± 15) *Gender M/F*: 83/64 *BMI*: 34 (SD ± 10) *ASA I*: 2 *ASA II*: 53 *ASA III*: 87 *ASA IV*: 5 **Country:** US **Setting:** hospital
Interventions	C-MAC (n = 149) vs Macintosh (n = 147) External laryngeal manipulation, use of gum-elastic bougie
Outcomes	*Continuous outcomes*: Number of attempts: no details on number of attempts provided in the paper Time for tracheal intubation: defined as time between blade insertion into the mouth and inflation of the endotracheal tube cuff *Dichotomous outcomes*: Failed intubation: defined as removal of laryngoscope from the mouth, then device selected at discretion of anaesthetist. Data taken only when an alternative device had been used Laryngeal/airway trauma Patient-reported sore throat Hypoxia: defined as oxygen desaturation < 90% Successful first attempt: defined as confirmation of endotracheal tube placement by end-tidal carbon dioxide with a single blade insertion CL view achieved: 1 to 4 Success also given per providers:anaesthesiologists: C-MAC 9/10, Mac 10/12; per residents: C-MAC 64/67, Mac 78/91; per CRNAs: C-MAC 65/72, Mac 36/44
Notes	*Experience of intubator*: C-MAC: anaesthesiologist 10; resident 67; CRNA (supervised) 72; Macintosh: anaesthesiologist 12; resident 91; CRNA (supervised) 44 *Funding/declarations of interest:* supported by an investigator-initiated grant (no. 00520743-2) from Karl Storz Endoscopy-America *Additional:* contact made with study author to confirm denominator figures in Table 3; email response in file

Aziz 2012 (*Continued*)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "Randomization was performed in a 1:1 allocation ratio via specialized computer software"
Allocation concealment (selection bias)	Unclear risk	Quote: "Individual randomization cards were placed in concealed envelopes" Comment: unclear if envelope was opaque, numbered or sealed
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Both the study team and the anesthesia team remained blinded until the patient entered the operating room" Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "One of the investigators or a study nurse followed each patient into the operating room to record the relevant intubation and post intubation data" Comment: for patient reported outcomes; no details of whether other outcome assessors were blinded or not
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Three hundred patients were consented and enrolled in this randomized controlled study. There were four randomization failures that were excluded from analysis" Comment: losses too few to create bias
Selective reporting (reporting bias)	Low risk	Quote: "pre-registered online as NCT00956592" Comment: clinical trial register protocol sourced; protocol outcomes comparable with study-reported outcomes
Experience of intubator	High risk	Quote: "In three cases, the anesthesia team deviated from randomization to DL (*Macintosh)* and intubated with a video laryngoscope because of provider preference" Comment: does not state whether all operators had equivalent experience with C-MAC, but it is known that some operators preferred a particular device. Also, the level of qualification of the operators differed be-

Aziz 2012 (*Continued*)

		tween devices, with more resident anaesthetists using the Macintosh, and more CRNAs using the C-MAC
Baseline characteristics	Low risk	Comment: baseline characteristics largely comparable
Funding sources	High risk	Comment: supported by an investigator-initiated grant (no. 00520743-2) from Karl Storz Endoscopy-America

Bensghir 2010

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 68 **Inclusion criteria:** > 18 years, ASA I or II, scheduled for elective thoracic surgery **Exclusion criteria:** rapid sequence induction, anticipated difficult airway, contraindication against use of double-lumen tube **Baseline characteristics:** **X-lite** *Age*: 41.8 (SD ± 9) *Gender M/F*: 28/6 *BMI*: 24 (SD ± 2.9) *ASA I*: 23 *ASA II*: 11 *Mallampati 1*: 26 *Mallampati 2*: 8 **Macintosh** *Age*: 44.6 (SD ± 10) *Gender M/F*: 29/5 *BMI*: 22.98 (SD ± 2.19) *ASA I*: 20 *ASA II*: 14 *Mallampati 1*: 24 *Mallampati 2*: 10 **Country:** Morrocco **Setting:** hospital
Interventions	X-lite videolaryngoscope (n = 34) vs Macintosh (n = 34) Stylet used in both groups Double-lumen tube used in both groups
Outcomes	*Continuous outcomes*: Time for tracheal intubation (from insertion of blade into mouth to capnography reading) *Dichotomous outcomes*:

	Failed intubation: defined as not successful after 3 attempts followed by intubation with alternative device Laryngeal/airway trauma (dental trauma, oesophageal or vocal cord trauma or bleeding) Hypoxia No. of attempts: 1 to 2 CL glottic view: 1 to 4
Notes	*Experience of intubator*: intubator with at least 5 years' experience, including experience with X-lite. No experience with double-lumen tube with X-lite *Funding/declarations of interest:* none

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Comment: computer-generated randomization
Allocation concealment (selection bias)	Unclear risk	Comment: numbers concealed in envelopes until moment of intubation; no additional details about envelopes
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: assumed outcome assessors were not blinded from outcomes measured in theatre
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	High risk	Comment: Anaesthetist had more than 5 years' experience with use of DLT and training in the use of X-lite but no experience in use of X-lite with double-lumen tube. No details of experience with Macintosh provided
Baseline characteristics	Low risk	Comment: baseline characteristics comparable
Funding sources	Low risk	Comment: none

Bensghir 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 70 **Inclusion criteria:** > 18 years old, ASA I or II, scheduled for elective thyroid surgery **Exclusion criteria:** anticipated difficult intubation, limited interdental distance, limited cervical mobility, limited thyromental difficulty or Mallampati 4. Those needing rapid sequence induction, those with gastro-oesophageal reflux, hiatus hernia, diabetes, obesity **Baseline characteristics:** **X-lite** *Age*: 43.5 (SD ± 11.1) *Gender M/F*: 11/24 *Height (cm)*: 172.7 (SD ± 3.4) *Weight (kg)*: 71.1 (SD ± 8.3) *BMI*: 23.9 (SD ± 2.9) *ASA I*: 28 *ASA II*: 7 *Mallampati 1*: 16 *Mallampati 2*: 13 *Mallampati 3*: 5 *Mallampati 4*: 1 **Macintosh** *Age*: 48.8 (SD ± 12.7) *Gender M/F*: 8/27 *Height (cm)*: 172.1 (SD ± 3.7) *Weight (kg)*: 73.9 (SD ± 8.2) *BMI*: 25.0 (SD ± 3.1) *ASA I*: 25 *ASA II*: 10 *Mallampati 1*: 15 *Mallampati 2*: 10 *Mallampati 3*: 8 *Mallampati 4*: 2 **Country:** Morrocco **Setting:** hospital
Interventions	X-lite videolaryngoscope (n = 35) vs Macintosh (n = 35) External laryngeal manoeuvres used, with gum-elastic bougie Macintosh blade #3
Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation: IDS scores for difficulty of tracheal intubation - X-lite 0: 13/35; 1 to 5: 20/35; > 5: 2/35; Mac 0: 7/35; 1 to 5 19/35; > 5: 9/35) Time for tracheal intubation: defined as sum of times for glottic visualization plus time from glottic visualization to tracheal intubation *Dichotomous outcomes*: Failed intubation (1 participant in Macintosh group was intubated with Airtraq after 3 attempts with Macintosh) Laryngeal/airway trauma (blood on scope; "no dental or laryngeal trauma was noted in

Bensghir 2013 (*Continued*)

	either group") Hypoxia: defined as oxygen saturation < 92% CL glottic view: 1 to 4
Notes	*Experience of intubator*: 3 intubators with experience of more than 500 intubations with Macintosh and more than 60 with X-lite *Funding/declarations of interest:* none *Addtional:* study also included use of Airtraq scope - excluded from this review

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Comment: computer-generated randomization
Allocation concealment (selection bias)	Unclear risk	Comment: concealed in envelopes, but no additional details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: outcome assessors independent but not possible to blind assessors in theatre
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no losses after randomization
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Comment: although intubators had less experience with X-lite, they were still sufficiently experienced in both devices
Baseline characteristics	Low risk	Comment: baseline characteristics comparable
Funding sources	Low risk	Comment: none

Bilehjani 2009

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 78 **Inclusion criteria:** patients scheduled for elective CABG

Bilehjani 2009 (*Continued*)

	Exclusion criteria: patients with renal, hepatic disease, bleeding diathesis, diabetes mellitus, Mallampati score of 3 or 4, history of a difficult intubation and ASA class IV **Baseline characteristics:** **GlideScope** *Age*: 57.28 (SD ± 9.91) *Gender M/F*: 23/17 *Height (cm)*: 163.73 (SD ± 10.15) *Weight (kg)*: 71.45 (SD ± 12.16) *Mallampati 1*: 21 *Mallampati 2*: 16 *Mallampati 3*: 3 *Mallampati 4*: 0 **Macintosh** *Age*: 58.58 (SD ± 10.87) *Gender M/F*: 29/9 *Height (cm)*: 165.47 (SD ± 8.10) *Weight (kg)*: 72.26 (SD ± 15.47) *Mallampati 1*: 25 *Mallampati 2*: 12 *Mallampati 3*: 1 *Mallampati 4*: 0 **Country:** Iran **Setting:** hospital
Interventions	GlideScope (n = 40) vs Macintosh (n = 38) Use of stylet in both groups when required Macintosh blade #3 or #4
Outcomes	*Continuous outcomes*: Number of attempts Time for tracheal intubation: defined as time from opening mouth to filling the tube cuff - measured in seconds *Dichotomous outcomes*: Failed intubation Respiratory complications Laryngeal/airway trauma Patient-reported sore throat (sore throat and odynophagia reported together) Successful first attempt
Notes	*Experience of intubator*: experienced, but no details on level of experience *Funding/declarations of interest:* none apparent

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Using online software (http://www.graphpad.com/quickcalcs/randomize1.cfm), patients

Bilehjani 2009 (*Continued*)

		were randomly allocated" Comment: computer generated
Allocation concealment (selection bias)	Unclear risk	Comment: no details given
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: no mention of blinding; unlikely as timing of intubation was involved
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Two patients were excluded because of long postoperative intubation period" Comment: low number unlikely to cause bias
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Quote: "all of tracheal intubations were performed by experienced anesthesiologists" Comment: no information on whether amount of experience with each device was equivalent
Baseline characteristics	Low risk	Comment: baseline characteristics comparable
Funding sources	Low risk	Comment: none apparent

Carassiti 2013

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 30 **Inclusion criteria:** adult patients scheduled for elective surgery under general anaesthesia, aged > 18 years to < 65 years, ASA I or II **Exclusion criteria:** patient likely to be difficult to intubate according to SIAARTI recommendations **Baseline characteristics:** **GlideScope followed by Macintosh** *Age*: 44 (SD ± 11) *Gender M/F*: 8/7 *BMI*: 25.5 (SD ± 3) **Macintosh followed by GlideScope**

	Age: 41 (SD ± 12) *Gender M/F*: 8/7 *BMI*: 26.4 (SD ± 2.8) **Country:** Italy **Setting:** hospital
Interventions	GlideScope (n = 15) vs Macintosh (n = 15) GlideScope blade #4; "hockey stick" stylet used in GlideScope group Macintosh blade #3 or #4
Outcomes	*Continuous outcomes*: Time for tracheal intubation: defined as time from insertion of blade between incisors until tube cuff was inflated *Dichotomous outcomes*: Failed intubation Laryngeal/airway trauma ("no injuries or dental damage were recorded") "All were successfully intubated" - but no definition of success given
Notes	*Experience of intubator*: 1 intubator experienced in both techniques; > 100 intubations with each device *Funding/declarations of interest:* department funding only; no conflicts of interest *Additional:* Study aimed to measure forces but also reported data on relevant outcomes. Study authors have not reported on CL grades, although this information is included in the Methods section

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Comment: use of a random number generator
Allocation concealment (selection bias)	Unclear risk	Quote: "numbered coded vehicles was the method used to achieve allocation concealment" Comment: not clear what this means and whether this is sufficient
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: participants blinded to group assignment, but intraoperative data collected by non-blinded anaesthetists and caregivers
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses

Carassiti 2013 (*Continued*)

Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought. Methods section stated that CL grades were recorded, but they were not reported in the Results section
Experience of intubator	Low risk	Comment: 1 intubator experienced in both techniques; > 100 intubations with each device
Baseline characteristics	Low risk	Comment: baseline characteristics comparable
Funding sources	Low risk	Comment: departmental funding only

Cavus 2011

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 150 **Inclusion criteria:** ASA I to III scheduled for elective surgery in supine position with general anaesthesia, requiring tracheal intubation **Exclusion criteria:** pathology of the upper respiratory or alimentary tract known or suspected, a rapid sequence induction indicated, an awake intubation appropriate because of a suspected or known difficult airway **Baseline characteristics:** **C-MAC3** *Age*: median (range) 54 (20-74) *Gender M/F*: 10/27 *Height (cm)*: median (range) 168 (150-186) *Weight (kg)*: median (range) 76 (54-98) *BMI*: median (range) 27 (20-40) *Mallampati 1*: 8 *Mallampati 2*: 23 *Mallampati 3*: 6 *Mallampati 4*: 0 **Macintosh** *Age*: median (range) 49 (23-82) *Gender M/F*: 21/29 *Height (cm)*: median (range) 170 (156-196) *Weight (kg)*: median (range) 81 (60-179) *BMI*: median (range) 27 (20-63) *Mallampati 1*: 16 *Mallampati 2*: 20 *Mallampati 3*: 13 *Mallampati 4*: 1 **C-MAC4** *Age*: median (range) 46 (34-72)

Cavus 2011 (*Continued*)

	Gender M/F: 11/7 *Height (m)*: median (range) 173 (163-188) *Weight (kg)*: median (range) 82 (54-150) *BMI*: median (range) 27 (20-40) *Mallampati 1*: 4 *Mallampati 2*: 6 *Mallampati 3*: 7 *Mallampati 4*: 1 **C-MAC4/SBT** *Age*: median (range) 58 (27-79) *Gender M/F*: 28/17 *Height (cm)*: median (range) 173 (155-193) *Weight (kg)*: median (range) 78 (48-135) *BMI*: median (range) 27 (19-44) *Mallampati 1*: 9 *Mallampati 2*: 21 *Mallampati 3*: 15 *Mallampati 4*: 0 **Country:** Germany **Setting:** hospital
Interventions	C-MAC 3 (n = 37) vs C-MAC4 (n = 18) vs C-MAC/STB (n = 45) vs Macintosh (50) Participants underwent 3 separate laryngoscopies with Macintosh or #3 or #4 C-MAC blade. After 50 participants, C-MAC #4 was changed to a straight blade technique (C-MAC/STB). Order of laryngoscopies was determined by randomization Macintosh blade #3 or #4
Outcomes	*Continuous outcomes*: Time for tracheal intubation: defined as time from touching tube to performing successful endotracheal placement *Dichotomous outcomes*: Failed intubation: defined as intubated with alternative device owing to limited glottic visualization Laryngeal/airway trauma (any palatoglossal arch or dental injury) Number of intubation attempts: 1 to 3 CL glottic view: not possible to interpret data from graphs
Notes	*Experience of intubator:* 1 of 3 anaesthesiologists with ≥ 8 years' experience (after training with manikins for C-MAC scope) *Funding/declarations of interest:* equipment supplied by Storz manufacturer. One study author is a member of the Storz advisory team and receives grant support for airway management studies *Additional:* cross-over study with 3 arms, changed to 4 arms part of the way through the study. High risk of bias was introduced with changing of the protocol part of the way through

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Cavus 2011 (*Continued*)

Random sequence generation (selection bias)	Low risk	Comment: computer generated
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: protocol changed part of the way through the study - data not provided before and after protocol change. Therefore, not possible to assess whether high levels of bias were introduced by the decision. An additional group was introduced part of the way through the study, which led to exclusion of some participants from C-MAC groups
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Comments: 1 of 3 anaesthesiologists with ≥ 8 years' experience (after training with manikins for C-MAC scope). Although personnel are described as experienced, the level of experience with C-MAC is unclear
Baseline characteristics	Low risk	Comment: baseline characteristics reported according to intubating device; some differences in male and female ratios between groups, but not anticipated to make a difference
Funding sources	High risk	Comment: equipment supplied by Storz manufacturer. One study author is a member of the Storz advisory team and receives grant support for airway management studies

Choi 2011

Methods	Randomized controlled trial Parallel group

Choi 2011 (*Continued*)

Participants	**Total number of participants:** 60 **Inclusion criteria:** ASA I or II, scheduled to undergo general anaesthesia between the ages of 15 and 60 years **Exclusion criteria:** thyroid-to-chin length ≤ 5 cm, Mallampati class ≥ 3, mouth opening < 3 cm, restriction in neck extension or protruding front teeth, predicted to be difficult in intubation. Also, airway difficulty score > 8, including the evaluation criteria mentioned above, were predicted to be difficult to intubate **Baseline characteristics:** **GlideScope** *Age*: 39.5 (SD ± 13.4) *Gender M/F*: 16/14 *Height (cm)*: 166.0 (SD ± 8.2) *Weight (kg)*: 64.5 (SD ± 9.2) **Macintosh** *Age*: 43.0 (SD ± 14.9) *Gender M/F*: 15/15 *Height (cm)*: 162.8 (SD ± 10.5) *Weight (kg)*: 61.2 (SD ± 11.7) **Country:** Korea **Setting:** hospital
Interventions	GlideScope (n = 30) vs Macintosh (n = 30) Macintosh blade #3 Use of cricoid pressure by assistant in both groups
Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation (airway difficulty score (ADS) on VAS by anaesthesiologist: 0 is most easy and 10 is most difficult. GlideScope 6.7 (SD ± 0.9); Macintosh 6.6 (SD ± 0.6)) Improved visualization (POGO score (%): GlideScope 89.6 (SD ± 20.0); Macintosh 67.6 (SD ± 24.7), P < 0.05) Time for tracheal intubation (measured in seconds): defined as time from when anaesthesiologist grabbed handle to when tube passed vocal cords
Notes	*Experience of intubator*: all intubations performed by 1 anaesthetist - fully experienced and familiar with GlideScope *Funding/declarations of interest:* none apparent Note: Some participants were younger than 18 years of age and were not separated in the data

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "All patients were randomly allocated" Comment: no additional details

Choi 2011 (*Continued*)

Allocation concealment (selection bias)	Unclear risk	Comment: no mention of concealment method
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: all outcomes assessed during intubation period were assumed to be not blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: protocol not sought
Experience of intubator	Low risk	Quote: "study was carried out by a fully experienced anesthesiologist familiar with the GVL (GlideScope)"
Baseline characteristics	Low risk	Quote: "no statistical differences in age, sex, height, weight and ADS between the two groups"
Funding sources	Low risk	Comment: none apparent

Cordovani 2013

Methods	Randomized controlled trial Cross-over design
Participants	**Total number of participants:** 44 **Inclusion criteria:** undergoing elective surgery under general anaesthetic with tracheal intubation, ≥ 1 risk factor for a difficult laryngoscopy (from unpublished data: ASA I to III; over 18 years of age; requiring single-lumen tracheal intubation) **Exclusion criteria:** (from unpublished data: rapid sequence induction or other alternative intubation methods indicated; known or suspected oral, pharyngeal or laryngeal masses. Or, if patients had poor dentition, symptomatic gastro-oesophageal reflux, cervical spine instability, unstable hypertension, coronary artery disease, cerebral disease, lack of resources available to conduct the procedure on scheduled date of surgery) **Baseline characteristics** (taken from unpublished data): **Intubation with GlideScope** *Age:* 56.5 (SD ± 11.6) *Gender (M/F):* 11/13 *Height (cm):* 165.3 (SD ± 12.1) *Weight (kg):* 79.9 (SD ± 15.1) *BMI (kg/m^2):* 29.2 (SD ± 4.6)

Cordovani 2013 (*Continued*)

	Mallampati ≥ 3: 24 **Intubation with Macintosh** *Age:* 54.0 (SD ± 11.2) *Gender (M/F):* 12/8 *Height (cm):* 167.0 (SD ± 8.6) *Weight (kg):* 74.7 (SD ± 13.4) *BMI (kg/m^2):* 26.8 (SD ± 4.3) *Mallampati ≥ 3:* 20 **Country:** Toronto, Ohio, USA **Setting:** hospital
Interventions	GlideScope (n = 24) vs Macintosh (n = 20)
Outcomes	*Continuous outcomes*: Time for tracheal intubation: defined as time from when laryngoscope passed between the participant's teeth to when laryngoscopy enabled placement of a styletted tracheal tube at, not through, laryngeal inlet. Results reported as median (IQR) seconds: GlideScope 30 (22-47); Macintosh 18 (14-28) *Dichotomous outcomes:* Failed intubation: defined as when laryngoscope was withdrawn beyond the teeth or lasting longer than 60 seconds
Notes	*Experience of intubator:* laryngoscopists experienced in both devices on ≥ 25 occasions (from unpublished manuscript) *Funding/declarations of interest:* none apparent **Comments:** study authors provided unpublished manuscript of study on email request. Data above and in risk of bias table were taken from this manuscript Study of forces, includes relevant outcomes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Comment: computer-generated randomization code
Allocation concealment (selection bias)	Unclear risk	Comment: randomization revealed immediately before induction of anaesthesia (but no other details on how it was concealed)
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: outcome assessors and data analysts blinded to forces outcome but this outcome not relevant for this review. Assumed other outcome assessments were not blinded

Cordovani 2013 (*Continued*)

Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: few losses after randomization due to study equipment failure, but data still collected for all outcomes when possible
Selective reporting (reporting bias)	Low risk	Comment: copy of protocol on clinicaltrials.gov sought and compared with published trial (clinical trials ID NCT01814176). All outcomes were reported
Experience of intubator	Low risk	Comment: laryngoscopists experienced in both devices, with use of GlideScope on at least ≥ 25 occasions
Baseline characteristics	Low risk	Comment: baseline characteristics comparable
Funding sources	Low risk	Comment: none apparent

Dashti 2014

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 59 **Inclusion criteria:** 40 to 60 years of age, untreated hypertension, undergoing elective surgery **Exclusion criteria:** blood pressure > 180/110 mmHg, predicted difficult airway, history of drug abuse, dehydration, history of other cardiovascular disease, history of consumption of any drugs known to affect cardiovascular system, diabetes mellitus, end-organ damage due to hypertension **Baseline characteristics:** **GlideScope** *Age:* 54.82 (SD ± 5.76) *Gender (M/F):* 19/11 *Weight (kg):* 72.14 (SD ± 9.72) **Macintosh** *Age:* 57.82 (SD ± 4.83) *Gender (M/F):* 15/14 *Weight (kg):* 66.25 (SD ± 6.15) **Country:** Iran **Setting:** hospital
Interventions	GlideScope (n = 30) vs Macintosh (n = 29)

Dashti 2014 (*Continued*)

Outcomes	*Continuous outcomes:* Time for tracheal intubation: defined as time from grasping endotracheal tube until passing tube through vocal cords
Notes	*Experience of intubator*: all intubations performed by 1 experienced anaesthesiology resident *Funding/declarations of interest:* none apparent *Additional:* Study aimed to assess haemodynamic changes but included relevant outcomes

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Comment: randomized using permutated blocks
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessor for relevant outcome
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: only 1 exclusion; not likely to affect outcome data
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Quote: "The patients were intubated by a single experienced anesthesiology resident" Comment: no details on whether experience is equivalent with both devices
Baseline characteristics	Low risk	Comment: baseline characteristics comparable
Funding sources	Low risk	Comment: none apparent

Enomoto 2008

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 203 **Inclusion criteria:** scheduled for elective surgery **Exclusion criteria:** pathology of the neck, upper respiratory tract or upper alimentary tracts, at risk of pulmonary aspiration of gastric contents **Total baseline characteristics:** *Age*: mean 57 (SD ± 16) (range 18-86) *Gender M/F*: 117/86 *Height (cm)*: mean 160 (SD ± 9) (range 130-181) *Weight (kg)*: mean 61 (SD ± 12) (range 34-105) *BMI*: mean 24 (SD ± 3.9) (range 16-37) *ASA I*: 62 *ASA II*: 140 *ASA III*: 1 *Mallampati 1*: 154 *Mallampati 2*: 40 *Mallampati 3*: 8 *Mallampati 4*: 1 **Country:** Japan **Setting:** hospital Participant's head and neck stabilized by assistants using in-line manual method
Interventions	Pentax AWS vs Macintosh Macintosh blade #3 or #4. Use of gum-elastic bougie allowed in Macintosh group
Outcomes	*Continuous outcomes*: Improved visualization Time for tracheal intubation (for Macintosh, time from tracheal tube passing gap between upper and lower incisors to confirmation of carbon dioxide waveforms after tracheal intubation; for Pentax, time from touching tracheal tube (attached to scope) to confirmation of carbon dioxide waveforms) *Dichotomous outcomes*: Failed intubation: defined as not complete within 120 seconds, then tried with another device. Some inconsistencies within study report with denominator figures for successful tracheal intubation CL glottic view: 1 to 4
Notes	*Funding/declarations of interest:* 1 study author given an honorarium from manufacturer for writing a lecture and was loaned an AWS for the study. Other departments had to provide their own

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "The order was randomized by tossing a coin"

Enomoto 2008 (*Continued*)

Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: no blinding possible
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no loss of participants
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Comment: no details of operator experience
Baseline characteristics	Unclear risk	Comment: not divided by group, as cross-over design
Funding sources	High risk	Comment: one study author given an honorarium from manufacturer for writing a lecture and was loaned an AWS for the study. Other departments had to provide their own

Frohlich 2011

Methods	Randomized controlled trial Parallel design
Participants	**Total number of participants:** 60 **Inclusion criteria:** ASA I to III, scheduled for elective surgical procedure requiring tracheal intubation **Exclusion criteria:** no details Baseline characteristics not included in abstract **Country:** Ireland **Setting:** hospital
Interventions	McGrath vs Macintosh Type of McGrath not specified in the paper Optimization manoeuvres used in both groups as required (readjustment of head, use of bougie, use of external laryngeal manipulation and use of second assistant)
Outcomes	*Continuous outcomes*: Tme for tracheal intubation (reported in study without SD) Difficulty of intubation *Dichotomous outcomes*: Successful first attempt

Frohlich 2011 (*Continued*)

	Larngeal/airway trauma (dental trauma) CL glottic view: 1 to 3 Number of attempts: 1 to 3
Notes	*Experience of intubator*: experience with McGrath on ≥ 5 occasions. Ten anaesthetists in total. Does not say if stratified *Funding/declarations of interest:* 1 McGrath VLS on loan from manufacturer *Other:* published only as an abstract

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Comment: participants described as "randomly assigned", but no additional details
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "All data were collected by an independent unblinded observer"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Quote: "Ten anaesthetists, who had received prior instruction and had experienced use of the McGrath videolaryngoscope on at least five previous occasions" Comment: unclear if this is sufficient equivalent experience
Baseline characteristics	Low risk	Quote: "There were no significant differences in baseline characteristics between the groups"
Funding sources	Unclear risk	Comment: 1 McGrath VLS on loan from manufacturer

Griesdale 2012

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 40 **Inclusion criteria:** over 16 years of age requiring urgent tracheal intubation in the critical care unit **Exclusion criteria:** requirement for immediate endotracheal intubation (within 5 minutes) as anticipated by the ICU team, spontaneous breathing endotracheal intubation technique or cervical spine precautions, history of (or anticipated) difficult intubation, previous cardiac arrest or cardiopulmonary instability (oxygen saturation 90% or systolic blood pressure 80 mmHg despite oxygen or fluid and vasopressor therapy), prior clinical deterioration requiring immediate tracheal intubation while awaiting randomization or deemed inappropriate for enrolment by the attending physician (e.g. patient considered unsuitable for either technique) **Baseline characteristics:** **GlideScope** *Age*: 68 (SD ± 16) *Gender M/F*: 15/5 *BMI*: 26 (SD ± 4) *Mallampati 1*: 5 *Mallampati 2*: 6 *Mallampati 3*: 2 *Mallampati 4*: 1 **Macintosh** *Age*: 61 (SD ± 16) *Gender M/F*: 13/7 *BMI*: 24 (SD ± 6) *Mallampati 1*: 3 *Mallampati 2*: 4 *Mallampati 3*: 3 *Mallampati 4*: 0 Note: 16 participants were not tested for their Mallampati score **Country:** Canada **Setting:** hospital, ICU or emergency department
Interventions	GlideScope (n = 20) vs Macintosh (n = 20) GlideScope blade #4; site of intubation ICU (19), ward (1), ED (0) Macintosh blade #3 or #4; site of intubation ICU (14), ward (3), ED (3)
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from when tip of laryngoscope entered the participant's mouth until detection of end-tidal carbon dioxide waveform on capnography) *Dichotomous outcomes*: Failed intubation (unsuccessful on first attempt and required use of alternative device) . Data presented for failure of first attempts. Not possible to combine data with those of other studies. In the GlideScope group, 5 of 12 (42%) first attempts failed, resulting in use of the Macintosh for subsequent attempts. In the Macintosh group, only 1 of 13 (5%) first attempts failed, resultingin use of the GlideScope for subsequent attempts (P

	= 0.03). The supervisor took over in 8 of 12 (67%) failed first attempts with Macintosh (data missing from 1 participant) compared with 4 of 12 (33%) in the GlideScope group (P = 0.22) Mortality (30 days) Successful first attempt CL glottic view: 1 to 4 (results reported for 19 participants only) No. of attempts: 1 to 4 Time for successful intubation, median (IQR): GlideScope 221 (103-291), Mac 156 (67-220), P = 0.15
Notes	*Experience of intubator*: all inexperienced in endotracheal intubation, defined as fewer than 5 endotracheal intubations in the preceding 6 months (medical students, or PGY 1-4) Supervisor could take over if initial attempt exceeded 1 minute *Funding/declarations of interest:* Canadian Anesthesiologists' Society 2009 Research Award; Clinician Scientist Award from Vancouver Coastal Health Research Institute *Additional:* pilot study

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Comment: random allocation table in permutated blocks of 4
Allocation concealment (selection bias)	Low risk	Comment: numbered opaque sealed envelopes opened by research co-ordinator at time of randomization
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: research co-ordinators not blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: data for CL scores not reported for 1 participant in each group
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Comment: both groups included inexperienced operators
Baseline characteristics	Low risk	Comment: baseline characteristics comparable

Griesdale 2012 (*Continued*)

Funding sources	Low risk	Comment: Canadian Anesthesiologists' Society 2009 Research Award; Clinician Scientist Award from Vancouver Coastal Health Research Institute

Gupta 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 120 **Inclusion criteria:** 18 to 65 years of age, either gender, ASA I or II undergoing elective cervical spine surgery for cervical compressive myelopathy **Exclusion criteria:** risk factors for difficult mask ventilation, gastric aspiration (obesity, pregnancy), difficult airway such as previous neck surgery and mouth opening < 3 cm **Baseline characteristics:** **C-MAC + stylet** *Age*: 40 (SD ± 12) *Gender M/F*: 25/5 *BMI*: 23.1 (SD ± 2.6) *ASA I*: 22 *ASA II*: 8 *Mallampati 1*: 4 *Mallampati 2*: 14 *Mallampati 3*: 12 **Macintosh + stylet** *Age*: 39 (SD ± 16) *Gender M/F*: 26/4 *BMI*: 21.6 (SD ± 2.1) *ASA I*: 21 *ASA II*: 9 *Mallampati 1*: 6 *Mallampati 2*: 11 *Mallampati 3*: 13 **C-MAC non-stylet** *Age*: 39 (SD 16) *Gender M/F*: 24/6 *BMI*: 21.6 (SD 2.7) *ASA I*: 23 *ASA II*: 7 *Mallampati 1*: 6 *Mallampati 2*: 15 *Mallampati 3*: 9 ***Macintosh non-stylet*** *Age*: 41 (SD 16) *Gender M/F*: 28/2 *BMI*: 22.0 (SD 2.4)

Gupta 2013 (*Continued*)

	ASA I: 25 *ASA II*: 5 *Mallampati 1*: 4 *Mallampati 2*: 15 *Mallampati 3*: 11 **Country:** India **Setting:** hospital
Interventions	C-MAC with stylet (n = 30) vs Macintosh with stylet (n = 30) vs C-MAC non-stylet (n = 30) vs Macintosh non-stylet (n = 30) Gum-elastic bougies used if required *Additional:* The neck of all participants was immobilized with MILS by holding the sides of the neck and the mastoid processes, thus preventing flexion/extension or rotational movements of the head and neck
Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation: measured on IDS; reported as median (IQR): C-MAC + stylet 2 (1-3); Macintosh + stylet 3 (2-4); C-MAC non-stylet 4 (2-6); Macintosh non-stylet 3 (2-8) Time for tracheal intubation: defined as time from insertion of laryngoscope blade between the teeth until ETT was placed through the vocal cords, as evidenced by visual confirmation; reported as median (IQR): C-MAC + stylet 27 (23-31); Macintosh + stylet 34 (22-53); C-MAC non-stylet 52 (28-76); Macintosh non-stylet 34 (22-70) *Dichotomous outcomes*: Failed intubation: defined as an attempt in which the trachea was not intubated, or that required longer than 120 seconds to perform Laryngeal/airway trauma (upper lip trauma, tooth damage, soft tissue bleeding, supraglottic trauma) Successful first attempt CL glottic view: 1 to 3 No. of attempts: 1 to 2
Notes	*Experience of intubator*: 1 of 2 anaesthesiologists experienced in the use of both laryngoscopes in patients requiring MILS, having done > 50 intubations with each device before the study *Funding/declarations of interest:* none apparent

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "computer-generated randomization"
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists

Gupta 2013 (*Continued*)

Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "Data were collected by a single independent observer" Comment: not possible for all outcomes to be blinded;unclear if independent observer is blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Four patients were excluded because of alternative intubation techniques preferred by the attending anesthesiologist" Comment: small number excluded prior to randomization
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "two anesthesiologists. ..experienced in the use of both laryngoscopes in patients requiring MILS, having done more than 50 such intubations with each device before this study"
Baseline characteristics	Low risk	Comment: baseline characteristics comparable
Funding sources	Low risk	Comment: none apparent

Hindman 2014

Methods	Randomized controlled trial Cross-over design - participants intubated with both types of scopes in random order
Participants	**Total number of participants:** 14 **Inclusion criteria:** adults undergoing elective surgery requiring general anaesthesia and oral endotracheal intubation, patients who were likely to be easy to intubate, Mallampati airway class 1 or 2, thyromental distance $\geq$ 6.0 cm, sternomental distance $\geq$ 12.5 cm, age 18 to 80 years, height between 1.52 and 1.83 m, BMI $\leq$ 30 kg/m^2 **Exclusion criteria:** maxillary incisors that were loose or in poor condition; previous difficult intubation; any cervical spine anatomical abnormalities such as disc disease, instability, myelopathy and/or any previous cervical spine surgery; symptomatic gastro-oesophageal reflux or reactive airway disease; any history of coronary artery disease or cerebral aneurysm; any history of vocal cord and/or glottic disease or dysfunction; pre-operative systolic blood pressure > 180 mmHg or diastolic blood pressure > 80 mmHg; ASA > III **Baseline characteristics:** reported for all participants, not by group *Age*: 47 (SD ± 20) *Gender M/F*: 9/5 *BMI*: 25.9 (SD ± 2.6) *ASA I*: 3 *ASA II*: 11

Hindman 2014 (*Continued*)

	Mallampati 1: 8 *Mallampati 2*: 6 **Country:** USA **Setting:** hospital
Interventions	Airtraq vs Macintosh Airtraq used with video camera attachment
Outcomes	*Continuous outcomes:* Time for tracheal intubation (definition not given): not included in meta-analysis but study authors report results as mean (± SD): Airtraq 19.6 (± 7.0); Macintosh 21.6 (± 7.8) *Dichotomous outcomes:* Success of intubation (not included in meta-analysis because of increased risk of bias due to study design, but study authors report that all intubations were successful except for 1 in a participant intubated with a Macintosh blade) Glottic view (POGO scores: "POGO scores at stage 3 were less during intubations with the Macintosh than with Airtraq, based on both anaesthesiologist report (P = 0.0007) and video analysis (P = 0.0002)") Adverse effects, but not reported by group. "On postoperative day 7, two patients reported very mild voice changes that were intermittent and nonbothersome"
Notes	*Experience of intubator:* 2 study anaesthesiologists, both with more than 27 years' experience of direct laryngoscopy and ≥ 50 successful intubations with Airtraq *Funding/declarations of interest:* supported by a National Institutes of Health grant *Additional: s*tudy designed to measure forces but includes relevant outcomes for this review

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Comment: use of an independent biostatistician to develop randomization sequence
Allocation concealment (selection bias)	Low risk	Comment: use of sealed opaque envelopes with matching patient identification number
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors to relevant outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: only 1 loss; reasons for loss reported

Hindman 2014 (*Continued*)

Selective reporting (reporting bias)	Low risk	Comment: registered with clinicaltrials.gov NCT01369381; protocol sourced and appears equivalent to full published report
Experience of intubator	Low risk	Comment: 2 study anaesthesiologists, each with more than 27 years' experience of direct laryngoscopy and ≥ 50 successful intubations with Airtraq
Baseline characteristics	Unclear risk	Comment: more women than men enrolled in the study; unclear if this affects results. All participants underwent laryngoscopy with each scope; therefore baseline characteristics were not presented separately
Funding sources	Low risk	Comment: supported by a National Institutes of Health grant

Hirabayashi 2007a

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 200 **Inclusion criteria:** ASA I or II undergoing general anaesthesia using tracheal intubation **Exclusion criteria:** history of previous difficult intubation, cervical spine fracture or cervical spine instability **Baseline characteristics:** Baseline characteristics not sufficiently supplied in short report. Author quote: "Patients were comparable with respect to age, weight and height" **Country:** Japan **Setting:** hospital
Interventions	Pentax AWS (n = 100) vs Macintosh (n = 100)
Outcomes	*Continuous outcome*: Time for tracheal intubation *Dichotomous outcomes*: Successful first attempt No. of attempts: 1 to 3
Notes	*Experience of intubator*: 26 non-anaesthesia residents, with median clinical training of 5 weeks (range 1-24 weeks) *Funding/declarations of interest:* none *Additional:* limited detail - short report only

Hirabayashi 2007a (*Continued*)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Comment: computer random number table
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "an independent observer recorded the duration of tracheal intubation attempts" Comment: independent but not blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no losses reported
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Comment: 26 residents, all with equivalent limited experience
Baseline characteristics	Low risk	Comment: described by study authors as comparable
Funding sources	Low risk	Comment: none

Hirabayashi 2009

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 521 **Inclusion criteria:** required general anaesthesia with tracheal intubation for surgery **Exclusion criteria:** history of previous difficult intubation, cervical spine fracture or cervical spine instability **Baseline characteristics:** **Pentax AWS** *Age*: 53 (SD ± 16) *Height (cm)*: 159 (SD ± 9) *Weight (kg)*: 59 (SD ± 12) *BMI*: 23 (SD ± 4) **Macintosh**

Hirabayashi 2009 (*Continued*)

	Age: 54 (SD ± 17) *Height (cm)*: 159 (SD ± 9) *Weight (kg)*: 59 (SD ± 11) *BMI*: 23 (SD ± 4) **Country:** Japan **Setting:** hospital
Interventions	Pentax AWS (n = 265) vs Macintosh (n = 256)
Outcomes	*Continuous outcomes*: Time for tracheal intubation: defined as time from interruption of intermittent positive-pressure ventilation to connection of the endotracheal tube to an anaesthesia circuit. If the first intubation attempt failed, duration of the subsequent attempt was added to time of the first attempt to secure the airway *Dichotomous outcomes*: Successful first attempt No. of attempts: 1 to 4
Notes	*Experience of intubator*: all medical residents with anaesthesia training of 9 (SD 6) weeks, 48 operators in total, supervised by anaesthesiologist, available for verbal information if necessary *Funding/declarations of interest:* departmental funding only

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "randomly assigned via table of random numbers as generated by a personal computer" Comment: However, study authors also state: "availability of the Pentax-AWS was slightly limited compared with the standard Macintosh laryngoscope." Unclear if this may have introduced bias
Allocation concealment (selection bias)	Unclear risk	Comment: no details given
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: all outcomes were assessed during intubation process; therefore not blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses

Hirabayashi 2009 (*Continued*)

Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	High risk	Quote: "each participant had taken part in a smaller number of intubations with the Pentax-AWS than the Macintosh laryngoscope" Comment: all operators had limited experience
Baseline characteristics	Low risk	Comment: baseline characteristics equivalent
Funding sources	Low risk	Comment: departmental funding only

Hsu 2012

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 60 **Inclusion criteria:** adult patients, ASA I or II, requiring a DLT for thoracic surgery **Exclusion criteria:** risk of regurgitation and pulmonary aspiration, history of gastro-oesophageal reflux, pregnancy, scheduled tracheostomy and planned postoperative ventilation in ICU, a potentially difficult laryngoscopy as suggested by limited neck extension (< 35°), distance between tip of the patient's mandible and thyroid notch < 7 cm, sternomental distance < 12.5 cm with the head fully extended and the mouth closed **Baseline characteristics:** **GlideScope** *Age*: 40.1 (SD ± 18.7) *Gender M/F*: 7/23 *Height (cm)*: 168 (SD ± 6.8) *Weight (kg)*: 60.1 (SD ± 9.5) *BMI*: 21.3 (± 3.4) *ASA I*: 14 *ASA II*: 16 *Mallampati 1*: 1 *Mallampati 2*: 27 *Mallampati 3*: 2 **Macintosh** *Age*: 37.2 (SD ± 15.4) *Gender M/F*: 11/19 *Height (cm)*: 165.6 (SD ± 8.4) *Weight (kg)*: 62. 4 (SD ± 12) *BMI*: 23.0 (± 5.6) *ASA I*: 12 *ASA II*: 18 *Mallampati 1*: 3 *Mallampati 2*: 27

Hsu 2012 (*Continued*)

	Mallampati 3: 0 **Country:** Taiwan **Setting:** hospital
Interventions	GlideScope (n = 30) vs Macintosh (n = 30) BURP manoeuvre used when required Use of double-lumen tubes for all participants
Outcomes	*Continuous outcome*: Time of intubation (time of DLT insertion calculated from time when the laryngoscope passed between participant's lips until 3 complete cycles of end-tidal carbon dioxide displayed on the capnograph) *Dichotomous outcomes*: Laryngeal/airway trauma (blood on the device or oral bleeding) Patient-reported sore throat (combined data for mild/moderate/severe classifications). Hoarseness data also presented but not reported in this review Successful first attempt No. of attempts: 1 to 3 or more
Notes	*Experience of intubator*: 2 experienced anaesthetists with experience of ≥ 300 tracheal intubations with each device *Funding/declarations of interest:* none

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "Patients were randomly assigned" Comment: no mention of method
Allocation concealment (selection bias)	Unclear risk	Quote: "opening a sealed envelope" Comment: no mention if opaque
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: some outcomes were assessed by an independent observer, but study authors did not state whether this person was blinded. For theatre outcomes, assumed the assessor was not blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Low risk	Comment: clinical trial register protocol sourced (unique identifier: NCT 014249605). Protocol outcomes compara-

Hsu 2012 (*Continued*)

		ble with study-reported outcomes
Experience of intubator	Low risk	Quote: "two experienced anaesthesiologists with experience of at least 300 tracheal intubations with each device"
Baseline characteristics	Unclear risk	Comment: more men in Macintosh group. Impact of this difference is uncertain
Funding sources	Low risk	Comment: none

Ilyas 2014

Methods	Randomized controlled trial Cross-over design
Participants	**Total number of participants:** 128 **Inclusion criteria:** age > 18 years, ASA I to III, full upper dentition at front **Exclusion criteria:** requiring awake fibreoptic intubation, with known laryngeal pathology or at risk of pulmonary aspiration **Baseline characteristics:** reported according to device with which participants were intubated **McGrath Series 5** *Age*: 42.3 (SD ± 14.0) *Gender M/F*: 35/29 *BMI*: 28.5 (SD ± 5.0) *ASA I*: 21 *ASA II*: 37 *ASA III: 6* *Mallampati 1*: 30 *Mallampati 2*: 26 *Mallampati 3*: 7 *Mallampati 4: 1* **Macintosh** *Age*: 42.5 (SD ± 13.1) *Gender M/F*: 25/39 *BMI*: 27.9 (SD ± 6.0) *ASA I*: 23 *ASA II*: 39 *ASA III: 2* *Mallampati 1*: 24 *Mallampati 2*: 34 *Mallampati 3*: 6 *Mallampati 4: 0* **Country:** Australia **Setting:** hospital

Ilyas 2014 (*Continued*)

Interventions	McGrath Series 5 (n = 64) vs Macintosh (n = 64) Alternative device was used initially to record laryngoscopic view, then was removed. Device to which participants were randomized was then used to re-record laryngoscopic view, then intubation was performed
Outcomes	*Continuous outcomes:* Time of intubation: defined as time from when laryngoscope entered the mouth until first capnographic square wave Intubation difficulty score: reported as median (IQR (range)): McGrath 0 (0-3 (0-7)); Macintosh 2 (0-3 (0-7)); P = 0.0024 *Dichotomous outcomes:* Failed intubation Sore throat/hoarseness Laryngeal/airway trauma (dental damage, blood on blade, mucosal laceration, other airway trauma) CL glottic view: reported as differences between intubations with each device. Study authors state that view was worse when Macintosh was used as opposed to McGrath laryngoscope
Notes	*Experience of intubator:* experienced anaesthetists; all were "clinically familiar with both devices and had undergone training in the use of the McGrath Series 5 before the start of the trial" *Funding/declarations of interest:* no external funding received *Additional:* manual in-line stabilization performed on all participants

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "group allocation was achieved using a computer-generated randomisation list and sealed envelopes"
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: no details of blinding; assumed no attempts were made
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought

Ilyas 2014 (*Continued*)

Experience of intubator	Unclear risk	Comment: experienced anaesthetists with at least 10 years' experience, described as clinically familiar with both devices and trained in use of McGrath before start of the trial. No further description of the degree of clinical experience to establish whether experience was sufficient and equivalent for each device
Baseline characteristics	Unclear risk	Comment: some differences in balance of gender between groups. Impact of this difference is uncertain
Funding sources	Low risk	Comment: no external funding sources

Ithnin 2009

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 59 **Inclusion criteria:** ASA I or II, 18 to 65 years of age, scheduled for elective surgery requiring tracheal intubation **Exclusion criteria:** known or predicted difficult airway, obesity (BMI > 35 kg/m^2), coronary artery or reactive airway disease, history of alcohol or substance abuse or gastro-oesophageal reflux **Baseline characteristics:** **GlideScope** *Age*: median (IQR (range)) 46 (36-50 (19-59)) *Height (cm)*: 158.0 (SD ± 5.9) *Weight (kg)*: 56.9 (SD ± 11.9) *ASA I*: 16 *ASA II*: 13 *Mallampati 1*: 25 *Mallampati 2*: 4 **Macintosh** *Age*: median (IQR (range)) 38 (34-45 (24-51)) *Height (cm)*: 155.8 (SD ± 5.8) *Weight (kg)*: 57.7 (SD ± 11.3) *ASA I*: 16 *ASA II*: 14 *Mallampati 1*: 22 *Mallampati 2*: 8 **Country:** Singapore **Setting:** hospital

Ithnin 2009 (*Continued*)

Interventions	GlideScope (n = 29) vs Macintosh (n = 30) This study compared the median effective concentration of anaesthetic required for optimal intubating conditions for each device. Bias was introduced by this study design. Investigators provided data on difficulty of intubation
Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation Subjective data for difficulty of intubation included 5 variables (jaw relaxation, laryngoscopy, vocal cord, coughing, movement) recorded on scales. Median (IQR (range) - GlideScope 8 (6-0 (5-12)); Mac 7 (6-11 (5-14) Study author quote: "There was no difference in the total intubation scores"
Notes	*Funding/declarations of interest:* none apparent

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "computer-generated list using the sealed envelope method"
Allocation concealment (selection bias)	Unclear risk	Comment: envelopes used, but no additional details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: outcome assessed by intubator
Incomplete outcome data (attrition bias) All outcomes	High risk	Quote: "If the anaesthetist was unable to grade the intubating condition during the rst attempt, the patient was excluded and subsequent airway management was performed according to the anaesthetist's discretion The patient was replaced so that there would be 30 patients in each group" Comment: 5 exclusions due to inability to grade intubating conditions; may have introduced bias to results
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Comment: no information about experience of intubators

Ithnin 2009 (*Continued*)

Baseline characteristics	Unclear risk	Comment: baseline characteristics largely equivalent. However, the mean age of participants in the Macintosh group is younger; unclear if this could result in easier intubations
Funding sources	Low risk	Comment: none apparent

Jungbauer 2009

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 200 **Inclusion criteria:** > 18 years old, recruited if modified Mallampati score was 3 or 4, history of a difficult intubation and mouth opening ≥ 2 cm **Exclusion criteria:** ASA ≥ IV, undergoing rapid sequence induction **Baseline characteristics:** **Berci-Kaplan VLS - C-MAC** *Age*: 56.8 (range 18-88) *Height (cm)*: 172 (SD ± 10) *Weight (kg)*: 83.2 (SD ± 20.8) *Mallampati 1*: 0 *Mallampati 2*: 1 *Mallampati 3*: 76 *Mallampati 4*: 23 *Mallampati 4*: 23 **Macintosh** *Age*: 54.2 (range 18-94) *Height (cm)*: 172 (SD ± 9) *Weight (kg)*: 78.7 (SD ± 19.4) *Mallampati 1*: 0 *Mallampati 2*: 2 *Mallampati 3*: 87 *Mallampati 4*: 11 **Country:** Germany **Setting:** hospital
Interventions	Berci-Kaplan VLS (n = 100) vs Macintosh (n = 100) Optimizing manoeuvres used included external manipulation of the larynx (BURP manoeuvre), use of a gum-elastic bougie (Eschmann stylet) and changes in head positioning
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from when participant's mouth was opened until cuff of tube was inflated *Dichotomous outcomes*: Failed intubation CL glottic view: 1 to 4

Jungbauer 2009 (*Continued*)

Notes	*Experience of intubator*: All intubations were performed by 2 experienced anaesthetists with 13 and 17 years of experience in clinical anaesthesia and at least 3 years of experience in difficult intubations *Funding/declarations of interest:* departmental funding only

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "computer-based randomization list"
Allocation concealment (selection bias)	Unclear risk	Comment: no details provided
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors for the included outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Quote: "All intubations were performed by two experienced anaesthesiologists with 13 and 17 yr of experience in clinical anaesthesia and at least 3 yr of experience in difficult intubations" Comment: no information on whether experience was equivalent for each device
Baseline characteristics	Low risk	Comment: comparable baseline characteristics
Funding sources	Low risk	Comment: departmental funding only

Kanchi 2011

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 30 **Inclusion criteria:** scheduled for elective CABG **Exclusion criteria:** risk factors for gastric aspiration, difficult intubation or both (Mal-

	lampati class 3 or 4; thyromental distance < 6 cm; interincisor distance < 3.5 cm), left main coronary artery disease, poor left ventricular function, conduction abnormality, use of a permanent pacemaker **Baseline characteristics:** **Pentax AWS** *Age*: 59 (SD ± 8) *Weight (kg)*: 62 (SD ± 5) *Mallampati 1*: mean 1.57 (SD ± 0.5) **Macintosh** *Age*: 55 (SD ± 8) *Weight (kg)*: 65 (SD ± 10) *Mallampati 1*: mean 1.01 (SD ± 0.8) **Country:** India **Setting:** hospital
Interventions	Pentax (n = 15) vs Macintosh (n = 15) Macintosh blade #3 in female, #4 in male patients
Outcomes	*Continuous outcome:* Time for tracheal intubation (in seconds): defined as time from picking up laryngoscopy to when the blade was removed from the mouth after successful intubation
Notes	*Experience of intubator*: 3 consultant anaesthetists who learnt and performed at least 20 intubations with the new device in the clinical setting, before the study *Funding/declarations of interest:* none apparent *Additional:* aim to look at haemodynamic changes for patients with CABG; reports time for intubation as only relevant outcome

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "The allocation sequence was generated by random number tables"
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "Data were collected by an independent unblinded observer"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought

Kanchi 2011 (*Continued*)

Experience of intubator	Low risk	Quote: "Tracheal intubation was performed in each patient by one of the three consultant anaesthesiologists who learnt and performed at least 20 intubations with the new device in the clinical setting, prior to the study"
Baseline characteristics	Low risk	Quote: "The demographic data, incidence of hypertension, serum creatinine, LV ejection fraction, and Mallampatti score were similar in both the groups"
Funding sources	Low risk	Comment: none apparent

Kill 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 60 **Inclusion criteria:** adult patients scheduled for elective surgery requiring general anaesthesia with endotracheal intubation and with ASA I to III **Exclusion criteria:** gastro-oesophageal reflux disease, with abnormal physical status of the upper airway (e.g. after C-spine trauma), C-spine previously operated on, oropharyngeal or hypopharyngeal tumours, macroglossia, mandibular retrusion, other known airway difficulties **Baseline characteristics:** **GlideScope** *Age*: 61 (SD ± 15) *Gender M/F*: 13/17 *Height (cm)*: 169 (SD ± 9) *Weight (kg)*: 82 (SD ± 7) *BMI*: 28.8 (SD ± 3.5) M*allampati 1*: 5 *Mallampati 2*: 19 *Mallampati 3*: 6 **Macintosh** *Age*: 63 (SD ± 12) *Gender M/F*: 19/11 *Height (cm)*: 172 (SD ± 8) *Weight (kg)*: 84 (SD ± 12) *BMI*: 28.3 (SD ± 5.8) M*allampati 1*: 9 *Mallampati 2*: 17 *Mallampati 3*: 4 **Country:** Germany **Setting:** hospital

Kill 2013 (*Continued*)

Interventions	GlideScope (n = 30) vs Macintosh (n = 30) GlideScope blade #4, Macintosh blade #3 or #4 External laryngeal pressure allowed to improve glottic view in both groups
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from beginning of laryngoscopy to successful placement of ET tube; median (min/max): VLS 53 (28 - 210) seconds; Mac 24 (min/max12 - 75) seconds *Dichotomous outcome*: Failed intubation (3 participants randomized to the conventional group in which conventional intubation failed, intubation could be successfully performed with videolaryngoscopy)
Notes	*Experience of intubator*: 33 laryngoscopists participated in the study; GlideScope experience of all participating anaesthesiologists: mean 9.9 (SD ± 8.6) intubations. The GlideScope had been available for 6 months before this investigation *Funding/declarations of interest:* travel grant from Verathon Europe. Study authors declare no conflicts of interest *Other information*: all anaesthesiologists were instructed to avoid moving the C-spine to minimize C-spine movements during laryngoscopy, but head and neck were not immobilized

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "Immediately after induction of anesthesia, the patients were randomly assigned" Comment: no details on method of randomization
Allocation concealment (selection bias)	Unclear risk	Quote: "sealed envelope randomization" Comment: insufficient details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: attempts at blinding for some study outcomes, but not possible to blind for relevant review outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "All enrolled patients were able to be included in further evaluation"
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought

Kill 2013 (*Continued*)

Experience of intubator	High risk	Quote: "Thirty-three laryngoscopists participated in the study; the GlideScope experience of all participating anesthesiologists was a mean of 9.9 (± 8.6) intubations. The GlideScope had been available for a period of 6 months before this investigation" Comment: large number of participating physicians with differing skill levels
Baseline characteristics	Low risk	Quote: "no significant differences in biometric data"
Funding sources	High risk	Comment: travel grant from Verathon Europe. Study authors declare no conflicts of interest

Kim 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 46 **Inclusion criteria:** aged 20 years or older, undergoing uvulopalatopharyngoplasty under general anaesthesia; diagnosis of obstructive sleep apnoea, confirmed by polysomnography, but otherwise healthy; ASA I or II **Exclusion criteria:** loosened teeth or mouth opening < 18 mm; any pathology in the neck, pharynx or larynx; risk factor for aspiration of gastric contents; history of hypersensitivity to an anaesthetic drug **Baseline characteristics:** **Pentax AWS** *Age*: 45.8 (range 23-62) *Gender M/F*: 16/6 *BMI*: 25.6 (SD ± 3.5) *ASA I*: 11 *ASA II*: 11 *Mallampati 1*: 0 *Mallampati 2*: 5 *Mallampati 3*: 10 *Mallampati 4*: 7 **Macintosh** *Age*: 43.7 (range 19-64) *Gender M/F*: 19/4 *BMI*: 25.8 (SD ± 3.2) *ASA I*: 9 *ASA II*: 14 *Mallampati 1*: 4 *Mallampati 2*: 9 *Mallampati 3*: 6

Kim 2013 (*Continued*)

	Mallampati 4: 4 **Country:** Republic of Korea **Setting:** hospital
Interventions	Pentax AWS (n = 23) vs Macintosh (n = 23) With the AWS, a well-lubricated tracheal tube was attached to a channel on the right side of the tube before insertion. When the Macintosh laryngoscope was used, a gum-elastic bougie could be used
Outcomes	*Continuous outcomes*: Time for tracheal intubation Difficulty of intubation: IDS scores *Dichotomous outcomes*: Failed intubation: defined as an attempt in which the trachea was not intubated or an attempt that took > 60 seconds to complete Laryngeal/airway trauma (visible trauma to lip or oral mucosa, bleeding, or dental trauma) Successful first attempt No. of attempts: 1 or 2 CL glottic view: 1 to 4
Notes	*Experience of intubator*: both anaesthetists experienced > 3 years of clinical anaesthesia, and had performed > 500 and ≥ 100 tracheal intubations with the Macintosh laryngoscope and the AWS, respectively *Funding/declarations of interest:* none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "Patients were randomly allocated into either the Macintosh group or AWS group" Comment: no additional details
Allocation concealment (selection bias)	Unclear risk	Quote: "sealed envelope method" Comment: insufficient details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "it was impossible to blind both the operator and the observer to the device being used"
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "An independent, but unblinded observer collected all data in every case of this trial"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "In a total of 46 patients enrolled, one patient in the AWS group was excluded because of a change in surgical plan"

Kim 2013 (*Continued*)

		Comment: low level of loss should not affect results
Selective reporting (reporting bias)	Low risk	Quote: "studies and registration in clinicaltrials.gov (Unique Identier: NCT01428570)" Comment: protocol sourced and outcomes comparable with reported study outcomes
Experience of intubator	Low risk	Quote: "Before this study, both anaesthetists experienced >3 yr of clinical anaesthesia, and had performed >500 and at least 100 tracheal intubations with the Macintosh laryngoscope and the AWS in patients, respectively"
Baseline characteristics	Unclear risk	Quote: "randomization of this study was not fully achieved. Even though the best efforts of randomization were made, more patients with higher Mallampati classification were included in the AWS group. This could be attributed to the limited number of patients recruited. However, the AWS was shown to overcome such a disadvantage" Comment: differences in baseline characteristics in the Mallampati scores. Impact of this difference is uncertain
Funding sources	Low risk	Comment: none

Komatsu 2010

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 100 **Inclusion criteria:** scheduled for various surgical procedures requiring tracheal intubation as part of anaesthesia, 18 years of age or older, ASA I to III **Exclusion criteria:** increased risk of pulmonary aspiration, cervical spine pathology or anticipated airway difficulties (i.e. Mallampati grade 4 or thyromental distance 6 cm) **Baseline characteristics:** **Pentax AWS** *Age*: 60 (SD ± 19) *Gender M/F*: 20/30 *Height (cm)*: 158 (SD ± 9) *Weight (kg)*: 56 (SD ± 10) *Mallampati 1*: 26 *Mallampati 2*: 17

Komatsu 2010 (*Continued*)

	Mallampati 3: 7 *Mallampati 4*: 0 **Macintosh** *Age*: 53 (SD ± 18) *Gender M/F*: 28/22 *Height (cm)*: 162 (SD ± 2) *Weight (kg)*: 58 (SD ± 10) *Mallampati 1*: 28 *Mallampati 2*: 14 *Mallampati 3*: 8 *Mallampati 4*: 0 **Country:** Japan **Setting:** hospital
Interventions	Pentax (n = 50) vs Macintosh (n = 50) Macintosh blade #3
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from picking up the laryngoscope to confirmation of tracheal intubation by capnography. In the event that tracheal intubation was accomplished after 1 or 2 failed attempts, times for all individual intubation attempts were totalled to calculate intubation time Improved visualization (with POGO) *Dichotomous outcomes*: Failed intubation: defined as unsuccessful after 3 attempts, then change of device used. Any single insertion of Airway scope or Macintosh laryngoscope into the participant's mouth was considered an intubation attempt Laryngeal/airway trauma (mucosal trauma, i.e. blood detected on the devices, dental injury) Hypoxia CL glottic view: 1 to 4 No. of attempts: 1 to 3
Notes	*Funding/declarations of interest:* instruments loaned from manufacturers. No financial support *Additional:* All participants had laryngoscopy performed with Macintosh #3 in normal position to obtain grades, then table was moved up alongside normal operating table for anaesthetist to kneel on to simulate ground position. Laryngoscopic view was taken again with #3 Macintosh, then intubation was performed in randomized groups

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "Randomization was based on computer-generated codes"

Komatsu 2010 (*Continued*)

Allocation concealment (selection bias)	Low risk	Quote: "maintained in sequentially numbered, opaque envelopes until just before experimental intubation"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Both investigators were blinded to the laryngeal view obtained by the other, and to the results of laryngoscopy performed under optimal conditions before group assignment" Comment: not possible to blind anaesthetists to primary outcomes
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: both investigators were blinded to the laryngeal view obtained by the other, and to the results of laryngoscopy performed under optimal conditions before group assignment. Not possible to blind other outcome data
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Quote: "The investigator... had previously performed 150 intubations using the Airway Scope in an optimal intubation condition, but none at the ground level"
Baseline characteristics	Unclear risk	Quote: "Morphometric and airway assessment data of patients assigned to either the Airway Scope or the Macintosh laryngoscope were similar" Comment: more males in Macintosh group. Impact of this difference is uncertain
Funding sources	Unclear risk	Comment: instruments loaned from manufacturers. No financial support

Lee 2009

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 44 **Inclusion criteria:** no details given **Exclusion criteria:** younger than 18 years of age, requiring other than blade #3 of

	laryngoscope, ASA ≥ IV, requiring surgery of the face or throat **Baseline characteristics:** Cross-over design. Baseline characteristics not divided by type of scope but by gender Female *Age*: 50 (SD ± 16) *BMI*: 26.8 (SD ± 5.5) *ASA I*: 11 *ASA II*: 12 *ASA III*: 1 *Mallampati 1*: 7 *Mallampati 2*: 14 *Mallampati 3*: 2 *Mallampati 4*: 1 Male *Age*: 56 (SD ± 13) *BMI*: 302 (SD ± 8.5) *ASA I*: 3 *ASA II*: 14 *ASA III*: 3 *Mallampati 1*: 10 *Mallampati 2*: 8 *Mallampati 3*: 2 *Mallampati 4*: 0 **Country:** The Netherlands **Setting:** hospital
Interventions	Storz VLS (type not specified by study authors) vs Macintosh Cross-over design with 2 scopes; each participant having both scopes (in a randomized order) with 2 anaesthetists
Outcomes	*Dichotomous outcomes*: Failed intubation Laryngeal/airway trauma (injuries or dental damage) CL glottic view: 1 to 4. Not possible to extract data for this outcome (presented as correlation data with Mallampati scores)
Notes	*Funding/declarations of interest:* none *Additional:* unclear whether 3 participants were lost during the study

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Comment: patients randomly selected to participate. Order of blades randomly decided. No additional details
Allocation concealment (selection bias)	Unclear risk	Comment: no details

Lee 2009 (*Continued*)

Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: assumed not blinded - no details
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: some apparent loss, not explained - 3 missing participants from VLS group. Unexplained discrepancies in tables
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "Ten anesthesiolgists (4 specialists, 6 residents), all familiar with the videolaryngoscope (minimum 30 uses) and classical intubation practices, participated in the study"
Baseline characteristics	Low risk	Comment: comparable baseline characteristics
Funding sources	Low risk	Comment: none

Lee 2012

Methods	Randomized controlled trial Cross-over with 4 scopes
Participants	**Total number of participants:** 50 **Inclusion criteria:** selected from a population of elective surgical patients. No additional details provided **Exclusion criteria:** younger than 18 years of age, requiring other than a #3 blade Macintosh laryngoscope, ASA ≥ IV, without both upper and lower teeth, requiring surgery of the face and/or throat **Baseline characteristics:** **GlideScope** *Age*: 56 (SD ± 17) *Gender M/F*: 6/19 *BMI*: 25 (SD ± 4) *ASA I*: 10 *ASA II*: 15 *ASA III*: 0 **Macintosh** *Age*: 54 (SD ± 16) *Gender M/F*: 10/15 *BMI*: 26 (SD ± 4) *ASA I*: 9

Lee 2012 (*Continued*)

	ASA II: 14 *ASA III*: 2 **McGrath Series 5** *Age*: 55 (SD ± 16) *Gender M/F*: 4/21 *BMI*: 26 (SD ± 5) *ASA I*: 9 *ASA II*: 14 *ASA III*: 2 **V-Mac Storz Berci DCI** *Age*: 52 (SD ± 16) *Gender M/F*: 10/15 *BMI*: 25 (SD ± 3) *ASA I*: 9 *ASA II*: 14 *ASA III*: 2 **Country:** The Netherlands **Setting:** hospital
Interventions	GlideScope (n = 25); McGrath Series 5 (n = 25); VMac (n = 25); Macintosh (n = 25). Total N = 50 Participants randomly assigned to receive a pair of scopes in random order
Outcomes	*Continuous outcomes*: Time for tracheal intubation: measured as time between picking up the ETT and positioning the tube directly anterior to the vocal cords at < 30 seconds, 30 to 60 seconds, > 60 seconds. Intubation time was measured as the sum of all attempts. Not possible to use these data, as not similar to other data in the review Study author quote: "The time taken to complete the placement of the ETT with the McGrath™ scope (Aircraft Medical) was significantly different from the other blades, with a greater proportion of the attempts requiring more than 30 s. There was also a statistically significant difference in time taken for the procedure between the Macintosh (Karl Storz) and GlideScope® blades (Verathon Inc), with the GlideScope® blade (Verathon Inc) having more attempts requiring between 30 and 60 s. No further differences in insertion time were significant" *Dichotomous outcomes*: Failed intubation: defined as more than 4 attempts or > 120 seconds Laryngeal/airway trauma Successful first attempt No. of attempts: 1 to 4 CL glottic view: 1 to 3
Notes	*Experience of intubator*: all laryngoscopies were performed by available staff members (only senior residents and specialists), all of whom were experienced in anaesthesia and use of the VLS studied. All staff members received an introductory VLS course in the hospital's airway skills lab and had used each VLS a minimum of 50 times before this study *Funding/declarations of interest:* none apparent

Lee 2012 (*Continued*)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Comment: participants randomly assigned to set of 2 blades, which were used in randomized order. No details of randomization method provided
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: outcome assessors were independent but it was not possible to blind them from group allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Comment: large number of anaesthetists in the study; all described as having equivalent training
Baseline characteristics	Unclear risk	Comment: more males in Macintosh and Berci DCI group. Impact of this difference is uncertain
Funding sources	Low risk	Comment: none apparent

Lee 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 40 **Inclusion criteria:** 18 to 60 years old, ASA I or II, scheduled for elective surgery that was expected to take 1 to 2 hours **Exclusion criteria:** known cardiovascular disease, diabetes, endocrine disease, allergies to any medications; anatomical characteristics associated with a difficult airway, such as unstable teeth, mouth opening < 3 cm, limited neck extension **Baseline characteristics:** **Pentax AWS** *Age*: 38.9 (SD ± 13.3)

Lee 2013 (*Continued*)

	Gender M/F: 12/8 *Height (cm)*: 168 (SD ± 9.3) *Weight (kg)*: 64.9 (SD ± 8.2) *BMI*: 23.0 (SD ± 2.6) **Macintosh** *Age*: 35.5 (SD ± 10.5) *Gender M/F*: 11/9 *Height (cm)*: 166.5 (SD ± 9.8) *Weight (kg)*: 66.0 (SD ± 14.9) *BMI*: 23.6 (SD ± 3.9) **Country:** Korea **Setting:** hospital
Interventions	Pentax AWS (n = 20) vs Macintosh (n = 20)
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from when the tip of the blade passes the incisors until the tip of the blade passes out of the incisors after insertion of the tracheal tube *Dichotomous outcome*: Patient-reported sore throat: measured at different time points; mild to moderate sore throat measured 30 minutes after extubation. Not possible to interpret data presented for sore throat at 30 minutes. No sore throat observed 24 hours after extubation in either group
Notes	*Experience of intubator*: single anaesthesiologist who was an expert in both intubation procedures *Funding/declarations of interest:* none apparent *Additional:* "If tracheal intubation failed at the first attempt or if a patient's Cormack-Lehane score was greater than three, the patient was immediately excluded from the study"

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "patients were randomly assigned to the two groups" Comment: no additional details
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind time to intubation outcome. However, nurses assessed sore throat in PACU and were

Lee 2013 (*Continued*)

		blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "single anesthesiologist who was an expert in both intubation procedures"
Baseline characteristics	Low risk	Quote: "There was no significant difference between the two groups in demographic data"
Funding sources	Low risk	Comment: none apparent

Lim 2005

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 60 **Inclusion criteria:** ASA I or II admitted for elective gynaecological procedures, Mallampati grades 1 and 2 **Exclusion criteria:** risk of aspiration, evidence of a potentially difficult airway **Baseline characteristics:** **GlideScope** *Age*: 39 (SD ± 13) *Height (cm)*: 158.3 (SD ± 4.5) *Weight (kg)*: 57.8 (SD ± 10.5) *ASA I*: 23 *ASA II*: 7 *Mallampati 1*: 25 *Mallampati 2*: 5 **Macintosh** *Age*: 40 (SD ± 10) *Height (cm)*: 157.5 (SD ± 4.7) *Weight (kg)*: 58.2 (SD ± 8.9) *ASA I*: 28 *ASA II*: 2 *Mallampati 1*: 26 *Mallampati 2*: 4 **Country:** Singapore **Setting:** hospital
Interventions	GlideScope (n = 30) vs Macintosh (n = 30) Stylet used in both groups

Lim 2005 (*Continued*)

Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation: Median difficulty score for GlideScope group was 20 (range 0-90) and for Macintosh group 10 (range 0-70) Time for tracheal intubation: defined as time from anaesthetist picking up device to when capnography confirmed correct placement of the tube. Intubation time was broken down by level of experience of the intubator *Dichotomous outcomes*: Failed intubation: defined as inability to secure airway in 3 attempts Laryngeal/airway trauma Successful first attempt No. of attempts: 1 to 2 CL glottic view: 1 to 4
Notes	*Experience of intubator*: 20 anaesthetists in the department with varying degrees of experience with GlideScope (from complete novice to more than 10 successful experiences) *Funding/declarations of interest:* none *Addtional:* in-line manual stabilization of head and neck to simulate difficult airway

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Comment: described as randomized with sealed envelopes. Insufficient details
Allocation concealment (selection bias)	Unclear risk	Comment: sealed envelopes. No further details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: outcome assessors independent - but not described as blinded for any outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	High risk	Comment: differing levels of experience of intubators, all detailed by study authors. Not clear whether experience of intubators was evenly distributed for each device
Baseline characteristics	Low risk	Comment: comparable baseline characteristics

Lim 2005 (*Continued*)

Funding sources	Low risk	Comment: none

Lin 2012

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 170 **Inclusion criteria:** adults scheduled for elective open thoracic surgery requiring double-lumen tube insertion for 1-lung ventilation **Exclusion criteria:** limited mouth opening, ASA III or IV, age < 18 years, history of known difficult airway **Baseline characteristics:** **CEL-100** *Age*: 58.2 (SD ± 9.6) *Gender M/F*: 55/28 *Height (cm)*: 162.5 (SD ± 7.5) *Weight (kg)*: 60.9 (SD ± 8.9) *BMI*: 22.9 (SD ± 2.7) *ASA I*: 60 *ASA II*: 16 *ASA III*: 7 *Mallampati 1*: 40 *Mallampati 2*: 36 *Mallampati 3*: 7 *Mallampati 4*: 0 **Macintosh** *Age*: 57.6 (SD ± 9.4) *Gender M/F*: 52/30 *Height (cm)*: 163.1 (SD ± 7.3) *Weight (kg)*: 61.2 (SD ± 8.3) *BMI*: 23.1 (SD ± 2.8) *ASA I*: 59 *ASA II*: 17 *ASA III*: 6 *Mallampati 1*: 45 *Mallampati 2*: 31 *Mallampati 3*: 6 *Mallampati 4*: 0 **Country:** China **Setting:** hospital
Interventions	CEL-100 videolaryngoscope (n = 85) vs Macintosh (n = 85) CEL-100 from Connell energy Technology Co. Ltd, Shanghai, China Use of stylet, and external laryngeal pressure if required

Lin 2012 (*Continued*)

Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation: subjectively assessed from 0: easy, to 100: difficult IDS scores: median (IQR) 0 = easy, 100 = difficult. CEL-100 0 (0-0 (0-60)); Macintosh 15 (0-30 (0-80)) Time for tracheal intubation: defined as time from insertion of laryngoscope blade into the mouth until first upstroke of the capnograph trace; If more than 1 intubation attempt was required, successful intubation time was the sum of the times for each attempt and did not include the time interval between attempts). Median (IQR) - CEL-100 45 (38-55); Mac 51 (40-61) out of 83 and 82 participants *Dichotomous outcomes*: Failed intubation: defined as failure after 3 attempts for either device with trachea intubated with a single-lumen tube or managed according to ASA difficult airway guidelines. Participants were then excluded from the study Laryngeal/airway trauma (oral mucosal bleeding) Patient-reported sore throat (or hoarseness, reported on first postoperative day) Hypoxia: oxygen saturation < 95% - reported as hypoxaemia. "No episodes in either group" Successful first attempt No. of attempts: 1 or > 2 CL glottic view: 1 to 4
Notes	*Experience of intubator*: all intubations were performed by 3 experienced anaesthetists who had each performed at least 30 successful double-lumen tube insertions using the CEL-100 device *Funding/declarations of interest:* none *Additional:* use of double-lumen tube in both groups

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "computer-generated codes"
Allocation concealment (selection bias)	Low risk	Quote: "maintained in sequentially numbered opaque envelopes"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "All postoperative data were collected by one independent observer who was blinded to the study randomisation" Comment: some outcomes, such as time for intubation, could not be blinded because of the nature of the intervention

Lin 2012 (*Continued*)

Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: 5 participants excluded from further analysis owing to failure of intubation. Low number, therefore low risk of bias
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "All the intubations were performed by three experienced anaesthetists who had each performed at least 30 successful double-lumen tube insertions using the CEL-100 device"
Baseline characteristics	Low risk	Quote: "Patients' characteristics, pre-operative airway assessments and the tubes used in the study were similar in both groups"
Funding sources	Low risk	Comment: none

Maassen 2012

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 80 **Inclusion criteria:** adult patients, ASA physical status II or III, scheduled for elective coronary artery bypass surgery requiring endotracheal intubation and intra-arterial blood pressure monitoring **Exclusion criteria:** obesity (BMI > 35 kg/m^2), chronic obstructive pulmonary disease, history of difficult intubation, mouth opening < 3 cm, inadequate neck mobility or left ventricular ejection fraction < 45% **Baseline characteristics:** **Cross-over design, all reported together** *Age*: 66.2 (SD ± 10.2) *Gender M/F*: 55/25 *Height (cm)*: 172 (SD ± 9) *Weight (kg)*: 80.9 (SD ± 15.5) *BMI*: 27.0 (SD ± 4) *ASA I*: 0 *ASA II*: 67 *ASA III*: 13 *Mallampati 1*: 34 *Mallampati 2*: 41 *Mallampati 3*: 5 *Mallampati 4*: 0 **Countries:** Belgium and The Netherlands **Setting:** hospital

Maassen 2012 (*Continued*)

Interventions	Storz C-MAC vs Macintosh, cross-over in randomized order Extra manoeuvres to optimize visualization of the glottis entrance (BURP). A stylet or a gum-elastic bougie was used to facilitate intubation
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time between picking up the ETT and visual passage of the tube until vocal cords were between the 2 black line markings on the distal end of the ETT. However, data were not reported by study authors *Dichotomous outcomes*: Failed intubation Laryngeal/airway trauma (reported for palatoglossal arch or dental injury) Patient-reported sore throat: Only 3 participants, who had an effective airway time longer than 50 seconds, reported postoperative minor, self-limiting sore throat, which did not require treatment. Study authors did not state to which group these participants were assigned No. of attempts: counted as each approach of the endotracheal tube (ETT) to the glottis entrance. If after 2 attempts the participant could not be intubated, a stylet or a gum-elastic bougie was used to facilitate intubation. However, no data were reported by study authors for this outcome
Notes	*Funding/declarations of interest:* none apparent *Additional:* Only data on failed intubation could be extracted for this study. All other outcomes were not relevant or were wrongly reported for our review

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "We performed a randomized cross-over study, in which each patient received sequential treatments in a random order" Comment: participants selected a sealed card. Insufficient details
Allocation concealment (selection bias)	Unclear risk	Comment: no details given
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "attending anaesthesiologist was not blinded to the type of laryngoscope used"
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: sore throat assessed by blinded investigator but not possible to blind personnel to primary outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no losses

Maassen 2012 (*Continued*)

Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought. Data not reported for number of attempts
Experience of intubator	Unclear risk	Comment: no details of anaesthetist experience
Baseline characteristics	Unclear risk	Comment: no baseline characteristics by group owing to cross-over design
Funding sources	Low risk	Comment: none apparent

Malik 2008

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 120 **Inclusion criteria:** ASA I to III, aged 16 years or older, undergoing surgical procedures requiring tracheal intubation **Exclusion criteria:** risk factors for gastric aspiration, difficult intubation or both (Mallampati class 3 or 4; thyromental distance < 6 cm; interincisor distance < 3.5 cm); history of relevant drug allergy **Baseline characteristics:** **GlideScope** *Age*: 45.03 (range 23-80) *Gender M/F*: 8/22 *BMI*: 26.5 (SD ± 3.3) *ASA median (IQR):* 2 (1-2) *Mallampati 1*: 10 *Mallampati 2*: 20 **Pentax AWS** *Age*: 43.9 (range 20-68) *Gender M/F: 11/19* *BMI*: 26.0 (SD ± 6.0) *ASA median (IQR):* 2 (1-2) *Mallampati 1*: 12 *Mallampati 2*: 18 **Truview EVO2** *Age*:43.2 (range 21-83) *Gender M/F:* 20/10 *BMI*: 25.3 (SD ± 3.5) *ASA median (IQR):* 2 (1-2) *Mallampati 1*: 14 *Mallampati 2*: 16 **Macintosh** *Age*: 50.8 (range 18-82) *Gender M/F:* 11/19

	BMI: 25.7 (SD ± 4.1) *ASA median (IQR):* 2 (1-2) *Mallampati 1*: 13 *Mallampati 2*: 17 **Country:** Ireland **Setting:** hospital
Interventions	GlideScope (n = 30) vs Pentax AWS (n = 30) vs Truview EVO2 (n = 30) vs Macintosh (n = 30) Truview EVO2 was used with camera attachment and therefore was included in this review Stylet was used for GlideScope and Truview EVO2 laryngoscopes. ETT was placed in side channel of Pentax AWS before intubation attempt Bougie, cricoid pressure, and second assistant were used for all scopes Macintosh blade #3 was used in females and #4 in males
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from insertion of the blade between the teeth until the ETT was placed through the vocal cords *Dichotomous outcomes*: Failed intubation: defined as trachea not intubated, or took > 60 seconds; maximum of 3 attempts, then manual in-line axial stabilization discontinued and Macintosh blade used Laryngeal/airway trauma (blood on laryngoscope blade, minor laceration, dental or other airway trauma) Successful first attempt No. of attempts: 1 to 3 CL glottic view: 1 to 4 IDS scores: 0 to 7
Notes	*Experience of intubator*: each investigator had performed at least 50 intubations with each device in manikins, and at least 20 intubations with each device in the clinical setting *Funding/declarations of interest:* Both Pentax and Truview were provided by manufacturers. Departmental funding only *Additional:* all participants underwent manual in-line axial stabilization

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "allocation sequence was generated by random number tables"
Allocation concealment (selection bias)	Unclear risk	Quote: "allocation concealed in sealed envelopes, which were not opened until patient consent had been obtained" Comment: insufficient details

Malik 2008 (*Continued*)

Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "All data were collected by an independent unblinded observer"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "Tracheal intubation was performed in each patient by one of the three anaesthetists... Each investigator had performed at least 50 intubations with each device in manikins, and at least 20 intubations in the clinical setting with each device"
Baseline characteristics	Unclear risk	Quote: "There were no significant differences in patient characteristics or baseline airway parameters between the groups, with the exception of a greater number of male patients in the Truview EVO2 group" Comment: higher mean age of participants in the Macintosh group and differences in ratio of male to female participants between groups. Unclear if this made intubations more difficult in this group
Funding sources	Unclear risk	Comment: both Pentax and Truview were provided by manufacturers. Departmental funding only

Malik 2009a

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 60 **Inclusion criteria:** ASA I to III, aged 16 years or older, undergoing general anaesthesia for surgery and requiring tracheal intubation **Exclusion criteria:** risk factors for gastric aspiration, difficult intubation (Mallampati class 3 or 4; thyromental distance < 6 cm; interincisor distance < 3.5 cm) or both, history of relevant drug allergy **Baseline characteristics:**

	Pentax AWS *Age*: 50.4 (range 23-82) *Gender M/F*: 13/17 *BMI*: 26.9 (SD ± 4.1) **Macintosh** *Age*: 47.4 (range 18-78) *Gender M/F*: 18/12 *BMI*: 26.3 (SD ± 4.9) **Country:** Ireland **Setting:** hospital
Interventions	Pentax AWS (n = 30) vs Macintosh (n = 30)
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from insertion of blade between the teeth until tracheal tube was placed through the vocal cords. Median (IQR): AWS 11 (9-13); Macintosh 11 (9-15) *Dichotomous outcomes*: Failed intubation (defined as an attempt in which the trachea was not intubated, or that required > 120 seconds to perform) Laryngeal/airway trauma (blood on laryngoscope blade, minor laceration, dental or other airway trauma) Successful first attempt No. of attempts: 1 to 3 CL glottic view: 1 to 4 IDS score: 0 to 7
Notes	*Experience of intubator*: 1 of 3 anaesthetists who were familiar with each of the devices. Each investigator had performed, with each device, at least 50 intubations in manikins and at least 20 intubations in the clinical setting *Funding/declarations of interest:* Pentax AWS supplied by manufacturer. Departmental funding only *Additional:* study also included an LMA CTrach laryngoscope, which does not meet our inclusion criteria; therefore, we have not included data for this arm. All participants were given manual in-line axial stabilization

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "allocation sequence was generated by random number tables"
Allocation concealment (selection bias)	Unclear risk	Quote: "allocation concealed in sealed envelopes, which were not opened until patient consent had been obtained" Comment: insufficient details

Malik 2009a (*Continued*)

Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "data were collected by an independent unblinded observer"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: data for CL scores not available for 3 patients in the Macintosh group, but overall few losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "one of the three anaesthetists... who were familiar with each of the devices. Each investigator had performed, with each device, at least 50 intubations in manikins and at least 20 intubations in the clinical setting"
Baseline characteristics	Unclear risk	Quote: "There were no significant differences in characteristics or baseline airway parameters between the groups" Comment: more males in Macintosh group. Impact of this difference is uncertain
Funding sources	Unclear risk	Comment: Pentax AWS supplied by manufacturer. Departmental funding only

Malik 2009b

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 75 **Inclusion criteria:** ASA I to III, aged 16 years or older, deemed on preoperative assessment by the primary anaesthetist to be at increased risk for difficult laryngoscopy, undergoing surgical procedures requiring tracheal intubation **Exclusion criteria:** risk factors for gastric aspiration, history of relevant drug allergy **Baseline characteristics:** **GlideScope** *Age*: 55 (range 22-85) *Gender M/F*: 13/12 *BMI*: 34.4 (SD ± 10.7) *Mallampati 1*: 0 *Mallampati 2*: 0

	Mallampati 3: 20 *Mallampati 4*: 5 **Pentax AWS** *Age*: 60 (range 29-84) *Gender M/F*: 14/11 *BMI*: 33.4 (SD ± 7.2) *Mallampati 1*: 0 *Mallampati 2*: 1 *Mallampati 3*: 21 *Mallampati 4*: 3 **Macintosh** *Age*: 54 (range 26-85) *Gender M/F*: 16/9 *BMI*: 33.6 (SD ± 9.4) *Mallampati 1*: 0 *Mallampati 2*: 0 *Mallampati 3*: 19 *Mallampati 4*: 6 **Country:** Ireland **Setting:** hospital
Interventions	GlideScope (n = 25) vs Pentax AWS (n = 25) vs Macintosh (n = 25) Use of bougie, external laryngeal manipulation, second assistant for all 3 scopes Stylet used in GlideScope bent into hockey stick curve Macintosh blade #3 in females; #4 in males
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from insertion of the blade between the teeth until the TT was placed through the vocal cords. Time for successful attempt: median (IQR): AWS 15 (8-31); GlideScope 17 (12-31); Macintosh 13 (8-23) *Dichotomous outcomes*: Failed intubation Laryngeal/airway trauma (minor: visible trauma to lip or oral mucosa or blood on the laryngoscope) Successful first attempt No. of attempts: 1 to 3 CL glottic view: 1 to 4 IDS score: 0 to 8 or > 8
Notes	Note more obese patients (BMI > 30) in all 3 groups *Experience of intubator*: each anaesthetist had performed more than 500 intubations with the Macintosh laryngoscope and at least 100 intubations with the Pentax AWS and GlideScope in manikins, and 50 intubations with the Pentax AWS and GlideScope in the clinical setting, before this study *Funding/declarations of interest:* Pentax provided by manufacturers. Departmental funding only
Risk of bias	

Malik 2009b (*Continued*)

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "random number tables"
Allocation concealment (selection bias)	Unclear risk	Quote: "allocation concealed in sealed envelopes" Comment: insufficient details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "All data were collected by an independent unblinded observer"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no losses reported in CONSORT figure
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "Each anaesthetist had performed more than 500 intubations with the Macintosh laryngoscope and at least 100 intubations with the Pentax AWS and GlideScope in manikins, and 50 intubations with the Pentax AWS and GlideScope in patients"
Baseline characteristics	Low risk	Comment: comparable baseline characteristics, although slightly higher number of males in Macintosh group
Funding sources	Unclear risk	Quote: "Pentax Ltd provided the Pentax AWS device and disposable blades free of charge for use in the study"

Maruyama 2008a

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 13 **Inclusion criteria:** aged 41 to 68 years, ASA I or II, scheduled to undergo elective surgery requiring general anaesthesia with tracheal intubation **Exclusion criteria:** previous neck surgery, possible pregnancy, difficult intubation anticipated, without incisor teeth **Baseline characteristics:**

Maruyama 2008a (*Continued*)

	Cross-over design with baseline characteristics reported together for 11 participants (2 excluded owing to technical difficulties) *Age*: 50 (range 41-68) *Gender M/F*: 7/4 *Height (cm)*: 161 (range 150-175) *Weight (kg)*: 55 (range 41-75) *Mallampati 1*: 10 *Mallampati 2*: 1 *Mallampati 3*: 0 *Mallampati 4*: 0 **Country:** Japan **Setting:** hospital
Interventions	Pentax AWS vs Macintosh
Outcomes	*Continuous outcomes*: Improved visualization ("Assessment of the glottic view during laryngoscopy by Cormack-Lehane grading resulted in a score of 1 with the AWS and a score of 2 with the Macintosh laryngoscope in all patients") Time for tracheal intubation: defined as time when the Macintosh laryngoscope or the AWS passed the central incisors to time when the tip of the tracheal tube passed through the glottis
Notes	*Experience of intubator*: Study authors stated, "The operator was familiar with both devices, and his technique was consistent"; however, no further information was provided to reveal level of experience *Funding/declarations of interest:* Airway scope provided by manufacturer *Additional:* video-fluoroscopic study. Head immobilised with blocks and restraining bands

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Comment: described as randomized, no additional details
Allocation concealment (selection bias)	Unclear risk	Comment: no details given
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: assumed outcome assessor not blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Two of the 13 patients were excluded from the study because of technical difficul-

Maruyama 2008a (*Continued*)

		ties" Comment: moderate loss
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Comment: no details on amount of experience with Pentax
Baseline characteristics	Unclear risk	Comment: cross-over design; baseline characteristics not divided by group
Funding sources	Unclear risk	Quote: "The AirWay Scope was provided by Pentax Corporation"

Maruyama 2008b

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 24 **Inclusion criteria:** aged 18 to 82 years, ASA I or II, scheduled to undergo elective surgery requiring general anaesthesia with tracheal intubation **Exclusion criteria:** previous neck surgery, possible pregnancy, unstable C-spine, difficult intubation anticipated, without incisors **Baseline characteristics:** **AWS** *Age*: 50.8 (range 27-82) *Gender M/F*: 6/6 *Height (cm)*: 162.0 (SD ± 7.1) *Weight (kg)*: 58.0 (SD ± 6.5) *Mallampati 1*: 8 *Mallampati 2*: 4 *Mallampati 3*: 0 *Mallampati 4*: 0 **Macintosh** *Age*:48.1 (range 24-63) *Gender M/F*: 6/6 *Height (cm)*: 161.6 (SD ± 10.2) *Weight (kg)*: 56.5 (SD ± 13.6) *Mallampati 1*: 8 *Mallampati 2*: 4 *Mallampati 3*: 0 *Mallampati 4*: 0 **Country:** Japan **Setting:** hospital
Interventions	Pentax AWS (n = 12) vs Macintosh (n = 12)

Maruyama 2008b (*Continued*)

Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time when the laryngoscope or the AWS passed the central incisors to time when the anaesthetist withdrew the device from the participant's mouth after tracheal intubation *Dichotomous outcome*: CL glottic view: 1 to 4
Notes	*Funding/declarations of interest:* Pentax AWS supplied by manufacturer *Additional:* study also included a group using a McCoy laryngoscope, which was not eligible for inclusion in this review; therefore, we did not extract data for this group. Fluoroscopic comparisons, but some relevant outcome data

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Comment: described as randomized with no additional details
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: assumed outcome assessors not blinded
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: 5 withdrawals. Most resulted from problems with recording data during laryngoscopies. High attrition rate
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Comment: no details
Baseline characteristics	Low risk	Comment: comparable baseline characteristics
Funding sources	Unclear risk	Comment: Pentax AWS supplied by manufacturer

McElwain 2011

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 90 **Inclusion criteria:** ASA I to III, aged 16 years or older, undergoing surgical procedures requiring tracheal intubation **Exclusion criteria:** risk factors for gastric aspiration, difficult intubation or both (Mallampati class 3 or 4; thyromental distance < 6 cm; interincisor distance < 3.5 cm), history of relevant drug allergy **Baseline characteristics:** **C-MAC** *Age*: 54 (SD ± 20) *Gender M/F*: 10/20 *BMI*: 29 (SD ± 5) *Mallampati 1*: 11 *Mallampati 2*: 19 *Mallampati > 2*: 0 **Macintosh** *Age*: 58 (SD ± 20) *Gender M/F*: 19/12 *BMI*: 28 (SD ± 7) *Mallampati 1*: 12 *Mallampati 2*: 18 *Mallampati > 2*: 1 **Airtraq** *Age*: 52 (SD ± 19) *Gender M/F*: 14/15 *BMI*: 28 (SD ± 4) *Mallampati 1*: 13 *Mallampati 2*: 16 *Mallampati > 2*: 0 **Country:** Ireland **Setting:** hospital
Interventions	C-MAC (n = 30) vs Airtraq (n = 29) vs Macintosh (n = 31)
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from insertion of the blade between the teeth until the anaesthetist had obtained the best possible view of the vocal cords *Dichotomous outcomes*: Failed intubation: defined as an attempt in which the trachea was not intubated, or in which the device was abandoned and another device was used Laryngeal/airway trauma (blood on laryngoscope blade/minor laceration/dental or other airway trauma) Successful first attempt No. of attempts: 1 to 3 CL glottic view: 1 to 3 IDS score: 0 to 8 or > 8

Notes	*Experience of intubator*: 1 anaesthetist experienced in the use of all 3 laryngoscopes *Funding/declarations of interest:* Storz C-MAC and Airtraq supplied by manufacturers. Departmental funding only *Additional:* Airtraq is used, with camera attached as a videolaryngoscope. Participants' neck immobilized in both groups through manual in-line axial stabilization

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "allocation sequence was generated using online randomization software"
Allocation concealment (selection bias)	Unclear risk	Quote: "allocation concealed in sealed envelopes, which were not opened until patient consent had been obtained" Comment: insufficient detail
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "All data were collected by an independent unblinded observer" Comment: despite use of independent assessors, not possible to blind assessors from outcomes measured in theatre
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "A total of 90 patients consented to participate in the study. One patient, who had been randomized to the C-MAC group, was not subsequently entered into the study due to a change in the choice of anaesthetic technique" Comment: low level of loss
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "The trachea was then intubated by one anaesthetist...experienced in the use of all three laryngoscopes"
Baseline characteristics	Unclear risk	Comment: more males in Macintosh group. Impact of this difference is uncertain
Funding sources	Unclear risk	Quote: "Storz Ltd provided the C-MAC device, and Prodol Ltd provided the Airtraq devices free of charge for use in the study"

Najafi 2014

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 300 **Inclusion criteria:** ASA I or II, MET > 4, scheduled for elective surgery under general anaesthesia in the supine position **Exclusion criteria:** age < 18 years or > 60 years; any anatomical abnormality in the head, neck or face; any ENT, neck or thoracic surgery; smoking history; edentulous patients; estimated surgery time > 4 hours; any clinical evidence of active pulmonary disease; common cold during recent 2 weeks; limited mouth opening or neck extension **Baseline characteristics:** **GlideScope** *Age*: 39.1 (SD ± 7.6) *Gender M/F*: 67/83 *ASA I*: 125 *ASA II*: 25 *Mallampati 1*: 71 *Mallampati 2*: 48 *Mallampati 3*: 18 *Mallampati 4*: 13 **Macintosh** *Age*: 40.2 (SD ± 7.2) *Gender M/F*: 70/80 *ASA I*: 127 *ASA II*: 23 *Mallampati 1*: 85 *Mallampati 2*: 40 *Mallampati 3*: 17 *Mallampati 4*: 8 **Country:** Iran **Setting:** hospital
Interventions	GlideScope (n = 150) vs Macintosh (n = 150) GlideScope blade #4; Macintosh blade #3 for women and #4 for men
Outcomes	*Continuous outcome*: Time for tracheal intubation: no definition reported *Dichotomous outcomes*: Failed intubation Patient-reported sore throat
Notes	*Experience of intubator*: 1 anaesthetist in both groups *Funding/declarations of interest:* university funding only

Risk of bias

Bias	Authors' judgement	Support for judgement

Najafi 2014 (*Continued*)

Random sequence generation (selection bias)	Low risk	Quote: "block randomization method"
Allocation concealment (selection bias)	Unclear risk	Comment: no details given
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "Patients and the anesthesia resident, who evaluated the patients postoperatively, were blinded" Comment: blinding for sore throat outcome but not for intubation time or failed intubation outcome
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought. Study authors did not report data for failed intubation
Experience of intubator	Unclear risk	Comment: 1 anaesthetist in both groups but no details of experience
Baseline characteristics	Unclear risk	Quote: "The two groups were comparable with respect to; age, sex, ASA class, and duration of operation" Comment: baseline demographics presents more participants with higher Mallampati score in the intervention group
Funding sources	Low risk	Comment: university funding only

Nishikawa 2009

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 40 **Inclusion criteria:** ASA I or II, adult patients between 20 and 65 years old, undergoing elective mastectomy or minor orthopaedic surgery in supine position **Exclusion criteria:** hypertension, hypotension, cardiovascular disease, or arteriosclerosis; known history of a previous difficult tracheal intubation **Baseline characteristics:** **Pentax** *Age*: 41.0 (SD ± 13.8)

Nishikawa 2009 (*Continued*)

	Gender M/F: 5/15 *Height (cm)*: 157.1 (SD ± 12.0) *Weight (kg)*: 55.3 (SD ± 11.6) **Macintosh** *Age*: 41.7 (SD ± 13.8) *Gender M/F*: 4/16 *Height (cm)*: 159.0 (SD ± 12.1) *Weight (kg)*: 54.1 (SD ± 10.6) **Country:** Japan **Setting:** hospital
Interventions	Pentax AWS (n = 20) vs Macintosh (n = 20) Macintosh blade #3 or #4 for women, #4 or #5 for men
Outcomes	*Continuous outcome*: Time for tracheal intubation: recorded as interval from the time the device was inserted (Macintosh laryngoscope or AWS) into the oropharynx to the time when the device was removed from the oral cavity *Dichotomous outcomes*: Failed intubation: defined as inability to place the tracheal tube into the trachea on the first attempt in the Macintosh group Patient-reported sore throat: reported at 24 hours postoperatively. Graded on a 4-point scale; no sore throat, mild, moderate or severe sore throat
Notes	*Experience of intubator*: all intubating procedures were performed by a single anaesthetist who had 2 years' experience with Macintosh blades and at least 50 experiences with the AWS *Funding/declarations of interest:* Grants-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science, and Technology of Japan to Koichi Nishikawa (No. 20390412) *Additional:* note bias introduced by exclusion criteria (study author quote: "Patients in whom there was failure to intubate and those requiring more than 30 seconds to achieve tracheal intubation were excluded from this study")

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "computer-generated random numbers"
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist

Nishikawa 2009 (*Continued*)

Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "The patients were interviewed in a standard fashion by a blinded investigator" Comment: not possible to blind outcome assessors for primary outcome, although investigator blinded for assessment of sore throat
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "No patient was excluded from analysis according to the exclusion criteria"
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "All intubating procedures were performed by a single anesthesiologist who had 2 years experience with Macintosh blades and at least 50 times experience with the AWS"
Baseline characteristics	Low risk	Quote: "There were no significant differences in terms of patient characteristics"
Funding sources	Low risk	Comment: Grants-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science, and Technology of Japan to Koichi Nishikawa (No. 20390412)

Peck 2009

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 54 **Inclusion criteria:** ASA I or II, undergoing elective surgical procedures **Exclusion criteria:** no details **Baseline characteristics:** Cross-over design with baseline characteristics reported together, not by scope *Age*: 53.4 (SD ± 15.4) *Gender M/F*: 27/27 *Height (cm)*: 168 (SD ± 10) *Weight (kg)*: 82.6 (SD ± 18.2) *BMI*: 29.3 (SD ± 6.0) **Country:** Canada **Setting:** hospital
Interventions	McGrath vs Macintosh Type of McGrath device not specified

Peck 2009 (*Continued*)

Outcomes	*Continuous outcomes*: Improved visualization (measured with POGO) Time for tracheal intubation *Dichotomous outcomes*: Failed intubation Patient-reported sore throat CL glottic view: 1 to 4
Notes	*Funding/declarations of interest:* none apparent *Additional:* simulated difficult laryngoscope with manual in-line immobilization Abstract only. Not possible to contact study author, as no contact information provided in abstract. Sufficient information in Methods and Results sections for inclusion in the review

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Comment: randomized but no additional details. Abstract only
Allocation concealment (selection bias)	Unclear risk	Comment: abstract only. No details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind anaesthetist to primary outcome
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Comment: abstract only. No details
Selective reporting (reporting bias)	Unclear risk	Comment: abstract only. No details
Experience of intubator	Unclear risk	Comment: no details
Baseline characteristics	Unclear risk	Comment: cross-over design. Baseline characteristics not presented by group
Funding sources	Low risk	Comment: none apparent

Pournajafian 2014

Methods	Randomized controlled trial Parallel design
Participants	**Total number of participants:** 95 **Inclusion criteria:** scheduled for elective surgery under general anaesthesia, ASA I or II, aged 18 to 60 years **Exclusion criteria:** hypertension, lung disease, cardiovascular disease, cervical spine disease, gastro-oesophageal reflux disease, predicted difficult intubation/laryngoscopy, history of regular drug intake, allergy to anaesthetic medications, oxygen desaturation during intubation ≤ 94%, intubation failures **Baseline characteristics:** **GlideScope** *Age*: 36.1 (SD ± 11.6) *Gender M/F*: 20/26 *Height (cm)*: 167.5 (SD ± 8.9) *Weight (kg)*: 69.7 (SD ± 9.1) *BMI (kg/m^2):* 24.9 (SD ± 3.5) **Macintosh** *Age*: 33.7 (SD ± 10.6) *Gender M/F*: 18/31 *Height (cm)*: 165.9 (SD ± 7.5) *Weight (kg)*: 66.2 (SD ± 9.8) *BMI (kg/m^2):* 24.1 (SD ± 3.3) **Country:** Iran **Setting:** hospital
Interventions	GlideScope (n = 46) vs Macinotsh (n = 49) Macintosh blade #3 for women and #4 for men
Outcomes	*Continuous outcome:* Time for tracheal intubation: defined as time from insertion of scope until tracheal tube positioned between vocal cords *Dichotomous outcome:* Intubation failure: defined as more than one attempt needed to achieve successful intubation, intubations needing > 30 seconds, need for another person to complete the procedure
Notes	*Funding/declarations of interest:* supported in part by grant from Iran University of Medical Sciences *Additional:* study aimed to consider haemodynamic changes, but also reported on relevant outcomes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Comment: generated by random allocation table in permutated blocks of 4

Pournajafian 2014 (*Continued*)

Allocation concealment (selection bias)	Low risk	Quote: "The numbered opaque sealed envelopes that contained patient allocation were opened at the time of randomization"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: study exclusion criteria were such that some patients were excluded because of intubation failure. For this review, we included in our outcome data the number of excluded patients due to intubation failure
Selective reporting (reporting bias)	Unclear risk	Comment: clinical trials identification number supplied (IRCT201111264969N4) but protocol not sourced
Experience of intubator	Low risk	Comment: about 4 years' experience with Macintosh and 20 successful intubations with GlideScope
Baseline characteristics	Low risk	Comment: comparable baseline characteristics
Funding sources	Unclear risk	Comment: supported in part by grant from Iran University of Medical Sciences

Robitaille 2008

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 20 **Inclusion criteria:** scheduled to undergo an elective interventional neuroradiological procedure under general anaesthesia **Exclusion criteria:** incapable of informed consent, clinical or radiological evidence of C-spine abnormalities, requiring rapid sequence induction or an induction without a neuromuscular blocking drug **Baseline characteristics:** None reported **Country:** Canada

Robitaille 2008 (*Continued*)

	Setting: hospital
Interventions	GlideScope vs Macintosh GlideScope blade size "large"; Macintosh blade #3 or #4
Outcomes	*Dichotomous outcome*: CL glottic view: 1 to 3
Notes	*Experience of intubator*: all intubations were performed by 2 senior anaesthesiology residents who had performed both laryngoscopy techniques at least 30 times at the beginning of the study *Funding/declarations of interest:* none apparent *Additional:* a trained assistant, positioned at the participant's head, maintained MILS of the C-spine throughout airway manoeuvres by grasping the mastoid processes bilaterally with the fingertips while cupping the occiput in the palms of the hands Study powered as comparison of spine movement during intubation with MILS, but has relevant outcomes Long study period with few participants

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "randomization table"
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "of blinding, since both the operators performing the laryngoscopies and the image assessors knew which technique was being executed, blinding being impossible to perform in the former and extremely difficult to achieve in the latter" Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "All intubations were performed by two senior anesthesiology residents...having performed both laryngoscopy techniques at

Robitaille 2008 (*Continued*)

		least 30 times at the beginning of the study"
Baseline characteristics	Unclear risk	Comment: none reported
Funding sources	Low risk	Comment: none apparent

Russell 2012

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 29 **Inclusion criteria:** ASA I or II, aged over 18 years, undergoing elective surgical procedures requiring tracheal intubation **Exclusion criteria:** rapid sequence intubation or another intubation method indicated; known or suspected oral, pharyngeal or laryngeal masses; poor dentition, symptomatic gastro-oesophageal reflux, cervical spine instability, unstable hypertension, coronary artery disease, cerebral disease or asthma; resources not available for procedure to be conducted on the scheduled date of surgery **Baseline characteristics:** not reported by group because of cross-over design *Age*: 47.9 (SD ± 14.4) *Gender M/F*: 14/9 *BMI < 30/30-35 kg/m^2:* 19/4 *ASA I*: 12 *ASA II*: 11 *Mallampati 1*: 7 *Mallampati 2*: 11 *Mallampati 3*: 5 **Country:** Canada **Setting:** hospital
Interventions	GlideScope vs Macintosh Macintosh blade #3, GlideScope blade size unknown
Outcomes	*Continuous outcome*: Time for tracheal intubation *Dichotomous outcome*: Successful first attempt
Notes	*Experience of intubator:* anaesthesia staff that included specialists, fellows and third- and fifth-year anaesthesia trainees with experience in using the GlideScope on more than 25 occasions *Funding/declarations of interest:* none apparent *Additional:* stylets used for both

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Russell 2012 (*Continued*)

Random sequence generation (selection bias)	Low risk	Comment: computer-generated codes used
Allocation concealment (selection bias)	Unclear risk	Comment: randomization codes revealed before induction, but no additional details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Comment: personnel with varying levels of anaesthetic experience. All had experience in using GlideScope on more than 25 occasions
Baseline characteristics	Unclear risk	Comment: cross-over design, characteristics not presented in groups
Funding sources	Low risk	Comment: none apparent

Russell 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 70 **Inclusion criteria:** aged over 18 years, undergoing elective surgical procedures requiring endobronchial intubation with a left-sided DLT **Exclusion criteria:** history of previous failed or difficult tracheal intubation, difficult tracheal intubation anticipated (2 risk factors of Mallampati score $\geq$ 3, incisor gap < 3. 5 cm, thyromental distance < 6.5 cm, reduced neck extension and flexion), alternative method of tracheal intubation indicated (e.g. rapid sequence intubation), contraindication to a left DLT, contraindication to 1-lung ventilation, anticipated difficult bag-mask ventilation of the lungs, BMI > 40 kg/m^2 **Baseline characteristics:** **GlideScope** *Age*: 59 (SD ± 12) *Gender M/F*: 15/20 *BMI*: 26 (SD ± 5) *ASA II*: 8

	ASA III: 24 *Mallampati 1*: 15 *Mallampati 2*: 13 *Mallampati 3*: 7 **Macintosh** *Age*: 62 (SD ± 14) *Gender M/F*: 18/17 *BMI*: 26 (SD ± 4) *ASA II*: 5 *ASA III*: 29 *Mallampati 1*: 22 *Mallampati 2*: 11 *Mallampati 3*: 2 **Country:** Canada **Setting:** hospital
Interventions	GlideScope vs Macintosh Macintosh and GlideScope blade size unknown
Outcomes	*Continuous outcome:* Time for tracheal intubation *Dichotomous outcomes*: Failed intubation Laryngeal/airway trauma Patient-reported sore throat Successful first attempt Difficulty of intubation (use of numerical rating scale ranging from 1 (none) to 10 (severe))
Notes	*Experience of intubator:* study centre performs more than 1500 thoracic cases per annum, and the GlideScope has been the primary video-laryngoscope since 2001. All anaesthetists were specialists or fellows who regularly perform thoracic anaesthesia and regularly use the GlideScope for tracheal intubation. However, most staff had used the GlideScope for DLT insertion only around 3 to 6 times *Funding/declarations of interest:* none apparent *Additional:* stylet used to shape DLT to replicate GlideScope or Macintosh blades, dependent on device used See also abstract reports of same study (Van Rensburg 2013a and Van Rensburg 2013b) . In these abstracts, study authors reported duration of first intubation as GlideScope 77 seconds (44) compared with Macintosh 51 seconds (61). They do not state whether this is a mean value (SD). Also in these abstracts, study authors stated different percentages for success of first intubation (74% vs 88%, unclear which figure relates to which scope) . For the purpose of this review, we have taken data from the full report, not from the abstracts

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Russell 2013 (*Continued*)

Random sequence generation (selection bias)	Low risk	Quote: "Randomisation was computer-generated"
Allocation concealment (selection bias)	Unclear risk	Quote: "revealed to the anaesthetist and research staff after the airway assessment and immediately before induction of anaesthesia" Comment: additional details required
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors for some reported outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses after randomization
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	High risk	Comment: operators were experienced in use of both laryngoscopes but had very limited experience with a GlideScope blade for DLT intubations
Baseline characteristics	Low risk	Quote: "Baseline characteristics and preoperative airway assessments were similar in both groups"
Funding sources	Low risk	Comment: none apparent

Sandhu 2014

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 200 **Inclusion criteria:** undergoing elective surgery under general anaesthesia **Exclusion criteria:** no details **Baseline characteristics:** No details, described as comparable in both groups **Country:** India **Setting:** hospital
Interventions	GlideScope (N = 100) vs Macintosh (N = 100)

Sandhu 2014 (*Continued*)

Outcomes	*Continuous outcomes:* Time for tracheal intubation Improved visualization (POGO scores): scores taken initially with all participants and again at laryngoscopy attempt, which included intubation. This review used POGO scores from second laryngoscopy Intubation difficulty score: data presented as mean (SD): GlideScope 0.4 (± 0.7); Macintosh 1.2 (± 1.3), P < 0.05 *Dichotomous outcomes:* Number of attempts (no data presented in abstract) CL glottic view: study authors' quote: "the difference in CL grades during final laryngoscopy between the two groups was statistically highly significant (P < 0.001)". No data presented in abstract, not stated in which direction this result is significant Adverse events: study authors' quote: "the incidence of adverse events was similar in two groups (P > 0.05)". No data presented in abstract
Notes	*Funding/declarations of interest:* no details *Additional: a*bstract only

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Comment: participants described as randomly assigned, but no additional details in abstract
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: no details given but not possible to blind assessors to many included outcomes
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Comment: no details reported in abstract
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Comment: no details of experience reported in abstract
Baseline characteristics	Unclear risk	Comment: described as comparable but no data presented

Sandhu 2014 (*Continued*)

Funding sources	Low risk	Comment: no details reported in abstract, assumed no funding

Serocki 2010

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 120 **Inclusion criteria:** at least 18 years of age, ASA ≤ 3, ≥ 1 positive predictor of a difficult airway, Mallampati score ≥ 2 **Exclusion criteria:** refusal of participation, indication for rapid sequence induction, known difficult facemask ventilation **Baseline characteristics:** **Macintosh blade** *Height (cm):* 170 (SD ± 9) *Weight (kg):* 77(SD ± 17) *Age:* 66 (SD ± 13) *Gender M/F:* 21/19 *ASA I:* 3 *ASA II:* 23 *ASA III:* 14 *Mallampati 1:* 0 *Mallampati 2:* 23 *Mallampati 3:* 17 *Mallampati 4:* 0 **DCI video laryngoscope** *Height (cm):* 172 (SD ± 12) *Weight (kg):* 78 (SD ± 15) *Age:* 63 (SD ± 15) *Gender M/F:* 21/19 *ASA I:* 4 *ASA II:* 28 *ASA III:* 8 *Mallampati 1:* 0 *Mallampati 2:* 23 *Mallampati 3:* 16 *Mallampati 4:* 1 **GlideScope** *Height (cm):* 173 (SD ± 10) *Weight (kg):* 83 (SD ± 13) *Age:* 66 (SD ± 10) *Gender M/F:* 26/14 *ASA I:* 2 *ASA II:* 29 *ASA III:* 9 *Mallampati 1:* 0

Serocki 2010 (*Continued*)

	Mallampati 2: 22 *Mallampati 3:* 16 *Mallampati 4: 2* **Country:** Germany **Setting:** hospital
Interventions	Repeated laryngoscopy comparing Macintosh, Storz DCI laryngoscopy and GlideScope Macintosh blade #3 for male female, #4 for tall participants GlideScope standard adult/large blade used in all DCI fixed blade size
Outcomes	*Continuous outcome*: Time for tracheal intubation *Dichotomous outcomes*: Failed intubation Hypoxia No. of attempts: 1 to 3 CL glottic view: 1 to 4
Notes	*Experience of intubator*: investigation was carried out by 2 board-certified anaesthetists. Both were familiar with all the laryngoscopes investigated (50 intubations each) *Funding/declarations of interest:* videolaryngoscopes supplied by manufacturers

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "randomized sequence" Comment: no additional details
Allocation concealment (selection bias)	Unclear risk	Quote: "allocation of patients by opening of a sealed envelope" Comment: no additional details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "In total, 120 patients were enrolled in this study; none had to be excluded for data analysis"
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought

Serocki 2010 (*Continued*)

Experience of intubator	Low risk	Quote: "The investigation was carried out by two board-certified anaesthetists... Both were familiar with all the laryngoscopes investigated (≥ 50 intubations each)"
Baseline characteristics	Unclear risk	Quote: "There were no significant differences between groups with regard to patients' characteristics and predictors of a difficult airway" Comment: more male participants in GlideScope group, and higher mean weight reported for this group. Impact of these differences is uncertain
Funding sources	Unclear risk	Comment: videolaryngoscopes supplied by manufacturers

Serocki 2013

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 96 **Inclusion criteria:** scheduled for elective ENT surgery requiring tracheal intubation, ≥ 1 of the following: Mallampati score ≥ 2, reduced mobility of the atlanto-occipital joint (≤ 15°), mouth opening < 4 cm, thyromental distance < 6 cm **Exclusion criteria:** refusal of participation, age < 18 years and ASA > III, indication for rapid sequence induction, known difficult facemask ventilation, hypopharyngeal or laryngeal tumours with risk of bleeding or swelling **Baseline characteristics:** **GlideScope** *Age*: 59 (SD ± 13) *Gender M/F*: 8/24 *Height (cm)*: 177 (SD ± 11) *Weight (kg)*: 81 (SD ± 14) *ASA I*: 0 *ASA II*: 21 *ASA III*: 11 *Mallampati 1*: 1 *Mallampati 2*: 16 *Mallampati 3*: 13 *Mallampati 4*: 2 **Macintosh** *Age*: 59 (SD ± 16) *Gender M/F*:16/16 *Height (cm)*: 171 (SD ± 94) *Weight (kg)*: 76 (SD ± 16) *ASA I*: 2 *ASA II*: 19

	ASA III: 11 *Mallampati 1*: 0 *Mallampati 2*: 20 *Mallampati 3*: 9 *Mallampati 4*: 3 **C-MAC D-blade** *Age*: 51 (SD ± 19) *Gender M/F*: 7/25 *Height (cm)*: 176 (SD ± 10) *Weight (kg)*: 81 (SD ± 17) *ASA I*: 3 *ASA II*: 21 *ASA III*: 8 *Mallampati 1*: 1 *Mallampati 2*: 16 *Mallampati 3*: 11 *Mallampati 4*: 4 **Country:** Germany **Setting:** hospital
Interventions	**Intervention characteristics:** Randomized repeated laryngoscopy was performed with Macintosh, GlideScope and C-MAC D-Blade. Intubation with final device Macintosh #3 blade was used routinely for female and male participants; blade #4 was used only for tall individuals GlideScope large blade was used in all intubations. C-MAC D-blade was used in all intubations. Additional difficult airway equipment: stylets were used. In hockey stick shape for GlideScope and C-MAC, moderate curve for Macintosh
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from touching ETT to inflating cuff *Dichotomous outcomes*: Failed intubation CL glottic view: 1 to 4 Successful first attempt No. of attempts: 1 to 3
Notes	*Experience of intubator*: investigation was carried out by 3 board certified anaesthetists familiar with all laryngoscopes (> 50 intubations each) *Funding/declarations of interest:* Volker Doerges (study author) reported his membership in the Karl Storz advisory board and involvement in the development of C-MAC. Also, manufacturers supplied the scopes

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Serocki 2013 (*Continued*)

Random sequence generation (selection bias)	Unclear risk	Quote: "randomized sequence" Comment: no additional details of method used
Allocation concealment (selection bias)	Unclear risk	Quote: "sealed envelope" Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors for relevant outcomes
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: 1 participant excluded from GlideScope group owing to problems with facemask. No other exclusions
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "The investigation was carried out by three board certified anaesthetists...familiar with all laryngoscopes (≥ 50 intubations each)"
Baseline characteristics	Unclear risk	Quote: "Except for distribution between the sexes, there were no significant differences between groups regarding demographic data and predictors of a difficult airway" Comment: participants in C-MAC group slightly younger. Impact of this difference is uncertain
Funding sources	High risk	Comment: One study author is a member of the Karl Storz advisory board and was involved in the development of C-MAC. Also, manufacturers supplied the scopes

Shippey 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 50 **Inclusion criteria:** no details **Exclusion criteria:** no details **Baseline characteristics:**

Shippey 2013 (*Continued*)

	McGrath *Age*: 55.5 (SD ± 17.0) *Gender M/F*: 18/7 *BMI*: 27 (SD ± 4.2) **Macintosh** *Age*: 52.7 (SD ± 14.3) *Gender M/F*: 15/10 *BMI*: 29.2 (SD ± 4.9) **Country:** UK **Setting:** hospital
Interventions	McGrath vs Macintosh in parallel trial Type of McGrath device not specified in abstract Blade sizes not specified
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from insertion of laryngoscope to first appearance of carbon dioxide on capnograph trace *Dichotomous outcomes*: Failed intubation Successful first attempt No. of attempts: 1 to 3
Notes	*Funding/declarations of interest:* none apparent *Additional:* cervical spine immobilisation maintained with rigid cervical collar Abstract only

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "single-blinded, randomised controlled trial" Comment: no details. Abstract only
Allocation concealment (selection bias)	Unclear risk	Comment: no details. Abstract only
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Comment: no details. Abstract only
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought

Shippey 2013 (*Continued*)

Experience of intubator	Unclear risk	Comment: no details
Baseline characteristics	Low risk	Comment: comparable baseline characteristics
Funding sources	Low risk	Comment: none apparent

Siddiqui 2009

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 40 **Inclusion criteria:** ASA I or II, normotensive patients, aged 18 to 65 years, scheduled for elective surgery requiring tracheal intubation **Exclusion criteria:** receiving medications known to affect blood pressure or heart rate, Mallampati classification 3 or 4, anticipated difficult airway **Baseline characteristics:** **GlideScope** *Age*: 38.9 (SD ± 10.9) *Gender M/F*: 17/3 *BMI*: 26.6 (SD ± 4.1) **Macintosh** *Age*: 43.7 (SD ± 16.1) *Gender M/F*: 9/11 *BMI*: 25.0 (SD ± 3.8) **Country:** Canada **Setting:** hospital
Interventions	GlideScope vs Macintosh Macintosh #3 blade used GlideScope blade not specified Stylet was used to stiffen tracheal tube to conform with the angle of the blade for the GlideScope group. No external manipulation of the larynx was performed in either group
Outcomes	*Continuous outcomes*: Number of attempts Time for tracheal intubation: defined as time from insertion of intubating device into the oral cavity to inflation of the endotracheal tube cuff *Dichotomous outcomes*: Failed intubation Patient-reported sore throat (graded as none (no sore throat), moderate (similar to that noted with a cold) and severe (more severe than a cold)) Hoarseness graded as none (no hoarseness), moderate (obvious to observer) and severe (aphonia)

Notes	*Experience of intubator*: Intubations were performed by a single anaesthetist who had performed more than 50 intubations with each device and was well experienced in all 3 techniques of tracheal intubation *Funding/declarations of interest:* none apparent *Additional:* a Trachlight was included in this study, although data were not recorded, as Trachlight did not meet our criteria

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "a computerized random-number generator"
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "An unblinded observer noted the number of intubation attempts" Quote: "The severity of postoperative sore throat and hoarseness were assessed in the recovery room by a second observer blinded to the intubation technique" Comment: attempts made by investigators to blind outcome assessors when possible; however, not possible to blind assessors to primary outcome of failed intubation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "All 60 patients were successfully intubated" Comment: no losses reported in CONSORT diagram
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "Intubations were performed by a single anaesthesiologist, who had performed more than 50 intubations with each device and is well experienced in all three techniques of tracheal intubations"
Baseline characteristics	Unclear risk	Quote: "There was a statistically significant difference in sex distribution among the groups with more men in the GlideScope group"

Siddiqui 2009 (*Continued*)

		Comment: unclear how this difference may have affected the results
Funding sources	Low risk	Comment: none apparent

Sun 2005

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 200 **Inclusion criteria:** presenting for surgery requiring tracheal intubation **Exclusion criteria:** raised intracranial pressure, known airway pathology or cervical spine injury, requiring rapid sequence induction **Baseline characteristics:** **GlideScope** *Age*: 52 (range 20-87) *Gender M/F*: 32/68 *Height (cm)*: 166 (SD ± 12) *Weight (kg)*: 75 (SD ± 21) *ASA I*: 27 *ASA II*: 44 *ASA III & IV*: 24 *Mallampati 1*: 52 *Mallampati 2*: 36 *Mallampati 3*: 11 *Mallampati 4*: 1 **Macintosh** *Age*: 54 (range 20-87) *Gender M/F*: 38/62 *Height (cm)*: 165 (SD ± 12) *Weight (kg)*: 73 (SD ± 17) *ASA I*: 26 *ASA II*: 45 *ASA III & IV*: 21 *Mallampati 1*: 50 *Mallampati 2*: 41 *Mallampati 3*: 9 *Mallampati 4*: 0 **Country:** Canada **Setting:** hospital
Interventions	GlideScope vs Macintosh #3 Macintosh blade used GlideScope size not mentioned
Outcomes	*Continuous outcome*: Time for intubation: defined as time from insertion of device until end-tidal carbon dioxide was detected

	Dichotomous outcomes: Failed intubation: defined as failure after 3 attempts, then change to another blade Successful first attempt No. of attempts: 1 and > 1 CL glottic view: 1 to 4
Notes	*Experience of intubator:* intubations were performed by 5 different anaesthetists, all of whom were experienced in anaesthesia (> 10 years' experience) and use of the GlideScope (20 intubations) before the study *Funding/declarations of interest:* none *Additional:* after approximately 3 minutes, all participants underwent an initial direct laryngoscopy, which was scored according to the CL grading system with the Macintosh laryngoscope and a size 3 blade. This was performed by a separate anaesthetist, who was neither 1 of the intubators nor involved with the participant's overall care. Then participants were allocated to randomized groups for intubation with given scope

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "patients were allocated by computer-generated randomization in blocks of six"
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Five patients from the pilot study were excluded from the nal TTI (*time to intubate)* analysis. Four of these patients required multiple attempts at intubation, and the recorded TTI included interim bag-and-mask time and did not re ect true intubation time; one of these patients was in the DL group (*Macintosh)* (C&L grade 2) and three were in the GS group (*Glidescope)* (one each of C&L grade 1, 2, and 3)" Comment: only small number of exclusions; unlikely to affect results and full explanations given
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought

Sun 2005 (*Continued*)

Experience of intubator	Low risk	Quote: "The intubations were performed by five different anaesthetists, all of whom were experienced in anaesthesia (> 10 yr experience) and the use of the GlideScope (> 20 intubations) prior to the study"
Baseline characteristics	Low risk	Quote: "Patient characteristics and the airway parameters were similar in the two groups"
Funding sources	Low risk	Comment: none

Suzuki 2008

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 200 **Inclusion criteria:** scheduled for elective anaesthesia **Exclusion criteria:** no details given. Abstract only **Baseline characteristics:** No details given in abstract. Study authors state, "Patient profiles such as height and body weight were similar in both groups" **Country:** Japan **Setting:** hospital
Interventions	Pentax AWS vs Macintosh (denominator figures not given by group)
Outcomes	*Continuous outcome*: Time for tracheal intubation: no definition given. AWS 19 seconds (SD ± 9); Macintosh 18 seconds (SD ± 8) *Dichotomous outcome*: Successful first attempt: "All intubations were successful at the first attempt"; however, numbers of participants per group not provided
Notes	*Funding/declarations of interest:* departmental funding only (response to email request) *Additional:* abstract only. Email request sent to study authors to request additional information; responses noted in risk of bias table

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "were randomly assigned to group" Comment: insufficient details

Suzuki 2008 (*Continued*)

Allocation concealment (selection bias)	Unclear risk	Comment: use of sealed envelope technique (response to email request). Insufficient detail
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: data analysed by independent assessor (response to email request) but assumed that people measuring outcomes were not blinded
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Comment: no details
Selective reporting (reporting bias)	Unclear risk	Comment: no details
Experience of intubator	Low risk	Comment: experience of at least 100 intubations with the Macintosh and 50 intubations with the Pentax AWS (response to email request)
Baseline characteristics	Unclear risk	Comment: no baseline characteristics reported
Funding sources	Low risk	Comment: departmental funding only (response to email request)

Takenaka 2011

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 69 **Inclusion criteria:** ASA I to III, scheduled for elective non-obstetrical surgery in the lateral position requiring general anaesthesia with tracheal intubation **Exclusion criteria:** BMI > 30 kg/m^2, cervical spine abnormality, pharyngolaryngeal disorder, anticipated difficult airway, increased risk of aspiration **Baseline characteristics:** **Pentax AWS** *Age*: 68.3 (range 30-83) *Gender M/F*: 12/23 *Height (cm)*: 156 (SD ± 9) *Weight (kg)*: 55.9 (SD ± 12.1) **Macintosh** *Age*: 67.6 (range 32-88) *Gender M/F*: 8/26

Takenaka 2011 (*Continued*)

	Height (cm): 154 (SD ± 9) *Weight (kg)*: 55.0 (SD ± 12.8) **Country:** Japan **Setting:** hospital
Interventions	Pentax AWS (n = 35) vs Macintosh (n = 34) External laryngeal manipulation and adjustment of participant's head and neck position were performed as necessary Stylet was used for intubation in the Macintosh group
Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation. Intubation difficulty score as median (IQR range): VLS 0 (0-0); Mac 0 (0-2) Time for tracheal intubation: defined as time from insertion of blade between the teeth until tracheal tube cuff was passed through vocal cords. Median (IQR range): VLS 14 (9-19), Mac 29 (20-31) *Dichotomous outcomes*: Failed intubation: defined as failure to intubate within 60 seconds. Required intubation with alternative device or change to lateral position Successful first attempt No. of attempts: 1 CL glottic view: 1 to 3
Notes	*Experience of intubator*: 2 anaesthetists experienced more than 5000 intubations with the Macintosh laryngoscope and more than 300 intubations with the AWS in the supine position. However, as they had few experiences in the lateral position, they practised tracheal intubation in this position with a mannequin *Funding/declarations of interest:* departmental funding only *Additional:* all participants in lateral position for intubation

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "patients were randomly assigned into two groups using a sealed envelope technique" Comment: insufficient detail
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors

Takenaka 2011 (*Continued*)

Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: only 1 loss after randomization due to cancellation of surgery
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Unclear risk	Comment: 2 anaesthetists experienced with both laryngoscopes in the supine position. Although they had fewer experiences in the lateral position, they had practised intubation in this position with a mannequin
Baseline characteristics	Unclear risk	Quote: "There were no significant differences in demographic data" Comment: some differences noted in ratio of male to female participants. Impact of these differences is uncertain
Funding sources	Low risk	Comment: departmental funding only

Taylor 2013

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 88 **Inclusion criteria:** ASA I or II, scheduled for elective surgery under general anaesthesia requiring tracheal intubation **Exclusion criteria:** required rapid sequence induction, history of previous difficult direct laryngoscopy and required awake tracheal intubation, unable or unwilling to provide informed consent, uncontrolled hypertension, history of ischaemic heart disease without optimal control of symptoms, history of acute or recent stroke or myocardial infarction, cervical spine instability or cervical myelopathy, symptomatic asthma or reactive airway disease requiring daily pharmacological treatment for control of symptoms, history of gastric reflux **Baseline characteristics:** **McGrath Series 5** *Age*: 52 (SD ± 13) *Gender M/F*: 18/26 *BMI*: 29.3 (SD ± 6.5) *ASA I*: 22 *ASA II*: 22 *Mallampati 1*: 14 *Mallampati 2*: 22 *Mallampati 3*: 7 *Mallampati 4*: 1 **Macintosh**

Taylor 2013 (*Continued*)

	Age: 54 (SD ± 16) *Gender M/F*: 20/24 *BMI*: 28.2 (SD ± 6.2) *ASA I*: 13 *ASA II*: 31 *Mallampati 1*: 24 *Mallampati 2*: 17 *Mallampati 3*: 2 *Mallampati 4*: 1 **Country:** Canada **Setting:** hospital
Interventions	McGrath Series 5 (n = 44) vs Macintosh (n = 44) McGrath blade equivalent to #3; Macintosh blade #3 Stylet used in all participants Cross-over groups labels: McGrath = Macintosh then McGrath; Macintosh = McGrath then Macintosh
Outcomes	*Continuous outcomes*: Improved visualization (POGO: 82 (23) for McGrath; 13 (23) for Macintosh) Time for tracheal intubation: defined as time from insertion of the laryngoscope into the oral cavity until its removal *Dichotomous outcomes*: Failed intubation (tracheal tube could not be placed owing to difficulty viewing the glottis) Laryngeal/airway trauma (mucosal bleeding) Patient-reported sore throat Successful first attempt CL glottic view: 1 to 4
Notes	*Experience of intubator*: each of the consultant anaesthetists involved in the study had previously practised with the McGrath video laryngoscope using a manikin until subjectively comfortable with the device *Funding/declarations of interest:* departmental funding. McGrath scopes supplied by Vitaid Canada. One investigator is a consultant for a McGrath distributor *Additional:* manual in-line stabilization used to simulate difficult airway

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Comment: no details
Allocation concealment (selection bias)	Unclear risk	Quote: "A sealed envelope was opened, revealing to which of two study groups the patient had been randomly assigned" Comment: no further details

Taylor 2013 (*Continued*)

Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: assumed other outcome assessors not blinded to devices used
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no apparent losses
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	High risk	Quote: "Each of the consultant anaesthetists involved in the study had previously practised with the McGrath videolaryngoscope using a manikin until subjectively comfortable with the device" Comment: assumed therefore that experience was greater in Macintosh group
Baseline characteristics	Unclear risk	Comment: some differences in ASA scores and Mallampati scores - unclear how this might affect the results. Otherwise baseline characteristics comparable
Funding sources	High risk	Comment: departmental funding. McGrath scopes supplied by Vitaid Canada. One investigator is a consultant for a McGrath distributor

Teoh 2010

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 400 **Inclusion criteria:** scheduled for elective gynaecological, orthopaedic, breast or aesthetic surgery in tertiary maternity and women's hospital, consented to general anaesthesia and tracheal intubation **Exclusion criteria:** pregnant, ASA IV, aged < 21 or > 80 years, weight < 30 kg, BMI > 40 kg/m^2, limited mouth opening (< 2.5 cm), respiratory tract pathology, preoperative sore throat, high risk of regurgitation or aspiration, allergy to any study medication **Baseline characteristics:** **GlideScope** *Age*: 43.4 (SD ± 11.2) *Height (cm)*: 157.1 (SD ± 6.5) *Weight (kg)*: 61.1 (SD ± 11.8)

Teoh 2010 (*Continued*)

	BMI: 24.7 (SD ± 4.6) *Mallampati 1*: 28 *Mallampati 2*: 43 *Mallampati 3*: 26 *Mallampati 4*: 3 **Pentax AWS** *Age*: 37.0 (SD ± 10.5) *Height (cm)*: 158.2 (SD ± 6.3) *Weight (kg)*: 59.7 (SD ± 13.9) *BMI*: 23.7 (SD ± 5.2) *Mallampati 1*: 48 *Mallampati 2*: 35 *Mallampati 3*: 17 *Mallampati 4*: 0 **C-MAC** *Age*: 41.5 (SD 12.3) *Height (cm)*: 157.9 (SD 6.2) *Weight (kg)*: 60.7 (SD 14.1) *BMI*: 24.3 (SD 5.6) *Mallampati 1*: 52 *Mallampati 2*: 33 *Mallampati 3*: 12 *Mallampati 4*: 3 **Macintosh** *Age*: 39.6 (SD ± 9.9) *Height (m)*: 157.4 (SD ± 5.7) *Weight (kg)*: 58.87 (SD ± 12.7) *BMI*: 23.6 (SD ± 4.2) *Mallampati 1*: 46 *Mallampati 2*: 32 *Mallampati 3*: 19 *Mallampati 4*: 3 **Country:** Singapore **Setting:** tertiary maternity and women's unit
Interventions	GlideScope (n = 100) vs Pentax AWS (n = 100) vs C-MAC (n = 100) vs Macintosh (n = 100) For participants assigned to GlideScope, tracheal tube was preloaded with the manufacturer's preconfigured stylet; if intubation after first or second attempt was not feasible with the Airway Scope, C-MAC or conventional Macintosh laryngoscope, use of a stylet or bougie was left to the preference of the anaesthetist
Outcomes	*Continuous outcomes*: Difficulty of tracheal intubation, ease of insertion of the blade and tracheal tube (as subjectively assessed from 0: easy, to 100: difficult): median (IQR (range)): AWS 0 (0-8.75 (0-60)); C-MAC 10 (0-20 (0-90)); GlideScope 0 (0-20 (0-80)); Macintosh 0 (0-20 (0-90)) Improved visualization: quality of the view (subjectively assessed from 0: good, 100: bad) Time for tracheal intubation: defined as interval from insertion of the laryngoscope blade

Teoh 2010 (*Continued*)

	into the mouth to inflation of the tracheal tube cuff *Dichotomous outcomes*: Failed intubation: required more than 3 attempts, or exceeded 120 seconds Laryngeal/airway trauma (mucosal bleeding, lip bleeding, dental trauma) Patient-reported sore throat: postoperative sore throat and above laryngeal/airway trauma recorded in recovery room Hypoxia Successful first attempt No. of attempts: 1 to 3 CL glottic view: 1 to 4
Notes	*Experience of intubator*: all intubations were performed by experienced anaesthetists who had performed > 30 intubations with each of the devices being tested *Funding/declarations of interest:* no external funding

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "computer-generated random number table"
Allocation concealment (selection bias)	Low risk	Quote: "After recruitment, the enrolling investigator opened a sealed opaque envelope that concealed group allocation in the anaesthetic induction room"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Participants were blinded to their group allocation" Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Quote: "An independent data collector recorded the observed manoeuvres used to optimise the laryngeal view" Comment: some outcomes assessed by independent observer, but not possible for observer to be blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Four hundred patients were successfully recruited and there were no drop-outs"
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "All intubations were performed by experienced anaesthetists who had performed > 30 intubations with each of the devices being tested"

Teoh 2010 (*Continued*)

Baseline characteristics	Unclear risk	Comment: most baseline characteristics comparable. Some differences in Mallampati scores in GlideScope and C-MAC groups - unclear how this might affect the results
Funding sources	Low risk	Comment: no external funding

Turkstra 2005

Methods	Randomized controlled trial Cross-over
Participants	**Total number of participants:** 18 **Inclusion criteria:** ASA physical status I to III, age 18 to 75 years, elective non-cardiac surgery requiring general anaesthesia with endotracheal intubation **Exclusion criteria:** gastro-oesophageal reflux disease, body mass index > 35 kg/m^2, possibility of pregnancy, previous neck surgery, unstable C-spine, difficult airway **Baseline characteristics:** **GlideScope and Macintosh** *Age*: 40 (SD ± 13) *Gender M/F*: 5/13 *Height (cm)*: 167 (SD ± 8) *Weight (kg)*: 70 (SD ± 14) *ASA I*: 3 *ASA II*: 12 *ASA III*: 3 *Mallampati 1*: 8 *Mallampati 2*: 8 *Mallampati 3*: 1 *Mallampati 4*: 1 **Country:** Canada **Setting:** hospital
Interventions	GlideScope and Macintosh
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined from time when the blade or stylet passed the central incisors to when the ETT was positioned at the vocal cords
Notes	*Experience of intubator*: all laryngoscopies were performed by 1 person to minimize interoperator variability. Before this study, intubator had performed > 50 intubations with the GlideScope and > 500 intubations with the Macintosh laryngoscope *Funding/declarations of interest:* supported, in part, by the 2004 Canadian Anesthesia Society *Additional:* this study included a Lightwand group, which was not included in this analysis. Fluoroscopic study but with relevant outcomes for tracheal intubation time; therefore included. While awake, participants were placed on the operating room table

Turkstra 2005 (*Continued*)

	with a rigid board under their torso to simulate field spinal precautions, or on the table on which trauma patients are placed in the emergency room. Manual in-line stabilization was then simulated by taping the patient's head into the Mayfield horseshoe. The head was taped circumferentially around the forehead

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Comment: use of computer-generated numbers
Allocation concealment (selection bias)	Unclear risk	Quote: "sealed envelopes" Comment: no additional details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors for the relevant outcome measured
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Near the end of the study, the radiology department suffered simultaneous failure of the main and back-up servers, and data for 11 patients were lost. As a result, an additional 7 patients were recruited before analysis, allowing 36 patients to be analyzed in the groups assigned" Comment: explanation given for losses; additional recruitment attempted
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "All laryngoscopies were performed by one person to minimize interoperator variability. Before this study, (*intubator*) had performed 50 intubations with..the GlideScope and 500 intubations using the Macintosh laryngoscope"
Baseline characteristics	Unclear risk	Comment: cross-over study; baseline characteristics not divided by group
Funding sources	Low risk	Comment: supported, in part, by the 2004 Canadian Anesthesia Society

Walker 2009

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 120 **Inclusion criteria:** aged 18 years, undergoing elective surgery, anaesthesia plan consisting of routine tracheal intubation under general anaesthesia performed by a first-year trainee anaesthetist and supervised by a senior colleague **Exclusion criteria:** other intubation techniques planned, rapid sequence induction indicated **Baseline characteristics:** **McGrath Series 5** *Age*: Median 48 (range 21-84) *Gender M/F*: 17/43 *Height (m)*: median 1.66 (range 1.50-1.89) *Weight (kg)*: median 71.0 (range 50.0-116.4) *BMI*: median 25.7 (range 16.1-39.5) *Mallampati 1*: 29 *Mallampati 2*: 29 *Mallampati 3*: 2 *Mallampati 4*: 0 **Macintosh** *Age*: median 60.5 (range 21-84) *Gender M/F*: 19/41 *Height (m)*: median 1.64 (range 1.48-1.90) *Weight (kg)*: median 69.8 (range 44.0-106.5) *BMI*: median 25.2 (range 17.3-47.2) *Mallampati 1*: 32 *Mallampati 2*: 27 *Mallampati 3*: 1 *Mallampati 4*: 0 **Country:** Scotland **Setting:** hospital
Interventions	McGrath Series 5 vs Macintosh
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time between anaesthetist taking the laryngoscope in his hand until effective ventilation was initiated via the tracheal tube. Median (range): VLS 47.0 (25-202); Mac 29.5 (15-121) *Dichotomous outcomes*: Failed intubation Laryngeal/airway trauma (trama/blood in airway after intubation). However, 3 participants in the Macintosh group had undergone surgery, which could have accounted for blood at successful first attempt CL glottic view: 1 to 4
Notes	*Experience of intubator*: all 4 anaesthetists who performed tracheal intubation had undergone between 6 and 12 months of anaesthesia training during the study. All had achieved the Royal College of Anaesthetists initial competency in general anaesthesia with tracheal

	intubation and had also received training in use of the McGrath laryngoscope. This followed a standard competency-based model, initially with a manikin, followed by 10 successful intubations in clinical practice *Funding/declarations of interest:* none. Scopes bought with charitable foundation fund *Additional:* When a Macintosh laryngoscope was used, a stylet or other intubation aid was used at the discretion of the anaesthetist, as were other aspects of the anaesthetic protocol. A shaped stylet (Mallinckrodt satin slip intubating stylet) was inserted into the tracheal tube for intubation with the McGrath laryngoscope because the view of the glottis is indirect

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "The randomization sequence was generated in advance by the study's statistical advisor" Comment: insufficient details on how randomization was completed
Allocation concealment (selection bias)	Low risk	Quote: "Sequentially numbered opaque envelopes were used to conceal the sequence and were opened only on arrival of the patient in the anaesthetic room"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists. Study was described as single-blinded; therefore we have assumed participants were blinded
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "All patients in the Macintosh group were intubated successfully, but in one patient in the McGrath group, a Macintosh laryngoscope had to be used because of battery failure in the McGrath during intubation. Time to intubation was also not recorded for this patient owing to an error with the stopwatch"
Selective reporting (reporting bias)	Low risk	Comment: Clinical trial register protocol sourced (unique identifier: NCT00633867). Protocol outcomes comparable with study reported outcomes

Walker 2009 (*Continued*)

Experience of intubator	Unclear risk	Comment: all 4 anaesthetists had undergone 6 to 12 months of training to include manikin training in use of the McGrath blade. Unclear whether this is equivalent to use of the Macintosh
Baseline characteristics	Unclear risk	Quote: "Both groups were comparable apart from a greater median age in the Macintosh group (60.5 vs 48.0 yr)" Comment: Impact of this difference is uncertain; intubation may be more difficult with older participants in the Macintosh group
Funding sources	Low risk	Comment: no external funding. Scopes were bought with charitable foundation fund

Woo 2012

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 159 **Inclusion criteria:** aged 18 to 65, scheduled for regular escharectomy under general anaesthesia with a hypermetabolic state due to burn injury (occurring < 1 month from surgery), ASA II or III, second- or third-degree burns over 25% of body surface **Exclusion criteria:** loose teeth, craniocervical or cervical injury or malformation, arteriosclerosis, uncontrolled hypertension, myocardial infarction, cerebrovascular disease, class 4 of Mallampati, existing endotracheal intubation, bandages due to burns on the face or neck, difficulties in manual ventilation **Baseline characteristics:** **Pentax-AWS** *Age*: 45.5 (SD ± 10.4) *Gender M/F*: 37/13 *Height (cm)*: 167.0 (SD ± 9.3) *Weight (kg)*: 66.6 (SD ± 16.0) *ASA II*: 34 *ASA III*: 16 *Mallampati 1*: 8 *Mallampati 2*: 32 *Mallampati 3*: 10 *Type of surgery*: escharectomy **Macintosh** *Age*: 47.4 (SD ± 10.5) *Gender M/F*: 38/12 *Height (cm)*: 166.4 (SD ± 9.6) *Weight (kg)*: 65.9 (SD ± 11.5)

	ASA II: 37 *ASA III*: 13 *Mallampati 1*: 6 *Mallampati 2*: 29 *Mallampati 3*: 15 *Type of surgery*: escharectomy **Country:** Korea **Setting:** theatre
Interventions	Pentax-AWS vs Macintosh Macintosh blade #3 (for females) and #4 (for males) After second attempt, cricoid pressure was applied in Pentax group, and cricoid pressure and a stylet in Macintosh group
Outcomes	*Continuous outcome*: Time for tracheal intubation: defined as time from moment when the blade of the laryngoscope passed the incisor to moment when it was outside the oral cavity after endotracheal intubation) *Dichotomous outcomes*: Failed intubation Patient-reported sore throat (measured on 4-point scale including none, reported on asking, self-reported, affecting voice/hoarseness. For this review, data were transferred to dichotomous, sore throat or not. Measured at 24 hours postoperatively Successful first attempt No. of attempts: 1 to 3 Improved visualization: with POGO scale. Measured in units of 10%. VLS : 97% (SD ± 4%); Mac 48% (SD ± 29%)
Notes	*Experience of intubator*: all endotracheal intubations were performed by a resident in the Department of Anesthesiology & Pain Medicine who had more than 3 years of experience in endotracheal intubation with the Macintosh laryngoscope and had performed more than 50 procedures with the Pentax-AWS *Funding/declarations of interest:* none apparent *Additional*: In case of failure of the first attempt, second attempt was performed after manual ventilation with 100% oxygen for 30 seconds. After the second attempt, cricoid pressure was applied in Group P (Pentax-AWS). In Group M (Macintosh) after the second attempt, cricoid pressure and a stylet were used

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Quote: "simple random sampling with 50 subjects each group" Comment: concerns about randomization methods. Insufficient detail given. Paper says that an additional 59 were randomized to the Macintosh group

Woo 2012 (*Continued*)

Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: 59 participants from Macintosh group were excluded owing to failed intubation on first attempt; therefore, no data for sore throat or time outcomes
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Quote: "All endotracheal intubations were performed by a resident in the Department of Anesthesiology & Pain Medicine, with over 3 years of experience in endotracheal intubation using the Macintosh laryngoscope and with more than 50 procedures using the Pentax-AWS"
Baseline characteristics	High risk	Quote: "There were no differences in gender, age, height, body weight, ASA physical status classification, Mallampati class distribution, thyromental distance, range of burn injury, and the presence and the degree of sore throat 24 hours after operation between Group M and Group P (Table 1) " Comment: However, baseline data given only for 50 participants in each group. Not a total of 159. Number of participants reported does not match that throughout the study. Macintosh group was sometimes reported as including 109 participants and sometimes as including 50
Funding sources	Low risk	Comment: none apparent

Xue 2007

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 57 **Inclusion criteria:** adults, ASA I, scheduled for elective plastic surgery during general anaesthesia requiring orotracheal intubation **Exclusion criteria:** receiving medications known to affect blood pressure or heart rate, predicted difficult airways **Baseline characteristics:** **GlideScope** *Age*: 28.2 (SD ± 9.5) *Gender M/F*: 11/17 *Height (cm)*: 165.4 (SD ± 6.1) *Weight (kg)*: 61.4 (SD ± 11.9) **Macintosh** *Age*: 32.3 (SD ± 11) *Gender M/F*: 9/18 *Height (cm)*: 165.1 (SD ± 6.9) *Weight (kg)*: 61.7 (SD ± 13.6) **Country:** People's Republic of China **Setting:** hospital
Interventions	GlideScope vs Macintosh Macintosh #3 blade
Outcomes	*Continuous outcome*: Time for tracheal intubation: from termination of manual ventilation with a facemask to restart of ventilation through a tracheal tube *Dichotomous outcomes*: Failed intubation Successful first attempt No. of attempts: 1 to 3
Notes	*Experience of intubator*: all intubation procedures were performed by a single anaesthesiologist experienced in using a Macintosh and a GlideScope *Funding/declarations of interest:* none apparent *Additional:* External laryngeal compression was applied if necessary. After visualization of the glottis, a precurved styletted tracheal tube was inserted into the glottis. Two participants were excluded from statistical analysis of data, both from the GlideScope group; 1 case failed on the first attempt because of poor laryngeal view caused by fogging of the camera lens; the other case failed because of difficult immobilization of the GlideScope blade owing to the lubricant

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "allocated by a sequence of random numbers"

Xue 2007 (*Continued*)

		Comment: insufficient detail
Allocation concealment (selection bias)	Unclear risk	Comment: no details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetists
Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: 2 participants excluded from statistical analysis, with explanations provided
Selective reporting (reporting bias)	Unclear risk	Comment: published protocol not sought
Experience of intubator	Low risk	Comment: 1 anaesthetist experienced in both devices
Baseline characteristics	Low risk	Quote: "There were no significant differences in demographic data between the two groups"
Funding sources	Low risk	Comment: none apparent

Yeatts 2013

Methods	Randomized controlled trial Parallel group
Participants	**Total number of participants:** 623 **Inclusion criteria:** all patients who required tracheal intubation in the trauma resuscitation unit during the study period were assessed for eligibility. Indications for intubation followed Eastern Association for the Surgery of Trauma guidelines; included airway obstruction, hypoventilation, severe hypoxia, cognitive impairment (Glasgow Coma Scale score $\leq$ 8) and haemorrhagic shock. Altered mental status, combativeness and extreme pain were additional criteria **Exclusion criteria:** minors, suspected laryngeal trauma or extensive maxillofacial injury requiring an immediate surgical airway, known or strongly suspected spinal cord injury with awake flexible fibre-optic intubation indicated, cardiac arrest on arrival, those who died in the trauma resuscitation unit **Baseline characteristics:** **GlideScope** *Age*: 42 (range 18-119) *Gender M/F*: 216/87 **Macintosh** *Age*: 43 (range 18-94)

Yeatts 2013 (*Continued*)

	Gender M/F: 244/76 **Country:** Baltimore, Maryland, USA **Setting:** shock trauma centre
Interventions	GlideScope vs Macintosh No mention of blade sizes
Outcomes	*Continuous outcome*: Time for intubation: defined as interval between when the laryngoscope was inserted into the participant's mouth and when it was fully removed. Mean (95% confidence intervals) 71.0 (65.3-76.7); 56.5 (51.1-62) *Dichotomous outcomes*: Mortality (30 days) Successful first attempt
Notes	*Experience of intubator*: emergency medicine or anaesthesiology residents with a minimum of 1 year of previous intubation experience performed most procedures under the direct supervision of an attending trauma anaesthesiologist. Remaining intubations were performed by the attending anaesthesiologist or by a nurse anaesthetist under attending guidance *Funding/declarations of interest:* intramural research funding from University of Maryland School of Medicine Program in Trauma *Additional:* GlideScope had been in routine use at the study institution for 2 years before initiation of the trial. All participants were given rapid sequence induction Re: mortality data, study authors state, "When post hoc analysis was performed on a much smaller cohort of patients, there was an observed higher mortality rate for the subgroup of patients with severe head injuries (head AIS score > 3) who were randomized to intubation with GVL (*GlideScope)* (22 [30%] of 73) versus DL (*Macintosh)* (16 [14%] of 112) (p = 0.047). This association between mortality and use of the GlideScope remained significant even when controlling for patient characteristics such as admission physiology, mechanism of injury, and injury severity"

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Comment: no details other than "randomly assigned". A large number of exclusions followed randomization at the discretion of the anaesthetist. However, analysis confirmed lack of selection bias
Allocation concealment (selection bias)	Unclear risk	Comment: equipment and study forms (airway kit) were kept in the bag until participant was selected. Insufficient details
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: not possible to blind anaesthetist

Yeatts 2013 (*Continued*)

Blinding of outcome assessment (detection bias) All outcomes	High risk	Comment: not possible to blind outcome assessors
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: large number of participants excluded at anaesthetist's discretion
Selective reporting (reporting bias)	Low risk	Comment: protocol sourced and outcomes comparable with reported study outcomes. Clinical trials identifier: NCT01235065
Experience of intubator	Unclear risk	Comment: GlideScope had been in routine use at the institution for 2 years. All personnel had at least 1 year of experience in intubation. However, it is unclear from this description whether personnel had sufficient equivalent experience with the GlideScope
Baseline characteristics	Unclear risk	Comment: few baseline characteristics were reported
Funding sources	Low risk	Comment: intramural research funding from University of Maryland School of Medicine Program in Trauma

= number; ADS = airway difficulty score; AIS = abbreviated injury score; ASA = American Society of Anesthesiologists (physical status classification); BMI = body mass index; BURP = 'backwards, upwards, rightward pressure'; CABG = coronary artery bypass graft; CL *or* C & L = Cormack and Lehane (Cormack 1984); C-MAC/SBT = C-MAC device with straight blade; CRNA = certified registered nurse anaesthetist; DLT = double-lumen tube; ED = emergency department; ENT = ear, nose and throat; ETT = endotracheal intubation; HR = heart rate; ICU = intensive care unit; ID = identification; IDS = intubation difficulty score; IQR = interquartile range; Mac = Macintosh; MAP = mean arterial pressure; MET = metabolic equivalents; M/F = male/female; MILS = manual in-line stablilization; min/max = minimum/maximum; no. = number; PACU = postanaesthesia care unit; POGO = percentage of glottic opening; Q1, Q3 = quartile range 1, quartile range 3; SD = standard deviation; SIAARTI = The National Congress of the Italian Society of Anaesthesiology and Intensive Care Medicine; USA = United States of America; VAS = visual analogue scale; VLS = videolaryngoscope.

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
AhamdanechIdrissi 2011	Difference in lumen tubes between groups
Ali 2012	Airtraq study - no details of whether Airtraq was used with a camera device

(*Continued*)

Ali 2013	Paediatric population
Amor 2013	Airtraq study - no details of whether Airtraq was used with a camera device
Araki 2002	Bullard study - no details of whether Bullard was used as a videolaryngoscope
Arenkiel 2013	Not compared against a Macintosh blade
Arora 2013	Truview EVO2 study - no details of whether Truview EVO2 was used as a videolaryngoscope
Barak 2007	Truview EVO2 study - no details of whether Truview EVO2 was used as a videolaryngoscope
Burnett 2014	Not compared against a Macintosh blade
Byars 2011	Participants not undergoing general anaesthesia
Carlino 2009	Truview EVO2 study - no details of whether Truview EVO2 was used as a videolaryngoscope
Chalkeidis 2010	Airtraq study - no details of whether Airtraq was used with a camera device
Corso 2010	Airtraq study - no details of whether Airtraq was used with a camera device
DiMarco 2011	Airtraq study - no details of whether Airtraq was used with a camera device
Enomoto 2008a	Not compared against a Macintosh blade
Erden 2010	Airtraq study - no details of whether Airtraq was used with a camera device
Ferrando 2011	Airtraq study - no details of whether Airtraq was used with a camera device
Gaszynski 2009	Airtraq study - no details of whether Airtraq was used with a camera device
Gupta 2012	Not compared against a Macintosh blade
Hastings 1995	Bullard study - no details of whether a Bullard was used as a videolaryngoscope
Hayes 2011	Airtraq study - no details of whether Airtraq was used with a camera device
Hayes 2012	Airtraq study - no details of whether Airtraq was used with a camera device
He 2008	Participants not undergoing general anaesthesia
Hirabayashi 2006	Nasotracheal intubation
Hirabayashi 2007b	Does not include review outcomes

(*Continued*)

Hirabayashi 2007c	Nasotracheal intubation
Hirabayashi 2008a	Airtraq study - no details of whether Airtraq was used with a camera device
Hirabayashi 2009a	Nasotracheal intubation
Hirabayashi 2010	RCT, cross-over design. GlideScope vs Macintosh, patients with ASA I or II scheduled for gynaecological procedures. Does not report relevant review outcomes
Hirabayashi 2013a	Nasotracheal intubation
Hirabayashi 2013b	Nasotracheal intubation
Jones 2008	Nasotracheal intubation
Jones 2010	Not compared against a Macintosh blade
Koh 2010	Airtraq study - no details of whether Airtraq was used with a camera device
Lange 2009	Not compared against a Macintosh blade
Li 2007	Nasotracheal intubation
Maassen 2009	Not compared against a Macintosh blade
Maharaj 2006	Airtraq study - no details of whether Airtraq was used with a camera device
Maharaj 2007	Airtraq study - no details of whether Airtraq was used with a camera device
Maharaj 2008	Airtraq study - no details of whether Airtraq was used with a camera device
Mahjoubifar 2010	RCT, parallel design. GlideScope vs Macintosh (total N = 200). Does not measure relevant outcomes
Marco 2011	Airtraq study - no details of whether Airtraq was used with a camera device
Miner 2012	Not compared against a Macintosh blade
Moharari 2010	Nasogastric tube insertion
Mont 2012	Nasotracheal intubation
Ndoko 2008a	Airtraq study - no details of whether Airtraq was used with a camera device
Ng 2011a	Not compared against a Macintosh blade
Ng 2011b	Not compared against a Macintosh blade

(*Continued*)

Ng 2012	Not compared against a Macintosh blade
Park 2010	Airtraq study - no details of whether Airtraq was used with a camera device
Rai 2005	Not compared against a Macintosh blade
Ranieri 2012	Airtraq study - no details of whether Airtraq was used with a camera device
Ranieri 2014	Airtraq study - no details of whether Airtraq was used with a camera device
Sahin 2004	Not compared against a Macintosh blade
Sansone 2012	Airtraq study - no details of whether Airtraq was used with a camera device
Saxena 2013	Airtraq study - no details of whether Airtraq was used with a camera device
Smith 1999	WuScope study - fibreoptic not video device
Stumpner 2011	Airtraq study - no details of whether Airtraq was used with a camera device
Suzuki 2008a	Not compared against a Macintosh blade
Teoh 2009	Not compared against a Macintosh blade
Terradillos 2009	Airtraq study - no details of whether Airtraq was used with a camera device
Tolon 2012	Airtraq study - no details of whether Airtraq was used with a camera device
Trimmel 2011	Airtraq study - no details of whether Airtraq was used with a camera device
Turkstra 2009a	Airtraq study - no details of whether Airtraq was used with a camera device
Turkstra 2009b	Airtraq study - no details of whether Airtraq was used with a camera device
Vernick 2006	Abstract from 2006. Insufficient detail to include and no contact details for study author
Wang 2009	Airtraq study - no details of whether Airtraq was used with a camera device
Wasem 2013	Airtraq study - no details of whether Airtraq was used with a camera device
Watts 1997	Bullard study - no details of whether Bullard was used as a videolaryngoscope
Yang 2013	Unclear whether Optiscope was used with a video camera

ASA = American Society of Anesthesiologists (physical status classification); RCT = randomized controlled trial.

Characteristics of studies awaiting assessment *[ordered by study ID]*

Ahmad 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** adult patients, ASA I and II, normal intraocular pressure
Interventions	GlideScope vs Macintosh. Total N = 50
Outcomes	No relevant outcomes reported in abstract
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Ahmadi 2014

Methods	Randomized controlled trial Parallel design
Participants	**Included:** adult patients, normal intraocular pressure, scheduled for ophthalmic surgery requiring tracheal intubation
Interventions	GlideScope vs Macintosh. Total N = 50 but no denominator figures by group
Outcomes	Time to tracheal intubation
Notes	Abstract only with insufficient details. Awaiting publication of full text

Ahmadi 2015

Methods	Quasi-randomized controlled trial Parallel design
Participants	**Included:** patients requiring emergency intubation
Interventions	GlideScope vs Macintosh. Total N = 97
Outcomes	Success of intubation Successful first attempt Time to intubation
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Akbar 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients without features of difficult airway, requiring general anaesthesia and tracheal intubation
Interventions	C-MAC vs Macintosh. Total N = 90
Outcomes	CL grades Time to intubation Intubation attempts
Notes	MILS to simulate difficult airway Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Amini 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients undergoing elective caesarean section by general anaesthesia requiring tracheal intubation
Interventions	GlideScope vs Macintosh. Total N = 70
Outcomes	Time to intubation
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Bakshi 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients with normal airway
Interventions	Truview and McGrath Series 5 vs Macintosh. Total N = 126
Outcomes	Time to intubate Difficulty of intubation Failure to intubate
Notes	Anaesthetists divided into groups depending on level of experience Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Bhandari 2013

Methods	Randomized controlled trial Parallel design
Participants	**Included:** no details
Interventions	Airtraq vs Macintosh. Total N = 80
Outcomes	Time to intubate POGO Ease of intubation
Notes	Does not state in abstract whether Airtraq was used with video camera Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Bhat 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** ASA I or II without difficult airway
Interventions	C-MAC vs Macintosh. Total = 100
Outcomes	Time to intubation Number of attempts CL grades
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Cattano 2013

Methods	Randomized controlled trial Parallel design
Participants	**Included:** adult patients, ASA I to III
Interventions	C-MAC indirect view vs C-MAC direct view. Total N = 50
Outcomes	Time to tracheal intubation
Notes	Study identified during peer review process. Review of full text required to assess eligibility during next update

Colak 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** adult patients, ASA I to III
Interventions	Truview EVO2 and Airtraq vs Macintosh. Total N = 150
Outcomes	Time to tracheal intubation
Notes	Does not state in abstract whether Airtraq was used with video camera Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Eto 2014

Methods	Randomized controlled trial Parallel design
Participants	**Included:** ASA I to III, scheduled to undergo surgery
Interventions	Pentax AWS vs Macintosh. Total N = 30
Outcomes	Time to tracheal intubation
Notes	Abstract only with no outcomes denominator figures. Awaiting publication of full text

Gharehbaghi 2012

Methods	Randomized controlled trial Parallel design
Participants	**Included:** mild to moderate obesity (BMI = 28-35)
Interventions	GlideScope vs Macintosh. Total N = 100 but no denominator figures by group
Outcomes	Time to tracheal intubation
Notes	Abstract only with insufficient details of outcomes. Awaiting publication of full text

Hamp 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** adult patients
Interventions	Airtraq vs Macintosh. Total N = 40

Hamp 2015 (*Continued*)

Outcomes	Time to intubation
Notes	Use of double-lumen tube Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Ishida 2011

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients scheduled for cardiovascular surgery
Interventions	Pentax AWS vs Mactintosh. Total N = 40
Outcomes	Intubation success Time to tracheal intubation CL glottic view
Notes	Abstract only with insufficient detail to allow inclusion. No study author contact details with abstract

Janz 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** adults undergoing tracheal intubation in ICU
Interventions	Videolaryngoscope vs direct laryngoscopes (types not specified in abstract). Total N = 150
Outcomes	Successful first attempt Time to intubation Glottic view
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Kido 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** adult patients scheduled for elective surgery under 1-lung ventilation, ASA I to III
Interventions	McGrath vs Macintosh. Total N = 50 Type not specified in abstract

Kido 2015 (*Continued*)

Outcomes	Number of attempts Time to intubation POGO scores
Notes	Use of double-lumen tube Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Kita 2014

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients without cervical spine abnormality
Interventions	McGrath vs Macintosh. Total N = 50 Type of McGrath not stated in abstract
Outcomes	Unknown
Notes	Data taken from English abstract. Requires full translation to establish whether relevant outcomes were measured

Laosuwan 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients undergoing elective orthopaedic surgery that did not involve cervical spine procedure
Interventions	McGrath Series 5 vs Macintosh. Total N = 22
Outcomes	Time to intubation Glottic view Successful intubation Number of attempts
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Liu 2010

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients scheduled to undergo general anaesthesia with tracheal intubation
Interventions	HPHJ-A videolaryngoscope (n = 50) vs Macintosh (n = 50)

Liu 2010 (*Continued*)

Outcomes	Time for tracheal intubation Number of attempts CL glottic view: 1 to 4
Notes	Data taken from English abstract and English baseline characteristics table. Requires full translation to establish risk of bias and for data related to time outcomes

Morello 2009

Methods	Randomized controlled trial Cross-over design
Participants	**Included:** ASA I to III, no signs of predictable difficult intubation **Country:** Italy
Interventions	Glidescope vs Macintosh. Total N = 300
Outcomes	*Dichotomous outcomes:* Intubation success Number of attempts: 1 to 2 CL grades: 1 to 4
Notes	Abstract only. Results available but numbers are inconsistent; contact with study authors required to confirm results. No contact details therefore, awaiting publication of full text

Nakayama 2010

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients scheduled for video-assisted thoracoscopic surgery for pulmonary resection requiring left-sided double-lumen tube insertion
Interventions	Airtraq and GlideScope vs Macintosh
Outcomes	Failure to intubate Time to intubation Sore throat, dental injury, mucosal bleeding
Notes	Use of double-lumen tube Study identified during January 2016 search. Review of full text required to assess eligibility during next update

NCT00178555

Methods	Randomized controlled trial Parallel design
Participants	Age 18 to 80 years ASA I to III Presenting for elective surgery Requires general anaesthesia Present as a possible difficult intubation (≥ 1 of the following): history of difficult intubations, morbid obesity, small mouth opening (< 3 fingerbreadths), limited neck mobility, Mallampati classes II and III, short thyromental distance (< 6 cm)
Interventions	Storz DCI videolaryngoscope vs Macintosh
Outcomes	5-Scale score of glottic view Time and number of attempts required Level of difficulty Degree of irritation of the pharynx, epiglottis and arytenoids Vital signs, oxygen saturation and end-tidal carbon dioxide
Notes	Registered at clinicaltrials.gov. Listed as completed, but no results posted and have not been able to source completed study

NCT00602979

Methods	Randomized controlled trial Parallel design
Participants	Elective adult surgical patient requiring tracheal anaesthesia Males and females ASA I to III Age 18 years of age and older
Interventions	Airtraq AWS and Storz DCI and GlideScope and McGrath vs Macintosh
Outcomes	Percentage distribution of Cook's modification of Cormack-Lehane's grading system. Each study subject will receive a grade of 1, 2A, 2B, 3A, 3B or 4 in the Cook classification Intubation time: measured from entry of the device into the oral cavity until confirmation of proper placement of tracheal tube, as judged by an exhaled tidal volume > 200 mL and the presence of end-tidal carbon dioxide (CO_2) Success rate: number of attempts required for successful intubation by an attending anaesthesiologist Maximal neck extension: using atlanto-occipital joint extension scale Ease of intubation: judged by laryngoscopist on a 5-point rating scale: 5 is excellent, 1 is poor Complication rate: All complications will be recorded, with special attention given to common complications, such as upper airway and dental trauma Interincisor distance: maximal mouth opening necessary for intubation Laryngoscopist's comments: pertinent device-specific clinical comments Vital signs (blood pressure, heart rate, mean arterial pressure, and pulse oximeter rate)

NCT00602979 (*Continued*)

Notes	Registered at clinicaltrials.gov. Listed as completed, but no results posted and have not been able to source completed study. No contact made with study authors

NCT00664612

Methods	RCT, cross-over design
Participants	Elective non-cardiac surgery requiring intubation Adults ASA I to III BMI < 35
Interventions	Airtraq vs Macintosh
Outcomes	Cervical spine movement Time to Intubation
Notes	Registered at clinicaltrials.gov. Listed as completed, but no results posted and have not been able to source completed study. No contact made with study authors

NCT01029756

Methods	Randomized controlled trial Parallel design
Participants	Adults 18 years and over Scheduled for elective surgery Anaesthetic plan would normally include oral intubation with a Macintosh laryngoscope blade by a junior anaesthetist Valid informed consent
Interventions	Pentax AWS vs Macintosh
Outcomes	Is there a clinically significant difference in the time taken to successfully intubate the trachea? Is there a difference in the intubation difficulty score?
Notes	Registered at clinicaltrials.gov. Status listed as unknown but estimated completion date registered as September 2012. No results posted and have not been able to source completed study No contact made with study authors

NCT01114945

Methods	Randomized controlled trial
Participants	Patients with documented BMI > 35 kg/m^2 Scheduled to undergo inpatient surgery procedures under general anaesthesia Willingness and ability to sign an informed consent document 18 to 80 years of age ASA II to III adults of either sex

NCT01114945 (*Continued*)

Interventions	Karl Storz Video-Mac and GlideScope and McGrath vs Macintosh
Outcomes	Intubation time using a stop watch Glottis visualization using CL and POGO score
Notes	Registered at clinicaltrials.gov. Listed as completed, but no results posted and have not been able to source completed study. No contact made with study authors

NCT01488695

Methods	Randomized controlled trial Parallel design
Participants	Any adult patient booked for elective surgery requiring orotracheal intubation with a double-lumen endotracheal tube
Interventions	GlideScope Groove vs Macintosh
Outcomes	Duration of Intubation Number of intubation attempts Number of failures to intubate Use of external laryngeal pressure Laryngoscopic grade distribution: CL grade observed during laryngoscopy Presence of sore throat: graded on postoperative day 2 as none, mild, moderate or severe
Notes	Registered at clinicaltrials.gov. Status listed as unknown, but estimated completion date registered as December 2014. No results posted and have not been able to source completed study. No contact made with study authors

NCT01516164

Methods	Randomized controlled trial Parallel design
Participants	Elective procedure requiring oral tracheal tube intubation Over 16 years of age Airway assessment suggests to the anaesthetist that a standard Macintosh laryngoscope approach to intubation would be appropriate
Interventions	McGrath vs Macintosh
Outcomes	Intubation difficulty score Time to intubation Number and types of alternative techniques used Perception of force used Complications Ease of intubation Failure to intubate

NCT01516164 (*Continued*)

Notes	Registered at clinicaltrials.gov. Listed as completed, but no results posted and have not been able to source completed study. No contact made with study authors

NCT02190201

Methods	Randomized controlled trial Parallel design
Participants	**Included:** adult patients, thoracic surgery requiring 1-lung ventilation
Interventions	McGrath Series 5 videolaryngoscope vs Macintosh
Outcomes	Intubation time measured with a stopwatch, defined as time from insertion of blade into the mouth to withdrawal of blade Number of successful intubations at first attempt
Notes	Registered at clinicaltrials.gov. Listed as completed, but no results posted and have not been able to source completed study. No contact made with study authors

Pieters 2015

Methods	Randomized controlled trial Cross-over design
Participants	**Included:** ASA I to III with non-anticipated difficult airways
Interventions	McGrath Series 5, C-MAC, GlideScope and Macintosh. Total N = 141
Outcomes	No relevant outcomes reported in abstract
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Postaci 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** female patients, ASA I to III, 18 to 65 years of age, BMI > 30 kg/m^2
Interventions	McGrath Series 5 vs Macintosh. Total = 84
Outcomes	CL grades Intubation difficulty Time to intubation

Postaci 2015 (*Continued*)

Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Rovsing 2010

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients scheduled for bariatric surgery, BMI > 35 kg/m^2
Interventions	GlideScope vs Macintosh. Total N = 100
Outcomes	Time to intubation Intubation difficulty Number of attempts CL grades Sore throat, hoarseness
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Silverberg 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients requiring urgent tracheal intubation
Interventions	GlideScope vs Macintosh. Total N = 117
Outcomes	Success of first intubation Rates of complications
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Wallace 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients without predictors of difficult tracheal intubation
Interventions	McGrath vs Macintosh. Number of participants not specified Type of McGrath not specified
Outcomes	Difficulty of intubation Time to intubation

Wallace 2015 (*Continued*)

Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update. Unclear if this is an RCT

Wang 2008

Methods	No English abstract available for additional details
Participants	
Interventions	
Outcomes	
Notes	Title suggests possible inclusion, but paper requires translation from Chinese

Yao 2015

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients with predicted good glottic view
Interventions	McGrath Series 5 vs Macintosh. Total N = 96
Outcomes	Time to intubate CL grades
Notes	Use of double-lumen tube Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Yousef 2012

Methods	Randomized controlled trial Parallel design
Participants	**Included:** morbidly obese patients (BMI > 35 kg/m^2) scheduled for general, gynaecological and bariatric surgery
Interventions	GlideScope and LMA CTrach TM vs Macintosh. Total N = 90
Outcomes	Intubation difficulty score Time to intubate Overall success rate Number of attempts CL grades
Notes	Study identified during January 2016 search. Review of full text required to assess eligibility during next update

Zhao 2014

Methods	Randomized controlled trial Parallel design
Participants	**Included:** patients scheduled for surgery under general anaesthesia
Interventions	Airtraq vs Macintosh. Total N = 149
Outcomes	Successful intubation CL grades Time to intubate
Notes	Does not state in abstract whether Airtraq is used with video camera Study identified during January 2016 search. Review of full text required to assess eligibility during next update

ASA = American Society of Anesthesiologists (physical status classification); BMI = body mass index; CL = Cormack and Lehane (Cormack 1984); MILS = manual in-line stabilization; POGO = percentage of glottic opening; RCT = randomized controlled trial

Characteristics of ongoing studies *[ordered by study ID]*

NCT01914523

Trial name or title	Comparison of the Macintosh, King Vision®, GlideScope® and Airtraq® laryngoscopes in routine airway management
Methods	RCT, parallel design
Participants	ASA I or II Aged 18 to 65 years Scheduled for elective minor surgery Under general anaesthesia Female
Interventions	King Vision, GlideScope, Airtraq, Macintosh
Outcomes	Time to tracheal intubation: time when the investigated laryngoscope passes the central incisors to time when the tip of the tracheal tube passes through the glottis Laryngoscopic view: best view during laryngoscopy (using Cormack and Lehane classification) Ease of intubation on a 100-mm visual analogue scale (0 for much ease and 100 for extremely difficult) Number of intubation attempts Number of optimization manoeuvres: If intubation was unsuccessful at the first attempt, took longer than 180 seconds, or if desaturation noted on the pulse oximeter (defined as SpO_2 < 93%) [14], intubation attempt will be stopped, and the lungs will be ventilated with an oxygen-volatile anaesthetic mixture for 3 minutes. Second attempt will be allowed with randomly allocated airway device Duration of laryngoscopy: time from holding of the investigated laryngoscope to appearance as the first upward deflection on the capnograph Haemodynamic parameters: heart rate, systolic and mean blood pressures

NCT01914523 (*Continued*)

Starting date	September 2013
Contact information	Mohamed R El Tahan, MD; mohamedrefaateltahan@yahoo.com
Notes	

NCT01914601

Trial name or title	King Vision and cervical spines movement
Methods	RCT, cross-over design
Participants	Sixteen participants, ASA I or II Aged 18 to 65 years Scheduled for elective minor surgery Under general anaesthesia
Interventions	King Vision, Macintosh
Outcomes	Cervical spine movement Time to intubation: time when the investigated laryngoscope passes the central incisors to time when the tip of the tracheal tube passed through the glottis Laryngoscopic view: glottic view during laryngoscopy will be assessed according to the Cormack-Lehane grading system: Grade 1, full view; Grade 2, only arytenoid cartilages visible; Grade 3, only epiglottis visible; Grade 4, epiglottis not visible Ease of intubation: rate ease of intubation on a 100-mm visual analogue scale (0 for much ease and 100 for extremely difficult) Number of intubation attempts Number of optimization manoeuvres
Starting date	October 2013
Contact information	Mohamed R El Tahan, MD; mohamedrefaateltahan@yahoo.com
Notes	Listed as ongoing study at clinicaltrials.gov

NCT02088801

Trial name or title	Evaluation of videolaryngoscopes in difficult airway (SWIVITII)
Methods	RCT, parallel design
Participants	Elective surgery with general anaesthesia requiring intubation > 18 years old ASA I to III

NCT02088801 (*Continued*)

Interventions	Airtraq, King Vision, AP Advance, Macintosh
Outcomes	First attempt intubation success rate Side effects: sore throat, bleeding, dental injuries
Starting date	February 2014
Contact information	Lorenz G Theiler, MD; lorenz.theiler@insel.ch
Notes	

NCT02167477

Trial name or title	Comparison of Indirect and Direct Laryngoscopy in Obese Patients
Methods	RCT, parallel design
Participants	Obese adult patients (BMI > 35 kg/m^2) for elective bariatric surgery
Interventions	Storz C-MAC, Macintosh
Outcomes	POGO (percentage of glottic opening) score at maximum laryngeal view for 3 laryngoscopes (Macintosh, Storz C-MAC, standard and D-blade) Subjective "ease of intubation" Time to intubate
Starting date	January 2013
Contact information	Peter Charters. Aintree University Hospital
Notes	

NCT02292901

Trial name or title	McGrath Mac videoLaryngoscope vs Macintosh laryngoscope (MGM-Eval)
Methods	RCT, parallel design
Participants	Adult patients scheduled for general anaesthesia with orotracheal intubation
Interventions	McGrath Mac videolaryngoscope vs Macintosh
Outcomes	Ease of tracheal intubation Ease of intubation measured on the Intubation Difficulty Scale Time to obtain first capnogram (seconds) Score of Cormak and Lehane modified by Yentis POGO (percentage of glottic opening) score

NCT02292901 (*Continued*)

	Rate of use of alternative techniques for intubation Rate of oesophageal intubation Incidence of arterial oxygen desaturation (SpO_2 < 92%) Rate of failure of tracheal intubation Rate of haemodynamic abnormality Postoperative throat pain Postoperative hoarseness Questionnaire of Salditt−Isabel
Starting date	November 2014
Contact information	Marc Fischler, MD; m.fischler@hopital-foch.org
Notes	

NCT02297113

Trial name or title	Rapid Sequence Intubation at the Emergency Department
Methods	RCT, parallel design
Participants	Patients requiring emergency rapid sequence intubation at the emergency department Male and female participants 18 years to 99 years of age Written confirmation by a physician not involved in this study Written informed consent by the participant (obtained afterwards) Participant not showing remarkable rejection in participation in this study
Interventions	C-MAC videolaryngoscope, Macintosh
Outcomes	Success rate defined as successful placement of endotracheal tube within the trachea Time to intubation defined as time between insertion of the videolaryngoscope/Macintosh blade into the mouth until detection of end-tidal CO_2 Laryngoscopic view: Cormack and Lehane score Number of intubation attempts Unrecognized oesophageal intubation Ease of intubation (1-5): (1) very easy, (2) easy, (3) somewhat difficult, (4) difficult, (5) impossible Violations of the teeth: number of patients; teeth will be inspected for potential damage and documented accordingly Necessity of using additional, alternative airway devices for successful intubation (if randomized airway device failed): number of participants requiring alternate device Maximum drop of saturation: SpO_2 will be measured continuously and documented accordingly
Starting date	November 2014
Contact information	Kurt Ruetzler, MD; kurt.ruetzler@usz.ch
Notes	

NCT02305667

Trial name or title	Videolaryngoscopes for Double Lumen Tube Intubations
Methods	RCT, parallel design
Participants	ASA II/III Elective thoracic procedures Adult Estimated 120 participants
Interventions	Airtraq, GlideScope, King Vision, Macintosh
Outcomes	Time to duration of endobronchial intubation: defined as time from when the laryngoscope entered between the participant's lips until successful DLT placement (regardless of the number of attempts) Best obtained glottis view during laryngoscopy using Cormack and Lehane direct view or 'video assisted view' seen on the video display screen Ease of endobronchial intubation on a visual analogue score (VAS) of ease of endobronchial intubation (0 for much ease and 100 for extremely difficult) Number of optimization manoeuvres Number of 'backwards upwards rightwards pressure' (BURP) manoeuvre Failure rate for double-lumen tube intubation Sore throat on a VAS from 0, indicating 'none', to 10, 'severe' sore throat Hoarseness on numerical scale observed by the anaesthesiologist (0: absent, 1: subjective, or 3: aphonic)
Starting date	January 2015
Contact information	Mohamed R El Tahan, MD; mohamedrefaateltahan@yahoo.com
Notes	

ASA = American Society of Anesthesiologists (physical status classification); BMI = body mass index; DLT = double-lumen tubes; RCT = randomized controlled trial; VAS = visual analogue scale.

DATA AND ANALYSES

Comparison 1. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Failed intubation	38	4127	Odds Ratio (M-H, Random, 95% CI)	0.35 [0.19, 0.65]

Comparison 2. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Hypoxia	8	1319	Odds Ratio (M-H, Random, 95% CI)	0.39 [0.10, 1.44]

Comparison 3. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mortality	2	663	Odds Ratio (M-H, Fixed, 95% CI)	1.09 [0.65, 1.82]

Comparison 4. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Laryngeal/airway trauma	29	3110	Odds Ratio (M-H, Random, 95% CI)	0.68 [0.48, 0.96]

Comparison 5. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Patient-reported sore throat	17	2392	Odds Ratio (M-H, Random, 95% CI)	0.82 [0.56, 1.19]
1.1 Postanaesthesia care unit	10	1548	Odds Ratio (M-H, Random, 95% CI)	1.00 [0.73, 1.38]
1.2 Postoperative day 1	8	844	Odds Ratio (M-H, Random, 95% CI)	0.54 [0.27, 1.07]

Comparison 6. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Hoarseness	6	527	Odds Ratio (M-H, Fixed, 95% CI)	0.57 [0.36, 0.88]

Comparison 7. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Successful first attempt	36	4731	Odds Ratio (M-H, Random, 95% CI)	1.27 [0.77, 2.09]

Comparison 8. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Number of attempts	28	6692	Odds Ratio (M-H, Random, 95% CI)	1.06 [0.68, 1.66]
1.1 1 attempt	28	3346	Odds Ratio (M-H, Random, 95% CI)	1.25 [0.68, 2.31]
1.2 2 to 4 attempts	28	3346	Odds Ratio (M-H, Random, 95% CI)	0.89 [0.47, 1.70]

Comparison 9. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Time for tracheal intubation	37		Mean Difference (IV, Random, 95% CI)	Subtotals only

Comparison 10. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Intubation difficult score (IDS)	7	568	Odds Ratio (M-H, Random, 95% CI)	7.13 [3.12, 16.31]

Comparison 11. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Improved visualization Cormack & Lehane (CL) 1	22	2240	Odds Ratio (M-H, Random, 95% CI)	6.77 [4.17, 10.98]

Comparison 12. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Improved visualization Cormack & Lehane (CL) 1 to 4	22	4480	Odds Ratio (M-H, Random, 95% CI)	1.00 [0.54, 1.87]
1.1 CL 1 to 2	22	2240	Odds Ratio (M-H, Random, 95% CI)	5.42 [3.70, 7.95]
1.2 CL 3 to 4	22	2240	Odds Ratio (M-H, Random, 95% CI)	0.18 [0.13, 0.27]

Comparison 13. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Improved visualization POGO	4		Mean Difference (IV, Random, 95% CI)	Totals not selected

Comparison 14. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Failed intubation by scope	33	3916	Odds Ratio (M-H, Random, 95% CI)	0.40 [0.21, 0.75]
1.1 GlideScope	16	1306	Odds Ratio (M-H, Random, 95% CI)	0.57 [0.25, 1.32]
1.2 Pentax AWS	11	1086	Odds Ratio (M-H, Random, 95% CI)	0.24 [0.05, 1.20]
1.3 McGrath	5	466	Odds Ratio (M-H, Random, 95% CI)	1.18 [0.06, 23.92]
1.4 C-MAC	8	1058	Odds Ratio (M-H, Random, 95% CI)	0.32 [0.15, 0.68]

Comparison 15. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Failed intubation by airway difficulty	34	3383	Odds Ratio (M-H, Random, 95% CI)	0.35 [0.18, 0.65]
1.1 Predicted not difficult	19	1743	Odds Ratio (M-H, Random, 95% CI)	0.61 [0.22, 1.67]
1.2 Predicted difficult	6	830	Odds Ratio (M-H, Random, 95% CI)	0.28 [0.15, 0.55]
1.3 Simulated difficult	9	810	Odds Ratio (M-H, Random, 95% CI)	0.18 [0.04, 0.77]

Comparison 16. VLS versus Macintosh

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Failed intubation by experience of personnel	22	2273	Odds Ratio (M-H, Random, 95% CI)	0.29 [0.13, 0.67]
1.1 Personnel experienced with both devices	17	1927	Odds Ratio (M-H, Random, 95% CI)	0.32 [0.13, 0.75]
1.2 Personnel less experienced with VLS	5	346	Odds Ratio (M-H, Random, 95% CI)	0.20 [0.02, 2.56]

Analysis 1.1. Comparison 1 VLS versus Macintosh, Outcome 1 Failed intubation.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 1 VLS versus Macintosh

Outcome: 1 Failed intubation

Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Andersen 2011	0/50	2/50		2.7 %	0.19 [0.01, 4.10]
Aoi 2010	1/18	1/18		2.9 %	1.00 [0.06, 17.33]
Arici 2014	0/40	0/40			Not estimable
Arima 2014	2/56	0/53		2.7 %	4.91 [0.23, 104.65]
Aziz 2012	6/149	12/147		6.2 %	0.47 [0.17, 1.29]
Bensghir 2010	0/34	2/34		2.7 %	0.19 [0.01, 4.07]
Bensghir 2013	0/35	1/35		2.5 %	0.32 [0.01, 8.23]
Bilehjani 2009	0/40	0/38			Not estimable
Carassiti 2013	0/15	0/15			Not estimable
Cavus 2011 (1)	0/100	6/50		2.9 %	0.03 [0.00, 0.62]
Cordovani 2013	3/24	5/20		5.0 %	0.43 [0.09, 2.08]
Enomoto 2008	0/99	11/104		2.9 %	0.04 [0.00, 0.70]
Ilyas 2014 (2)	5/64	0/64		2.8 %	11.92 [0.65, 220.30]
Jungbauer 2009	1/100	8/100		4.0 %	0.12 [0.01, 0.95]
Kill 2013	0/30	3/30		2.7 %	0.13 [0.01, 2.61]
Komatsu 2010	1/50	0/50		2.5 %	3.06 [0.12, 76.95]
Lee 2009	0/41	0/44			Not estimable
Lee 2012 (3)	3/75	1/25		3.7 %	1.00 [0.10, 10.07]
Lim 2005	0/30	0/30			Not estimable
Lin 2012	2/85	3/85		4.6 %	0.66 [0.11, 4.04]
Malik 2008 (4)	3/90	2/30		4.5 %	0.48 [0.08, 3.04]
Malik 2009a	0/30	0/30			Not estimable
Malik 2009b (5)	1/50	4/25		3.8 %	0.11 [0.01, 1.02]
McElwain 2011 (6)	1/58	2/31		3.5 %	0.25 [0.02, 2.92]
Nishikawa 2009	0/20	0/20			Not estimable

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Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Peck 2009	0/27	13/27		2.9 %	0.02 [0.00, 0.35]
Pournajafian 2014	6/52	3/52		5.3 %	2.13 [0.50, 9.02]
Russell 2013	6/35	3/35		5.3 %	2.21 [0.51, 9.64]
Serocki 2010 (7)	2/80	4/40		4.7 %	0.23 [0.04, 1.32]
Serocki 2013 (8)	0/63	4/32		2.8 %	0.05 [0.00, 0.96]
Siddiqui 2009	0/20	0/20			Not estimable
Sun 2005	0/100	1/100		2.5 %	0.33 [0.01, 8.20]
Takenaka 2011	0/35	5/34		2.8 %	0.08 [0.00, 1.42]
Taylor 2013	0/44	18/44		2.9 %	0.02 [0.00, 0.28]
Teoh 2010 (9)	0/300	0/100			Not estimable
Walker 2009	1/60	0/60		2.5 %	3.05 [0.12, 76.39]
Woo 2012	0/50	59/109		3.0 %	0.01 [0.00, 0.14]
Xue 2007	2/30	0/27		2.6 %	4.82 [0.22, 105.10]
Total (95% CI)	**2279**	**1848**		**100.0 %**	**0.35 [0.19, 0.65]**

Total events: 46 (Experimental), 173 (Control)

Heterogeneity: Tau^2 = 1.37; Chi^2 = 57.76, df = 28 (P = 0.00078); I^2 =52%

Test for overall effect: Z = 3.33 (P = 0.00088)

Test for subgroup differences: Not applicable

(1) Multi-arm study. Data combined for each VLS group

(2) Two failed due to equipment failure, three failed due to difficulty passing tube

(3) Multi-arm study. Data combined for each VLS group

(4) Multi-arm study. Data combined for each VLS group

(5) Multi-arm study. Data combined for each VLS group

(6) Multi-arm study. Data combined for each VLS group

(7) Multi-arm study. Data combined for each VLS group

(8) Multi-arm study. Data combined for each VLS group

(9) Multi-arm study. Data from each VLS group combined

Analysis 2.1. Comparison 2 VLS versus Macintosh, Outcome 1 Hypoxia.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 2 VLS versus Macintosh

Outcome: 1 Hypoxia

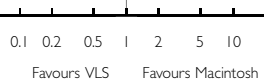
Study or subgroup	VLS n/N	Macintosh n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Andersen 2011	0/50	0/50			Not estimable
Aziz 2012	8/149	7/147		37.0 %	1.13 [0.40, 3.21]
Bensghir 2010	2/34	13/34		28.3 %	0.10 [0.02, 0.49]
Bensghir 2013	5/35	11/35		34.6 %	0.36 [0.11, 1.19]
Komatsu 2010	0/50	0/50			Not estimable
Lin 2012	0/83	0/82			Not estimable
Serocki 2010 (1)	0/80	0/40			Not estimable
Teoh 2010 (2)	0/300	0/100			Not estimable
Total (95% CI)	**781**	**538**		**100.0 %**	**0.39 [0.10, 1.44]**

Total events: 15 (VLS), 31 (Macintosh)

Heterogeneity: $Tau^2 = 0.93$; $Chi^2 = 6.61$, df = 2 (P = 0.04); $I^2 = 70\%$

Test for overall effect: Z = 1.42 (P = 0.16)

Test for subgroup differences: Not applicable



(1) Multi-arm study. Data combined for each VLS group

(2) Multi-arm study. Data combined for each VLS group

Analysis 3.1. Comparison 3 VLS versus Macintosh, Outcome 1 Mortality.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 3 VLS versus Macintosh

Outcome: 1 Mortality

Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Griesdale 2012	9/20	12/20		23.8 %	0.55 [0.16, 1.91]
Yeatts 2013	28/303	24/320		76.2 %	1.26 [0.71, 2.22]
Total (95% CI)	**323**	**340**		**100.0 %**	**1.09 [0.65, 1.82]**

Total events: 37 (Experimental), 36 (Control)

Heterogeneity: Chi^2 = 1.41, df = 1 (P = 0.24); I^2 =29%

Test for overall effect: Z = 0.32 (P = 0.75)

Test for subgroup differences: Not applicable

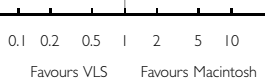
Analysis 4.1. Comparison 4 VLS versus Macintosh, Outcome 1 Laryngeal/airway trauma.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 4 VLS versus Macintosh

Outcome: 1 Laryngeal/airway trauma

Study or subgroup	VLS n/N	Macintosh n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Abdallah 2011	2/50	0/49		1.2 %	5.10 [0.24, 109.06]
Andersen 2011	0/50	0/50			Not estimable
Aoi 2010	3/17	5/17		3.7 %	0.51 [0.10, 2.61]
Arici 2014	0/40	0/40			Not estimable
Aziz 2012	27/149	18/147		11.8 %	1.59 [0.83, 3.03]
Bensghir 2010	1/34	3/34		2.0 %	0.31 [0.03, 3.17]
Bensghir 2013	2/35	7/35		3.6 %	0.24 [0.05, 1.26]
Bilehjani 2009	1/40	2/38		1.8 %	0.46 [0.04, 5.31]
Carassiti 2013	0/15	0/15			Not estimable
Cavus 2011 (1)	0/100	0/50			Not estimable
Frohlich 2011	0/30	0/30			Not estimable
Gupta 2013 (2)	5/60	9/60		6.2 %	0.52 [0.16, 1.64]
Hsu 2012	0/30	2/30		1.2 %	0.19 [0.01, 4.06]
Ilyas 2014	4/64	8/64		5.5 %	0.47 [0.13, 1.64]
Kim 2013	0/22	1/23		1.1 %	0.33 [0.01, 8.63]
Komatsu 2010	6/50	12/50		6.9 %	0.43 [0.15, 1.26]
Lee 2009	0/41	0/44			Not estimable
Lee 2012 (3)	3/75	4/25		3.9 %	0.22 [0.05, 1.06]
Lim 2005	2/30	5/30		3.4 %	0.36 [0.06, 2.01]
Lin 2012	9/83	17/82		8.8 %	0.47 [0.19, 1.11]
Maassen 2012	0/80	0/80			Not estimable
Malik 2008 (4)	13/90	5/30		6.5 %	0.84 [0.27, 2.60]
Malik 2009a	5/30	2/30		3.4 %	2.80 [0.50, 15.73]
Malik 2009b (5)	12/50	8/25		7.0 %	0.67 [0.23, 1.94]
McElwain 2011 (6)	4/58	2/31		3.3 %	1.07 [0.19, 6.22]



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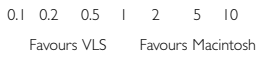
Study or subgroup	VLS n/N	Macintosh n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Russell 2013	9/35	3/35		4.7 %	3.69 [0.91, 15.05]
Taylor 2013	6/44	11/44		6.7 %	0.47 [0.16, 1.42]
Teoh 2010 (7)	10/300	1/100		2.5 %	3.41 [0.43, 27.01]
Walker 2009	3/60	8/60		4.8 %	0.34 [0.09, 1.36]
Total (95% CI)	**1762**	**1348**		**100.0 %**	**0.68 [0.48, 0.96]**

Total events: 127 (VLS), 133 (Macintosh)

Heterogeneity: $Tau^2 = 0.16$; $Chi^2 = 27.94$, df = 21 (P = 0.14); $I^2 = 25\%$

Test for overall effect: Z = 2.18 (P = 0.029)

Test for subgroup differences: Not applicable



(1) Multi-arm study. Data combined for each VLS group

(2) Multi-arm study. Data combined for each VLS group

(3) Multi-arm study. Data combined for each VLS group

(4) Multi-arm study. Data combined for each VLS group

(5) Multi-arm study. Data combined for each VLS group

(6) Multi-arm study. Data combined for each VLS group

(7) Multi-arm study. Data combined for each VLS group

Analysis 5.1. Comparison 5 VLS versus Macintosh, Outcome 1 Patient-reported sore throat.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 5 VLS versus Macintosh

Outcome: 1 Patient-reported sore throat

Study or subgroup	VLS n/N	Macintosh n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
1 Postanaesthesia care unit					
Andersen 2011	20/50	21/50		7.1 %	0.92 [0.41, 2.04]
Aoi 2010	8/17	4/17		4.0 %	2.89 [0.66, 12.57]
Aziz 2012	57/149	52/147		8.8 %	1.13 [0.71, 1.82]
Bilehjani 2009	11/40	14/38		6.2 %	0.65 [0.25, 1.69]
Ilyas 2014	24/64	25/64		7.5 %	0.94 [0.46, 1.91]
Najafi 2014 (1)	29/150	42/150		8.5 %	0.62 [0.36, 1.06]
Peck 2009	4/27	2/27		3.1 %	2.17 [0.36, 13.01]
Russell 2013	5/35	2/35		3.3 %	2.75 [0.50, 15.25]
Taylor 2013	5/44	8/44		5.1 %	0.58 [0.17, 1.93]
Teoh 2010 (2)	24/300	3/100		5.0 %	2.81 [0.83, 9.55]
Subtotal (95% CI)	**876**	**672**		**58.7 %**	**1.00 [0.73, 1.38]**
Total events: 187 (VLS), 173 (Macintosh)					
Heterogeneity: Tau^2 = 0.06; Chi^2 = 11.79, df = 9 (P = 0.23); I^2 =24%					
Test for overall effect: Z = 0.03 (P = 0.98)					
2 Postoperative day 1					
Abdallah 2011	16/50	16/49		6.8 %	0.97 [0.42, 2.25]
Hsu 2012	6/30	18/30		5.3 %	0.17 [0.05, 0.53]
Lee 2013	0/20	0/20			Not estimable
Lin 2012	11/83	20/82		7.0 %	0.47 [0.21, 1.06]
Najafi 2014	34/150	81/150		8.7 %	0.25 [0.15, 0.41]
Nishikawa 2009	2/20	6/20		3.2 %	0.26 [0.05, 1.49]
Siddiqui 2009	5/20	2/20		3.2 %	3.00 [0.51, 17.74]
Woo 2012	29/50	26/50		7.1 %	1.27 [0.58, 2.81]
Subtotal (95% CI)	**423**	**421**		**41.3 %**	**0.54 [0.27, 1.07]**
Total events: 103 (VLS), 169 (Macintosh)					
Heterogeneity: Tau^2 = 0.58; Chi^2 = 22.84, df = 6 (P = 0.00085); I^2 =74%					
Test for overall effect: Z = 1.76 (P = 0.079)					

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Study or subgroup	VLS n/N	Macintosh n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Total (95% CI)	**1299**	**1093**		**100.0 %**	**0.82 [0.56, 1.19]**

Total events: 290 (VLS), 342 (Macintosh)

Heterogeneity: $Tau^2 = 0.37$; $Chi^2 = 47.69$, df = 16 (P = 0.00005); $I^2 = 66\%$

Test for overall effect: Z = 1.05 (P = 0.29)

Test for subgroup differences: $Chi^2 = 2.58$, df = 1 (P = 0.11), $I^2 = 61\%$

(1) Data taken from measurement at one hour postoperatively

(2) Multi-arm study Data from all three VLS intervention groups combined in this analysis

Analysis 6.1. Comparison 6 VLS versus Macintosh, Outcome 1 Hoarseness.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 6 VLS versus Macintosh

Outcome: 1 Hoarseness

Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Andersen 2011	12/50	16/50		22.9 %	0.67 [0.28, 1.62]
Aoi 2010	2/17	3/17		5.0 %	0.62 [0.09, 4.29]
Bilehjani 2009	4/30	14/30		22.8 %	0.18 [0.05, 0.63]
Hsu 2012	4/83	8/82		14.4 %	0.47 [0.14, 1.62]
Ilyas 2014	22/64	23/64		28.4 %	0.93 [0.45, 1.93]
Siddiqui 2009	0/20	3/20		6.4 %	0.12 [0.01, 2.53]
Total (95% CI)	**264**	**263**		**100.0 %**	**0.57 [0.36, 0.88]**

Total events: 44 (Experimental), 67 (Control)

Heterogeneity: $Chi^2 = 6.29$, df = 5 (P = 0.28); $I^2 = 21\%$

Test for overall effect: Z = 2.53 (P = 0.011)

Test for subgroup differences: Not applicable

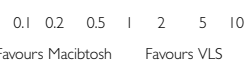
Analysis 7.1. Comparison 7 VLS versus Macintosh, Outcome 1 Successful first attempt.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 7 VLS versus Macintosh

Outcome: 1 Successful first attempt

Study or subgroup	VLS n/N	Macintosh n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Abdallah 2011 (1)	43/50	45/49		3.4 %	0.55 [0.15, 2.00]
Andersen 2011	49/50	46/50		2.3 %	4.26 [0.46, 39.54]
Aoi 2010	14/18	14/18		3.1 %	1.00 [0.21, 4.81]
Arici 2014	40/40	40/40			Not estimable
Arima 2014	26/56	40/53		3.9 %	0.28 [0.12, 0.64]
Aziz 2012	138/149	124/147		4.0 %	2.33 [1.09, 4.97]
Bensghir 2010	32/34	23/34		3.0 %	7.65 [1.55, 37.87]
Bilehjani 2009	29/40	35/38		3.3 %	0.23 [0.06, 0.89]
Cavus 2011 (2)	74/100	48/50		3.2 %	0.12 [0.03, 0.52]
Frohlich 2011	14/30	28/30		3.0 %	0.06 [0.01, 0.31]
Griesdale 2012	8/20	7/20		3.4 %	1.24 [0.34, 4.46]
Gupta 2013 (3)	60/60	55/60		1.8 %	11.99 [0.65, 221.86]
Hirabayashi 2009	253/264	179/256		4.1 %	9.89 [5.11, 19.14]
Hsu 2012	30/30	26/30		1.7 %	10.36 [0.53, 201.45]
Kim 2013	22/22	19/23		1.7 %	10.38 [0.53, 205.27]
Komatsu 2010	37/50	45/50		3.6 %	0.32 [0.10, 0.97]
Lee 2012 (4)	36/75	21/25		3.5 %	0.18 [0.06, 0.56]
Lim 2005	28/30	26/30		2.8 %	2.15 [0.36, 12.76]
Lin 2012	77/83	65/82		3.7 %	3.36 [1.25, 9.01]
Malik 2008 (5)	79/90	26/30		3.5 %	1.10 [0.32, 3.77]
Malik 2009a	28/30	29/30		2.1 %	0.48 [0.04, 5.63]
Malik 2009b (6)	40/50	17/25		3.6 %	1.88 [0.63, 5.59]
McElwain 2011 (7)	54/58	25/31		3.3 %	3.24 [0.84, 12.51]
Russell 2013	29/35	32/35		3.2 %	0.45 [0.10, 1.98]



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Study or subgroup	VLS n/N	Macintosh n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Serocki 2010 (8)	73/80	35/40		3.5 %	1.49 [0.44, 5.03]
Serocki 2013 (9)	56/63	27/32		3.5 %	1.48 [0.43, 5.10]
Shippey 2013	25/25	19/25		1.7 %	17.00 [0.90, 320.37]
Sun 2005	94/100	97/100		3.2 %	0.48 [0.12, 1.99]
Suzuki 2008	25/25	25/25			Not estimable
Takenaka 2011	35/35	29/34		1.7 %	13.24 [0.70, 249.38]
Taylor 2013	44/44	26/44		1.8 %	62.13 [3.59, 1074.00]
Teoh 2010 (10)	279/300	98/100		3.2 %	0.27 [0.06, 1.18]
Walker 2009	57/60	59/60		2.3 %	0.32 [0.03, 3.19]
Woo 2012	50/50	50/109		1.8 %	119.00 [7.16, 1977.82]
Xue 2007	28/30	27/27		1.6 %	0.21 [0.01, 4.52]
Yeatts 2013	242/303	259/320		4.3 %	0.93 [0.63, 1.39]
Total (95% CI)	**2579**	**2152**		**100.0 %**	**1.27 [0.77, 2.09]**

Total events: 2248 (VLS), 1766 (Macintosh)

Heterogeneity: $Tau^2 = 1.48$; $Chi^2 = 158.56$, df = 33 (P<0.00001); $I^2 = 79\%$

Test for overall effect: Z = 0.93 (P = 0.35)

Test for subgroup differences: Not applicable

(1) Data for VLS group is included as per study report. Note there is an unexplained difference between results for Abdallah 2011 for analysis 6.1 and 7.1

(2) Multi-arm study. Data combined for each VLS group

(3) Combined data for VLS with and without stylet versus Macintosh with and without stylet

(4) Multi-arm study. Data combined for each VLS group

(5) Multi-arm study. Data combined for each VLS group

(6) Multi-arm study. Data combined for each VLS group

(7) Multi-arm study. Data combined for each VLS group

(8) Multi-arm study. Data combined for each VLS group

(9) Multi-arm study. Data combined for each VLS group

(10) Multi-arm study. Data combined for each VLS group

Analysis 8.1. Comparison 8 VLS versus Macintosh, Outcome 1 Number of attempts.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 8 VLS versus Macintosh

Outcome: 1 Number of attempts

Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
1 1 attempt					
Abdallah 2011	44/50	45/49		2.0 %	0.65 [0.17, 2.47]
Andersen 2011	49/50	46/50		1.5 %	4.26 [0.46, 39.54]
Aoi 2010	14/18	14/18		1.9 %	1.00 [0.21, 4.81]
Bensghir 2010	32/34	23/34		1.9 %	7.65 [1.55, 37.87]
Bilehjani 2009	29/40	35/38		2.0 %	0.23 [0.06, 0.89]
Cavus 2011 (1)	74/100	48/50		2.0 %	0.12 [0.03, 0.52]
Frohlich 2011	14/30	28/30		1.9 %	0.06 [0.01, 0.31]
Griesdale 2012	8/20	7/20		2.1 %	1.24 [0.34, 4.46]
Gupta 2013	60/60	55/60		1.2 %	11.99 [0.65, 221.86]
Hirabayashi 2009	253/264	179/256		2.4 %	9.89 [5.11, 19.14]
Hsu 2012	30/30	26/30		1.2 %	10.36 [0.53, 201.45]
Kim 2013	22/22	19/23		1.2 %	10.38 [0.53, 205.27]
Komatsu 2010	37/50	45/50		2.2 %	0.32 [0.10, 0.97]
Lee 2012 (2)	36/75	21/25		2.1 %	0.18 [0.06, 0.56]
Lim 2005	28/30	26/30		1.8 %	2.15 [0.36, 12.76]
Lin 2012	77/83	65/82		2.2 %	3.36 [1.25, 9.01]
Malik 2008 (3)	79/90	26/30		2.1 %	1.10 [0.32, 3.77]
Malik 2009a	28/30	29/30		1.4 %	0.48 [0.04, 5.63]
Malik 2009b (4)	40/50	17/25		2.2 %	1.88 [0.63, 5.59]
McElwain 2011 (5)	54/58	25/31		2.0 %	3.24 [0.84, 12.51]
Serocki 2010 (6)	73/80	35/40		2.1 %	1.49 [0.44, 5.03]
Serocki 2013 (7)	56/63	27/32		2.1 %	1.48 [0.43, 5.10]
Shippey 2013	25/25	19/25		1.2 %	17.00 [0.90, 320.37]
Sun 2005	94/100	97/100		2.0 %	0.48 [0.12, 1.99]

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Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Teoh 2010 (8)	279/300	98/100		2.0 %	0.27 [0.06, 1.18]
Walker 2009	57/60	59/60		1.5 %	0.32 [0.03, 3.19]
Woo 2012	50/50	50/109		1.3 %	119.00 [7.16, 1977.82]
Xue 2007	28/30	27/27		1.1 %	0.21 [0.01, 4.52]
Subtotal (95% CI)	**1892**	**1454**		**50.5 %**	**1.25 [0.68, 2.31]**
Total events: 1670 (Experimental), 1191 (Control)					
Heterogeneity: Tau^2 = 1.95; Chi^2 = 126.37, df = 27 (P<0.00001); I^2 =79%					
Test for overall effect: Z = 0.72 (P = 0.47)					
2.2 to 4 attempts					
Abdallah 2011	6/50	4/49		2.0 %	1.53 [0.41, 5.81]
Andersen 2011	1/50	4/50		1.5 %	0.23 [0.03, 2.18]
Aoi 2010	4/18	4/18		1.9 %	1.00 [0.21, 4.81]
Bensghir 2010	2/34	11/34		1.9 %	0.13 [0.03, 0.65]
Bilehjani 2009	11/40	3/38		2.0 %	4.43 [1.13, 17.38]
Cavus 2011 (9)	26/100	2/50		2.0 %	8.43 [1.91, 37.17]
Frohlich 2011	16/30	2/30		1.9 %	16.00 [3.22, 79.56]
Griesdale 2012	12/20	13/20		2.1 %	0.81 [0.22, 2.91]
Gupta 2013	0/60	5/60		1.2 %	0.08 [0.00, 1.54]
Hirabayashi 2009	11/264	77/256		2.4 %	0.10 [0.05, 0.20]
Hsu 2012	0/30	4/30		1.2 %	0.10 [0.00, 1.88]
Kim 2013	0/22	4/23		1.2 %	0.10 [0.00, 1.90]
Komatsu 2010	13/50	5/50		2.2 %	3.16 [1.03, 9.69]
Lee 2012 (10)	39/75	4/25		2.1 %	5.69 [1.78, 18.17]
Lim 2005	2/30	4/30		1.8 %	0.46 [0.08, 2.75]
Lin 2012	6/83	17/82		2.2 %	0.30 [0.11, 0.80]
Malik 2008 (11)	11/90	4/30		2.1 %	0.91 [0.27, 3.09]
Malik 2009a	2/30	1/30		1.4 %	2.07 [0.18, 24.15]
Malik 2009b (12)	10/50	8/25		2.2 %	0.53 [0.18, 1.58]
McElwain 2011 (13)	4/58	6/31		2.0 %	0.31 [0.08, 1.19]
Serocki 2010 (14)	7/80	1/40		1.6 %	3.74 [0.44, 31.50]
Serocki 2013 (15)	7/63	1/32		1.6 %	3.88 [0.46, 32.96]
Shippey 2013	0/25	6/25		1.2 %	0.06 [0.00, 1.11]

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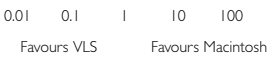
Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Sun 2005	6/100	3/100		2.0 %	2.06 [0.50, 8.49]
Teoh 2010 (16)	21/300	2/100		2.0 %	3.69 [0.85, 16.02]
Walker 2009	3/60	1/60		1.5 %	3.11 [0.31, 30.73]
Woo 2012	0/50	59/109		1.3 %	0.01 [0.00, 0.14]
Xue 2007	2/30	0/27		1.1 %	4.82 [0.22, 105.10]
Subtotal (95% CI)	**1892**	**1454**		**49.5 %**	**0.89 [0.47, 1.70]**
Total events: 222 (Experimental), 255 (Control)					
Heterogeneity: Tau^2 = 2.19; Chi^2 = 130.97, df = 27 (P<0.00001); I^2 =79%					
Test for overall effect: Z = 0.35 (P = 0.72)					
Total (95% CI)	**3784**	**2908**		**100.0 %**	**1.06 [0.68, 1.66]**
Total events: 1892 (Experimental), 1446 (Control)					
Heterogeneity: Tau^2 = 2.06; Chi^2 = 264.73, df = 55 (P<0.00001); I^2 =79%					
Test for overall effect: Z = 0.26 (P = 0.79)					
Test for subgroup differences: Chi^2 = 0.56, df = 1 (P = 0.45), I^2 =0.0%					



(1) Multi-arm study. Data combined for each VLS.

(2) Multi-arm study. Data combined for each VLS.

(3) Multi-arm study. Data combined for each VLS.

(4) Multi-arm study. Data combined for each VLS.

(5) Multi-arm study. Data combined for each VLS.

(6) Data taken from DCI videolaryngoscope group

(7) Multi-arm study. Data combined for each VLS.

(8) Multi-arm study. Data combined for each VLS.

(9) Multi-arm study. Data combined for each VLS group

(10) Multi-arm study. Data combined for each VLS group

(11) Multi-arm study. Data combined for each VLS group

(12) Multi-arm study. Data combined for each VLS group

(13) Multi-arm study. Data combined for each VLS group

(14) Multi-arm study. Data combined for each VLS group

(15) Multi-arm study. Data combined for each VLS group. Four failures in Macintosh group.

(16) Multi-arm study. Data combined for each VLS group

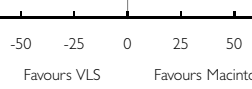
Analysis 9.1. Comparison 9 VLS versus Macintosh, Outcome 1 Time for tracheal intubation.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 9 VLS versus Macintosh

Outcome: 1 Time for tracheal intubation

Study or subgroup	Experimental N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aoi 2010	18	62.9 (26)	18	55.6 (26)			7.30 [-9.69, 24.29]
Arici 2014	40	47.25 (14.92)	40	32.2 (6.58)			15.05 [10.00, 20.10]
Aziz 2012	149	46 (34.2530897)	147	33 (21.6506351)			13.00 [6.48, 19.52]
Bensghir 2010	34	47.9 (5.4)	34	39.9 (4.4)			8.00 [5.66, 10.34]
Bensghir 2013	35	36.6 (3.7)	35	41.1 (4.4)			-4.50 [-6.40, -2.60]
Bilehjani 2009	40	48.8 (47.82)	38	14.5 (8.3)			34.30 [19.25, 49.35]
Carassiti 2013	15	20 (1)	15	22 (3)			-2.00 [-3.60, -0.40]
Cavus 2011 (1)	18	21 (24)	50	11 (14)			10.00 [-1.75, 21.75]
Choi 2011	30	18.2 (5)	30	18.6 (5.1)			-0.40 [-2.96, 2.16]
Dashti 2014	30	9.8 (1.29)	29	8.2 (1.17)			1.60 [0.97, 2.23]
Enomoto 2008	203	53.8 (13.7)	203	50.5 (27)			3.30 [-0.86, 7.46]
Hirabayashi 2009	264	44 (19)	256	71 (44)			-27.00 [-32.86, -21.14]
Hsu 2012	30	45.6 (10.7)	30	62.5 (29.7)			-16.90 [-28.20, -5.60]
Ilyas 2014	64	82.7 (80)	64	50 (32.6)			32.70 [11.54, 53.86]
Kanchi 2011	15	36.43 (2)	15	22.08 (8)			14.35 [10.18, 18.52]
Kim 2013	22	12.9 (6)	23	29.9 (28.5)			-17.00 [-28.91, -5.09]
Komatsu 2010	50	18 (4)	50	35 (16)			-17.00 [-21.57, -12.43]
Lee 2013	20	18.5 (1.55)	20	12.8 (1.39)			5.70 [4.79, 6.61]
Lim 2005	30	41.8 (20.2)	30	56.2 (26.6)			-14.40 [-26.35, -2.45]
Malik 2008 (2)	30	20.5 (5.7)	30	11.6 (6)			8.90 [5.94, 11.86]
Maruyama 2008b	12	29.8 (15.4)	12	16.8 (10.7)			13.00 [2.39, 23.61]
Najafi 2014	150	37.2 (6.4)	150	25.6 (4.1)			11.60 [10.38, 12.82]
Nishikawa 2009	20	22.2 (3.5)	20	21.2 (2.3)			1.00 [-0.84, 2.84]
Peck 2009	27	38.4 (18.9)	27	22.2 (8)			16.20 [8.46, 23.94]
Pournajafian 2014	46	15.9 (6.7)	49	7.8 (3.7)			8.10 [5.90, 10.30]



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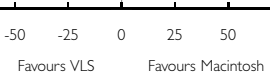
Study or subgroup	Experimental N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Sandhu 2014	100	24.9 (5.6)	100	20.7 (3.6)			4.20 [2.90, 5.50]
Serocki 2013 (3)	31	18.7 (14)	32	11.2 (5.6)			7.50 [2.20, 12.80]
Shippey 2013	25	52.2 (20.9)	25	73.2 (48.1)			-21.00 [-41.56, -0.44]
Siddiqui 2009	20	30.9 (9)	20	13.9 (7.8)			17.00 [11.78, 22.22]
Sun 2005	96	46 (14.8)	99	30 (10)			16.00 [12.44, 19.56]
Suzuki 2008	25	19 (9)	25	18 (8)			1.00 [-3.72, 5.72]
Taylor 2013	44	35.8 (20.4)	44	21.7 (9.4)			14.10 [7.46, 20.74]
Teoh 2010 (4)	100	31.9 (17.6)	100	22.4 (13.6)			9.50 [5.14, 13.86]
Turkstra 2005	9	27 (12)	9	17 (8)			10.00 [0.58, 19.42]
Woo 2012	50	15 (2)	50	15 (2)			0.0 [-0.78, 0.78]
Xue 2007	28	37.4 (9.9)	27	28.4 (11.7)			9.00 [3.26, 14.74]
Yeatts 2013	303	71 (50.4201)	320	56.5 (50.0079)			14.50 [6.61, 22.39]
Test for subgroup differences: Not applicable							



(1) VLS is CMAC4

(2) VLS is Truview EVO2

(3) VLS is Glidescope

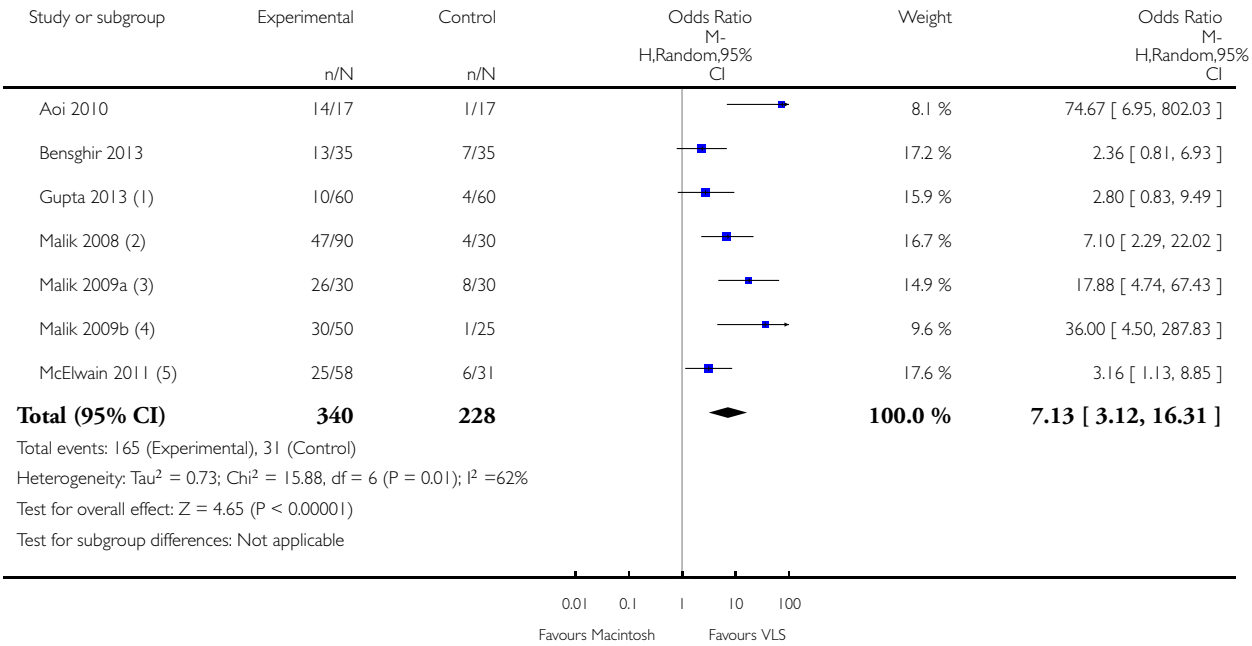
(4) VLS is CMAC

Analysis 10.1. Comparison 10 VLS versus Macintosh, Outcome 1 Intubation difficult score (IDS).

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 10 VLS versus Macintosh

Outcome: 1 Intubation difficult score (IDS)



(1) Combined VLS with and without stylet versus Macintosh with and without stylet

(2) Multi-arm study. Data combined for each VLS group

(3) Multi-arm study. Data combined for each VLS group

(4) Multi-arm study. Data combined for each VLS group

(5) Multi-arm study. Data combined for each VLS group

Analysis 11.1. Comparison 11 VLS versus Macintosh, Outcome 1 Improved visualization Cormack & Lehane (CL) 1.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 11 VLS versus Macintosh

Outcome: 1 Improved visualization Cormack % Lehane (CL) 1

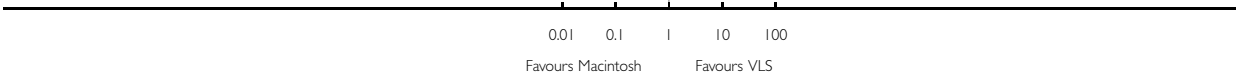
Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Andersen 2011	35/50	23/50		6.3 %	2.74 [1.20, 6.23]
Aoi 2010	17/17	1/17		1.7 %	385.00 [14.63, 10135.01]
Arici 2014	33/40	27/40		5.6 %	2.27 [0.79, 6.49]
Aziz 2012	103/149	72/147		7.1 %	2.33 [1.45, 3.75]
Bensghir 2010	24/34	13/34		5.7 %	3.88 [1.41, 10.66]
Bensghir 2013	26/35	14/35		5.7 %	4.33 [1.57, 11.97]
Frohlich 2011	29/30	21/30		3.1 %	12.43 [1.46, 105.74]
Griesdale 2012	17/19	6/19		3.8 %	18.42 [3.18, 106.59]
Gupta 2013 (1)	17/60	7/60		5.9 %	2.99 [1.14, 7.88]
Kim 2013	22/22	0/23		1.2 %	2115.00 [40.22, 111205.69]
Komatsu 2010	23/50	24/50		6.4 %	0.92 [0.42, 2.02]
Lee 2012 (2)	24/25	14/25		3.0 %	18.86 [2.20, 161.99]
Lim 2005	20/30	4/30		4.9 %	13.00 [3.55, 47.60]
Lin 2012	75/83	50/82		6.2 %	6.00 [2.56, 14.09]
Malik 2008 (3)	62/90	6/30		5.8 %	8.86 [3.26, 24.07]
Malik 2009a (4)	30/30	6/27		2.0 %	201.77 [10.79, 3774.56]
Malik 2009b (5)	47/50	2/25		3.6 %	180.17 [28.12, 1154.35]
Maruyama 2008b	12/12	10/12		1.8 %	5.95 [0.26, 138.25]
McElwain 2011 (6)	35/58	6/31		5.7 %	6.34 [2.25, 17.84]
Takenaka 2011	35/35	20/34		2.1 %	50.22 [2.84, 886.73]
Teoh 2010 (7)	262/300	58/100		7.0 %	4.99 [2.96, 8.42]
Walker 2009	55/60	47/60		5.5 %	3.04 [1.01, 9.16]
Total (95% CI)	**1279**	**961**		**100.0 %**	**6.77 [4.17, 10.98]**

Total events: 1003 (Experimental), 431 (Control)

Heterogeneity: $Tau^2 = 0.80$; $Chi^2 = 79.95$, df = 21 (P<0.00001); $I^2 = 74\%$

Test for overall effect: Z = 7.74 (P < 0.00001)

Test for subgroup differences: Not applicable



(1) Combined VLS with and without stylet versus Macintosh with and without stylet

(2) Data used from the Storz comparison only

(3) Multi-arm study. Data combined for each VLS group

(4) Data in Macintosh group is missing 3 patients

(5) Multi-arm study. Data combined for each VLS group

(6) Multi-arm study. Data combined for each VLS group

(7) Multi-arm study. Data combined for each VLS group

Analysis 12.1. Comparison 12 VLS versus Macintosh, Outcome 1 Improved visualization Cormack & Lehane (CL) 1 to 4.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 12 VLS versus Macintosh

Outcome: 1 Improved visualization Cormack % Lehane (CL) 1 to 4

Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
1 CL 1 to 2					
Andersen 2011	48/50	36/50		2.8 %	9.33 [1.99, 43.68]
Aoi 2010	17/17	8/17		1.9 %	39.12 [2.03, 754.53]
Arici 2014	38/40	40/40		1.9 %	0.19 [0.01, 4.09]
Aziz 2012	139/149	119/147		3.2 %	3.27 [1.53, 7.01]
Bensghir 2010	32/34	24/34		2.8 %	6.67 [1.34, 33.28]
Bensghir 2013	33/35	26/35		2.8 %	5.71 [1.13, 28.75]
Frohlich 2011	30/30	28/30		1.9 %	5.35 [0.25, 116.31]
Griesdale 2012	17/19	14/19		2.7 %	3.04 [0.51, 18.11]
Gupta 2013	49/60	24/60		3.2 %	6.68 [2.90, 15.37]
Kim 2013	22/22	8/23		1.9 %	82.06 [4.41, 1528.53]
Komatsu 2010	48/50	47/50		2.6 %	1.53 [0.24, 9.59]
Lee 2012 (1)	25/25	21/25		1.9 %	10.67 [0.54, 209.64]

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Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Lim 2005	30/30	22/30		2.0 %	23.04 [1.26, 420.37]
Lin 2012	82/83	77/82		2.4 %	5.32 [0.61, 46.61]
Malik 2008	88/90	25/30		2.7 %	8.80 [1.61, 48.12]
Malik 2009a	30/30	25/27		1.9 %	5.98 [0.27, 130.33]
Malik 2009b	50/50	17/25		2.0 %	49.06 [2.69, 894.72]
Maruyama 2008b	12/12	12/12			Not estimable
McElwain 2011	54/58	21/31		3.0 %	6.43 [1.82, 22.76]
Takenaka 2011	35/35	32/34		1.9 %	5.46 [0.25, 118.05]
Teoh 2010	297/300	95/100		2.9 %	5.21 [1.22, 22.21]
Walker 2009	59/60	60/60		1.8 %	0.33 [0.01, 8.21]
Subtotal (95% CI)	**1279**	**961**		**50.0 %**	**5.42 [3.70, 7.95]**
Total events: 1235 (Experimental), 781 (Control)					
Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 21.11$, df = 20 (P = 0.39); $I^2 = 5\%$					
Test for overall effect: Z = 8.66 (P < 0.00001)					
2 CL 3 to 4					
Andersen 2011	2/50	14/50		2.8 %	0.11 [0.02, 0.50]
Aoi 2010	0/17	9/17		1.9 %	0.03 [0.00, 0.49]
Arici 2014	2/40	0/40		1.9 %	5.26 [0.24, 113.11]
Aziz 2012	10/149	28/147		3.2 %	0.31 [0.14, 0.66]
Bensghir 2010	2/34	10/34		2.8 %	0.15 [0.03, 0.75]
Bensghir 2013	2/35	9/35		2.8 %	0.18 [0.03, 0.88]
Frohlich 2011	0/30	2/30		1.9 %	0.19 [0.01, 4.06]
Griesdale 2012	2/19	5/19		2.7 %	0.33 [0.06, 1.96]
Gupta 2013 (2)	11/60	36/60		3.2 %	0.15 [0.07, 0.34]
Kim 2013	0/22	15/23		1.9 %	0.01 [0.00, 0.23]
Komatsu 2010	2/50	3/50		2.6 %	0.65 [0.10, 4.09]
Lee 2012 (3)	0/25	4/25		1.9 %	0.09 [0.00, 1.84]
Lim 2005	0/30	8/30		2.0 %	0.04 [0.00, 0.79]
Lin 2012	1/83	5/82		2.4 %	0.19 [0.02, 1.64]
Malik 2008 (4)	2/90	5/30		2.7 %	0.11 [0.02, 0.62]
Malik 2009a (5)	0/30	2/27		1.9 %	0.17 [0.01, 3.64]
Malik 2009b (6)	0/50	8/25		2.0 %	0.02 [0.00, 0.37]

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Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Maruyama 2008b	0/12	0/12			Not estimable
McElwain 2011 (7)	4/58	10/31		3.0 %	0.16 [0.04, 0.55]
Takenaka 2011	0/35	2/34		1.9 %	0.18 [0.01, 3.96]
Teoh 2010 (8)	3/300	5/100		2.9 %	0.19 [0.05, 0.82]
Walker 2009	1/60	0/60		1.8 %	3.05 [0.12, 76.39]
Subtotal (95% CI)	**1279**	**961**		**50.0 %**	**0.18 [0.13, 0.27]**
Total events: 44 (Experimental), 180 (Control)					
Heterogeneity: Tau^2 = 0.04; Chi^2 = 21.11, df = 20 (P = 0.39); I^2 =5%					
Test for overall effect: Z = 8.66 (P < 0.00001)					
Total (95% CI)	**2558**	**1922**		**100.0 %**	**1.00 [0.54, 1.87]**
Total events: 1279 (Experimental), 961 (Control)					
Heterogeneity: Tau^2 = 2.99; Chi^2 = 208.60, df = 41 (P<0.00001); I^2 =80%					
Test for overall effect: Z = 0.00 (P = 1.0)					
Test for subgroup differences: Chi^2 = 150.12, df = 1 (P = 0.00), I^2 =99%					

(1) Data taken from Storz group only

(2) Combined VLS with and without stylet versus Macintosh with and without stylet

(3) Data taken from Storz group

(4) Multi-arm study. Data combined for each VLS group

(5) Data in Macintosh group is missing 3 patients

(6) Multi-arm study. Data combined for each VLS group

(7) Multi-arm study. Data combined for each VLS group

(8) Multi-arm study. Data combined for each VLS group

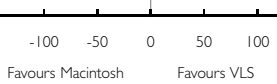
Analysis 13.1. Comparison 13 VLS versus Macintosh, Outcome 1 Improved visualization POGO.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 13 VLS versus Macintosh

Outcome: 1 Improved visualization POGO

Study or subgroup	Experimental N	Mean(SD)	Control N	Mean(SD)	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
Choi 2011	30	89.6 (20)	30	67.6 (24.7)		22.00 [10.63, 33.37]
Peck 2009	54	77.3 (26.5)	54	11.7 (21.3)		65.60 [56.53, 74.67]
Sandhu 2014	100	94.4 (10.5)	100	74.2 (29.5)		20.20 [14.06, 26.34]
Woo 2012	50	97 (4)	50	48 (29)		49.00 [40.89, 57.11]

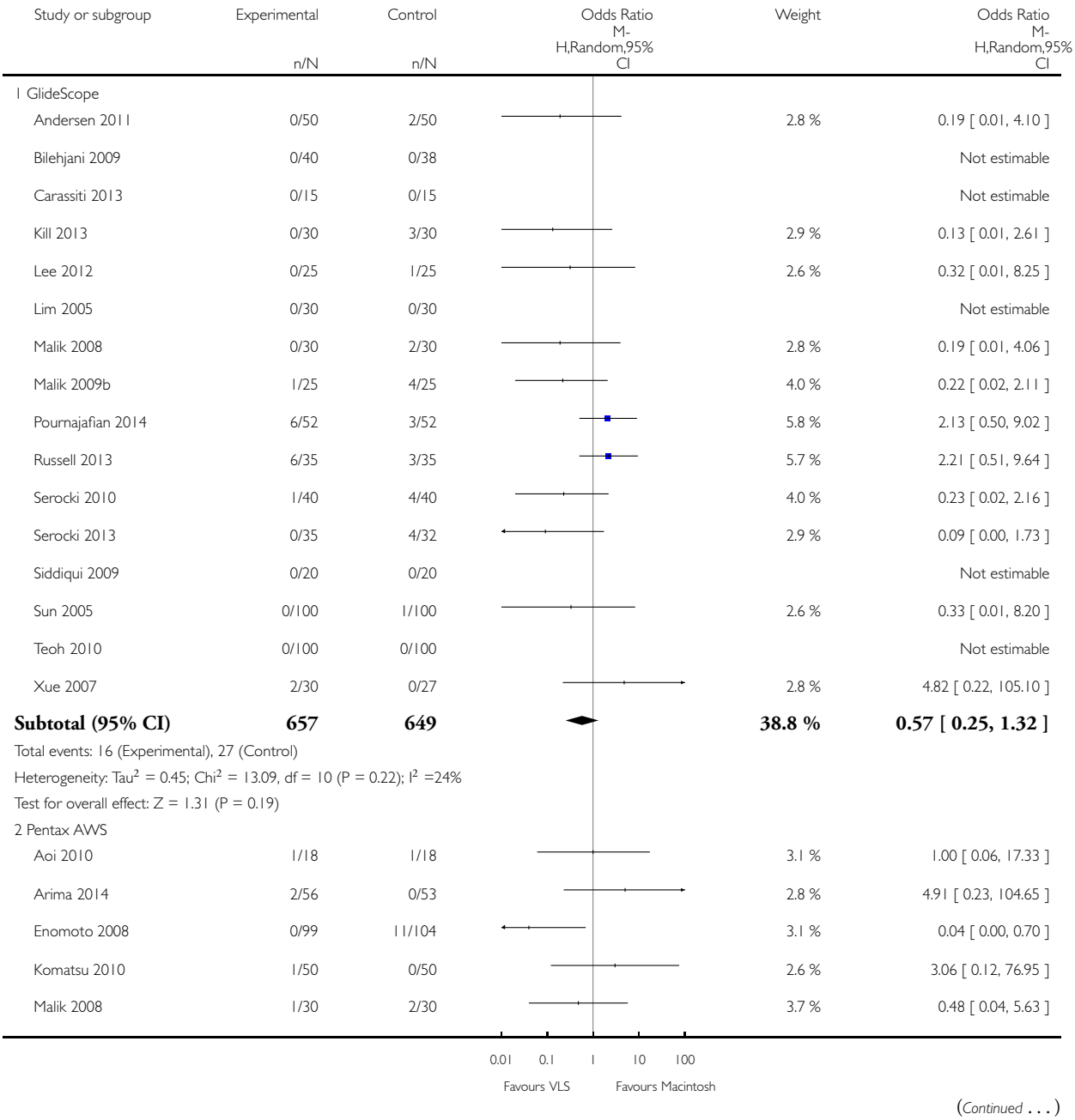


Analysis 14.1. Comparison 14 VLS versus Macintosh, Outcome 1 Failed intubation by scope.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 14 VLS versus Macintosh

Outcome: 1 Failed intubation by scope



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Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Malik 2009a	0/30	0/30			Not estimable
Malik 2009b	0/25	4/25		2.9 %	0.09 [0.00, 1.84]
Nishikawa 2009	0/20	0/20			Not estimable
Takenaka 2011	0/35	5/34		3.0 %	0.08 [0.00, 1.42]
Teoh 2010	0/100	0/100			Not estimable
Woo 2012	0/50	59/109		3.1 %	0.01 [0.00, 0.14]
Subtotal (95% CI)	**513**	**573**		**24.2 %**	**0.24 [0.05, 1.20]**
Total events: 5 (Experimental), 82 (Control)					
Heterogeneity: Tau^2 = 3.10; Chi^2 = 17.06, df = 7 (P = 0.02); I^2 =59%					
Test for overall effect: Z = 1.74 (P = 0.082)					
3 McGrath					
Arici 2014	0/40	0/40			Not estimable
Ilyas 2014 (1)	5/64	0/64		3.0 %	11.92 [0.65, 220.30]
Lee 2012	3/25	1/25		3.9 %	3.27 [0.32, 33.84]
Taylor 2013	0/44	18/44		3.1 %	0.02 [0.00, 0.28]
Walker 2009	1/60	0/60		2.6 %	3.05 [0.12, 76.39]
Subtotal (95% CI)	**233**	**233**		**12.5 %**	**1.18 [0.06, 23.92]**
Total events: 9 (Experimental), 19 (Control)					
Heterogeneity: Tau^2 = 7.36; Chi^2 = 13.80, df = 3 (P = 0.003); I^2 =78%					
Test for overall effect: Z = 0.11 (P = 0.92)					
4 C-MAC					
Aziz 2012	6/149	12/147		6.8 %	0.47 [0.17, 1.29]
Cavus 2011	0/37	6/50		3.0 %	0.09 [0.00, 1.67]
Jungbauer 2009	1/100	8/100		4.3 %	0.12 [0.01, 0.95]
Lee 2009	0/41	0/44			Not estimable
Lee 2012	0/25	1/25		2.6 %	0.32 [0.01, 8.25]
McElwain 2011	1/29	2/31		3.7 %	0.52 [0.04, 6.04]
Serocki 2010	1/40	4/40		4.0 %	0.23 [0.02, 2.16]
Teoh 2010	0/100	0/100			Not estimable
Subtotal (95% CI)	**521**	**537**		**24.4 %**	**0.32 [0.15, 0.68]**
Total events: 9 (Experimental), 33 (Control)					
Heterogeneity: Tau^2 = 0.0; Chi^2 = 2.51, df = 5 (P = 0.77); I^2 =0.0%					
Test for overall effect: Z = 2.96 (P = 0.0031)					
Total (95% CI)	**1924**	**1992**		**100.0 %**	**0.40 [0.21, 0.75]**
Total events: 39 (Experimental), 161 (Control)					
Heterogeneity: Tau^2 = 1.26; Chi^2 = 52.10, df = 28 (P = 0.004); I^2 =46%					

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Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Test for overall effect: Z = 2.86 (P = 0.0042)					
Test for subgroup differences: Chi^2 = 1.87, df = 3 (P = 0.60), I^2 =0.0%					

(1) Two failed due to equipment failure, three failed due to difficulty passing tube

Analysis 15.1. Comparison 15 VLS versus Macintosh, Outcome 1 Failed intubation by airway difficulty.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 15 VLS versus Macintosh

Outcome: 1 Failed intubation by airway difficulty

Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
1 Predicted not difficult					
Andersen 2011	0/50	2/50		2.8 %	0.19 [0.01, 4.10]
Arici 2014	0/40	0/40			Not estimable
Bensghir 2010	0/34	2/34		2.8 %	0.19 [0.01, 4.07]
Bensghir 2013	0/35	1/35		2.6 %	0.32 [0.01, 8.23]
Bilehjani 2009	0/40	0/38			Not estimable
Carassiti 2013	0/15	0/15			Not estimable
Ilyas 2014 (1)	5/64	0/64		3.0 %	11.92 [0.65, 220.30]
Kill 2013	0/30	3/30		2.9 %	0.13 [0.01, 2.61]
Lee 2012 (2)	3/75	1/25		3.9 %	1.00 [0.10, 10.07]
Lin 2012	2/85	3/85		4.9 %	0.66 [0.11, 4.04]
Nishikawa 2009	0/20	0/20			Not estimable
Pournajafian 2014	6/52	3/52		5.7 %	2.13 [0.50, 9.02]

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Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Russell 2013	6/35	3/35		5.7 %	2.21 [0.51, 9.64]
Siddiqui 2009	0/20	0/20			Not estimable
Sun 2005	0/100	1/100		2.6 %	0.33 [0.01, 8.20]
Takenaka 2011	0/35	5/34		3.0 %	0.08 [0.00, 1.42]
Walker 2009	1/60	0/60		2.6 %	3.05 [0.12, 76.39]
Woo 2012	0/50	59/109		3.1 %	0.01 [0.00, 0.14]
Xue 2007	2/30	0/27		2.8 %	4.82 [0.22, 105.10]
Subtotal (95% CI)	**870**	**873**		**48.2 %**	**0.61 [0.22, 1.67]**
Total events: 25 (Experimental), 83 (Control)					
Heterogeneity: Tau^2 = 1.93; Chi^2 = 29.56, df = 13 (P = 0.01); I^2 =56%					
Test for overall effect: Z = 0.96 (P = 0.34)					
2 Predicted difficult					
Aziz 2012	6/149	12/147		6.8 %	0.47 [0.17, 1.29]
Cordovani 2013	3/24	5/20		5.4 %	0.43 [0.09, 2.08]
Jungbauer 2009	1/100	8/100		4.3 %	0.12 [0.01, 0.95]
Malik 2009b (3)	1/50	4/25		4.0 %	0.11 [0.01, 1.02]
Serocki 2010 (4)	2/80	4/40		5.0 %	0.23 [0.04, 1.32]
Serocki 2013 (5)	0/63	4/32		2.9 %	0.05 [0.00, 0.96]
Subtotal (95% CI)	**466**	**364**		**28.4 %**	**0.28 [0.15, 0.55]**
Total events: 13 (Experimental), 37 (Control)					
Heterogeneity: Tau^2 = 0.0; Chi^2 = 4.12, df = 5 (P = 0.53); I^2 =0.0%					
Test for overall effect: Z = 3.70 (P = 0.00021)					
3 Simulated difficult					
Aoi 2010	1/18	1/18		3.1 %	1.00 [0.06, 17.33]
Enomoto 2008	0/99	11/104		3.1 %	0.04 [0.00, 0.70]
Komatsu 2010	1/50	0/50		2.6 %	3.06 [0.12, 76.95]
Lim 2005	0/30	0/30			Not estimable
Malik 2008 (6)	3/90	2/30		4.8 %	0.48 [0.08, 3.04]
Malik 2009a	0/30	0/30			Not estimable
McElwain 2011 (7)	1/58	2/31		3.7 %	0.25 [0.02, 2.92]
Peck 2009	0/27	13/27		3.0 %	0.02 [0.00, 0.35]
Taylor 2013	0/44	18/44		3.1 %	0.02 [0.00, 0.28]
Subtotal (95% CI)	**446**	**364**		**23.3 %**	**0.18 [0.04, 0.77]**
Total events: 6 (Experimental), 47 (Control)					
Heterogeneity: Tau^2 = 2.05; Chi^2 = 12.88, df = 6 (P = 0.04); I^2 =53%					

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Study or subgroup	Experimental n/N	Control n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Test for overall effect: Z = 2.31 (P = 0.021)					
Total (95% CI)	**1782**	**1601**	◆	**100.0 %**	**0.35 [0.18, 0.65]**
Total events: 44 (Experimental), 167 (Control)					
Heterogeneity: Tau^2 = 1.27; Chi^2 = 52.44, df = 26 (P = 0.002); I^2 =50%					
Test for overall effect: Z = 3.29 (P = 0.00099)					
Test for subgroup differences: Chi^2 = 2.29, df = 2 (P = 0.32), I^2 =13%					

(1) Two failed due to equipment failure, three failed due to difficulty passing tube

(2) Multi-arm study. Data combined for each VLS group

(3) Multi-arm study. Data combined for each VLS group

(4) Multi-arm study. Data combined for each VLS group

(5) Multi-arm study. Data combined for each VLS group

(6) Multi-arm study. Data combined for each VLS group

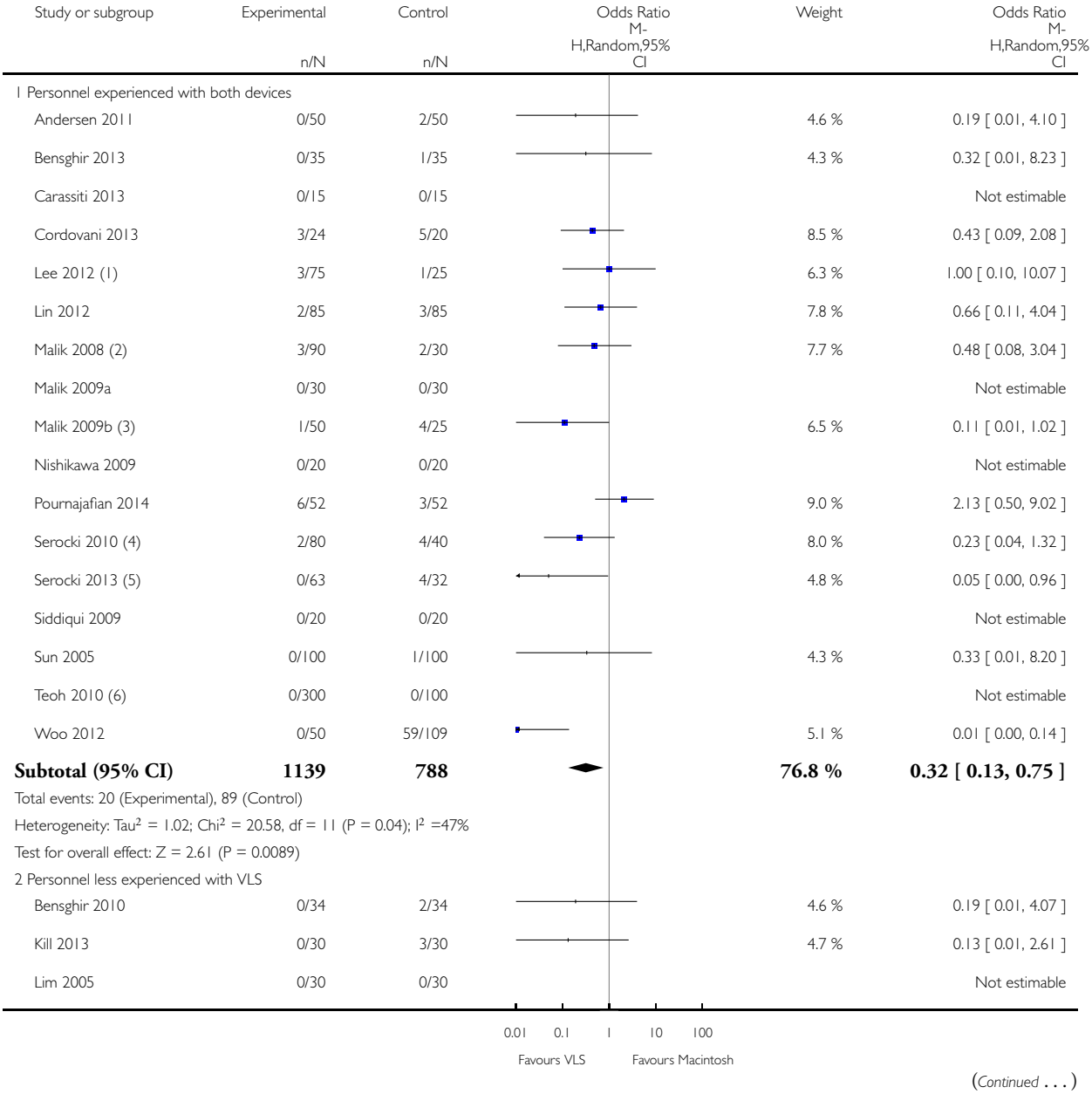
(7) Multi-arm study. Data combined for each VLS group

Analysis 16.1. Comparison 16 VLS versus Macintosh, Outcome 1 Failed intubation by experience of personnel.

Review: Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation

Comparison: 16 VLS versus Macintosh

Outcome: 1 Failed intubation by experience of personnel



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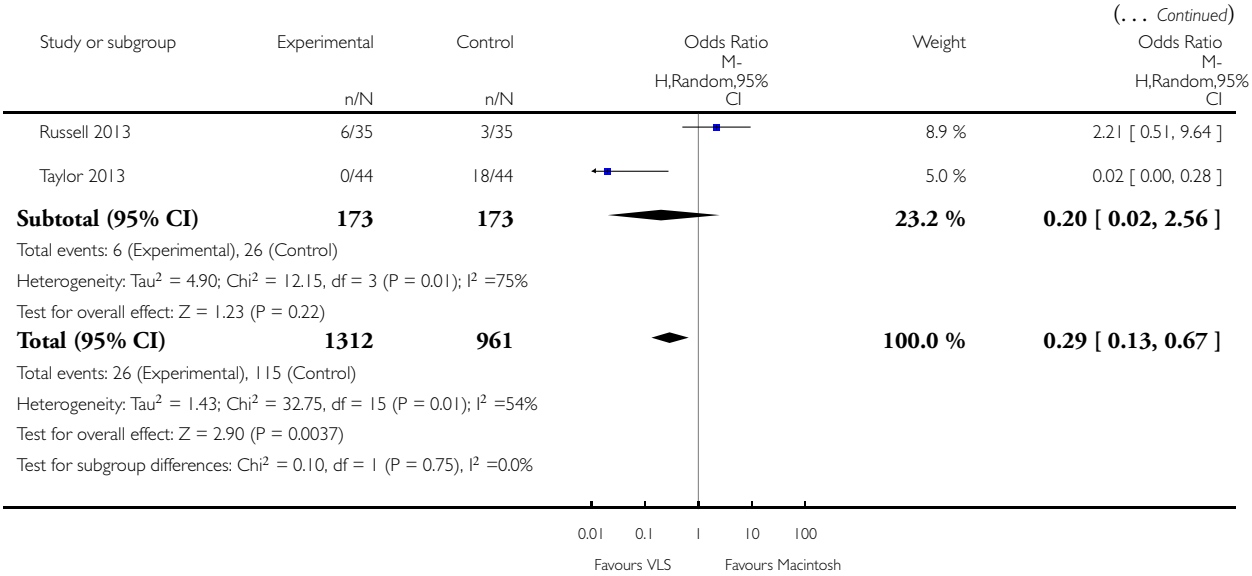

(1) Multi-arm study. Data combined for each VLS group

(2) Multi-arm study. Data combined for each VLS group

(3) Multi-arm study. Data combined for each VLS group

(4) Multi-arm study. Data combined for each VLS group

(5) Multi-arm study. Data combined for each VLS group

(6) Multi-arm study. Data from each VLS group combined

APPENDICES

Appendix 1. Example manufacturers of videolaryngoscopes and stylets

1. Storz V-MAC, Storz C-MAC and Storz C-Mac D-blade *(*Karl Storz GmbH & Co KG, Tuttlingen, Germany).
2. McGrath Series 5 and McGrath Mac (Aircraft Medical Limited, Edinburgh, UK).
3. Glidescope Video Laryngoscope (Verathon Medical Inc, Bothell, WA, USA).
4. Pentax Airway scope (Pentax˙AWS, Ambu A/S, Ballerup, Denmark).
5. Airtraq (Prodol Meditec S.A.,Vizcaya, Spain). Bullard (Circon ACMI, Stamford, CT, USA).
6. Venner AP Advance (Intervent Direct, Buckinghamshire, UK). King Vision (Kingsystems, IN, USA).
7. Vividtrac (Vivid Medical Inc, CA, USA). CoPilot VL (Magaw Medical, TX, USA).
8. Disposable videolaryngoscope (Anatech Medical Ltd, New Zealand).
9. Ue scope (Taizhou Hanchuang Medical Apparatus Technology Co Ltd, Taizhou, China).

Appendix 2. MEDLINE search strategy - via Ovid

1. (video?laryngoscop* or ((video or indirect) adj3 laryngoscop*) or Airtraq or Bullard or Pentax or Glidescope or McGrath or Storz or Venner or King Vision or Vividtrac or CoPilot VL or UE scope).mp.
2. ((randomized controlled trial or controlled clinical trial).pt. or randomized.ab. or placebo.ab. or drug therapy.fs. or randomly.ab. or trial.ab. or groups.ab.) not (animals not (humans and animals)).sh.
3. 1 and 2

Appendix 3. Embase search strategy - via Ovid

1. (video?laryngoscop* or ((video or indirect) adj3 laryngoscop*) or Airtraq or Bullard or Pentax or Glidescope or McGrath or Storz or Venner or King Vision or Vividtrac or CoPilot VL or UE scope).mp.
2. ((randomized controlled trial or controlled clinical trial).pt. or randomized.ab. or placebo.ab. or drug therapy.fs. or randomly.ab. or trial.ab. or groups.ab.) not (animals not (humans and animals)).sh.
3. 1 and 2

Appendix 4. CENTRAL search strategy

1. video*laryngoscop*
2. (video or indirect) next/3 laryngoscop*
3. Airtraq
4. Bullard
5. Pentax
6. Glidescope
7. McGrath
8. Storz
9. Venner
10. King Vision
11. Vividtrac
12. CoPilot VL
13. UE Scope
14. #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13

Appendix 5. Details of VLS designs

Names of VLS in common use	Acronyms, where relevant	Additional details
GlideScope	-	Use with a stylet recommended
Pentax AWS	AWS (Airway Scope)	Conduited May be used with a stylet
C-MAC	Full name, not an acronym	May be used with a stylet
Berci DCI	DCI (Direct Coupled Interface)	May be used with a stylet
Truview EVO2	EVO (Evolution)	May be used with a stylet

(*Continued*)

CEL-100	Full name, not an acronym, but made by Connell Energy Technology	May be used with a stylet
McGrath Series 5	-	May be used with a stylet
C-MAC D-blade	D (Dorges), but official name is D-blade	Use with stylet is preferred
Airtraq (with video)	-	Conduited May be used with a stylet

CONTRIBUTIONS OF AUTHORS

Sharon R Lewis (SL), Andrew R Butler (AB), Joshua Parker (JP), Tim M Cook (TC), Andrew F Smith (AS).

Conceiving the review: AS.

Co-ordinating the review: SL.

Undertaking manual searches: SL.

Screening search results: SL, AB.

Organizing retrieval of papers: SL.

Screening retrieved papers against inclusion criteria: SL, AB.

Appraising quality of papers: SL, AB, JP.

Abstracting data from papers: SL, AB, JP.

Writing to authors of papers for additional information: SL.

Managing data for the review: SL.

Entering data into Review Manager (RevMan 5.3): SL.

Analysing RevMan statistical data: SL.

Interpreting data: SL, AB, AS, TC.

Making statistical inferences: SL, TC, AS.

Writing the review: SL, AB, AS, TC.

Securing funding for the review: AS.

Performing previous work that was the foundation of the present study: N/A

Serving as guarantor for the review (one review author): AS.

Taking responsibility for reading and checking the review before submission: SL.

DECLARATIONS OF INTEREST

Sharon R Lewis: see Sources of support.

Andrew R Butler: see Sources of support.

Joshua Parker: none known.

Tim M Cook was paid for lecturing, several years ago (> 36 months), by Intavent Orthofix and the LMA Company. This company manufactures and distributes several supraglottic airway devices and one videolaryngoscope: AP Venner. Dr Cook's department has received free or at cost airway equipment from numerous 'airway' companies for evaluation or research. He and his family have no financial investments and no ownership of any such company of which he is aware. Dr Cook has reported no other conflicts of interest. He spoke at a Storz educational meeting in 2015, and the company paid the costs of travel to this meeting and accommodations. He received no financial benefit from the meeting and was not paid to speak.

Andrew Bulter: See Sources of support.

Andrew F Smith: See Sources of support.

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

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DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We made the following changes to the protocol (Lewis 2014).

Title

We changed the title from "Videolaryngoscopy versus direct laryngoscopy for adult surgical patients requiring tracheal intubation for general anaesthesia" to "Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation" because this better reflects the focus of the review.

Review authors

Amanda Nicholson contributed to the protocol but not to the review.

Objectives

We stated inclusion of participants with a known or predicted difficult airway, which reflected our intended subgroup analysis.

Searching of other resources

We did not contact investigators known to be involved in previous studies to enquire about ongoing or unpublished studies.

Types of outcome measures

We edited the definition of our secondary outcome, serious respiratory complications, which stated "including aspiration" to "pulmonary aspiration of gastric contents and lower respiratory tract infection". This added greater detail to the definition.

Selection of studies; data extraction and management

We did not use paper eligibility and data extraction forms as previously indicated in the protocol. We used on-line software (www.covidence.org) for this stage of the review.

Measures of treatment effect

We did not collect time-to-event data for mortality. Only two studies reported mortality, and we did not combine these results.

Unit of analysis issues

We were not able to amalgamate data into a single pair-wise comparison without creating a unit of analysis issue. Therefore, we made the decision during the review to include data from the VLS group that would be closest to a result of 'no effect', and to assess this decision in sensitivity analysis.

Dealing with missing data

We did not perform sensitivity analysis for missing data to compare effects of complete case scenario, worst case scenario and last observation carried forward.

Assessment of reporting bias

We did not conduct further assessment of publication bias with the Eggers test.

Effects of interventions

We altered time points for the sore throat outcome to reflect the time points commonly reported in the included studies.

Subgroup analysis and investigation of heterogeneity

We did not carry out subgroup analysis on outcomes other than our primary outcome of failed intubation. We added a sentence to the review to explain how we had defined intubator experience by number of uses.

Summary of findings

We did not include the outcome 'Number of attempts' in the 'Summary of findings table' but replaced it with the outcome 'Proportion of successful first attempts'. We added data for the outcome 'Sore throat'. We altered the definition of hypoxia in the 'Summary of findings table' to match that provided in the 'Primary outcomes' section. We altered the order of outcomes in the 'Summary of findings' section to reflect the order in the sections Types of outcome measures and Effects of interventions.