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A comparison of McGrath MAC, AIRWAY SCOPE®, and AceScope® video laryngoscopes in novice healthcare providers: a randomized crossover simulation study

Musashi Yahagi[1*], Kyuma Omi[1] and Yuichi Yaguchi[1]

Abstract

Background Video laryngoscopes are widely used for tracheal intubation, particularly in challenging airway scenarios. The McGrath MAC, AIRWAY SCOPE®, and AceScope® are popular video laryngoscopes with different design features. This study aimed to compare the effectiveness and usability of these three devices in novice healthcare providers during simulated tracheal intubation scenarios employing a manikin.

Methods Sixty novice healthcare providers, including nurses and pharmacists, were enrolled in this randomized crossover study. Participants performed tracheal intubation using the McGrath MAC, AIRWAY SCOPE, and AceScope in both normal airway and cervical spine immobilization models. Primary outcomes were intubation success rate and time to intubation. Secondary outcomes included user preferences, device ease of use, and the incidence of dental injuries.

Results The AIRWAY SCOPE demonstrated the shortest intubation time in both normal airway and cervical spine immobilization models (14.90 ± 1.76 s and 23.80 ± 2.43 s, respectively), followed by the McGrath MAC and AceScope. All devices exhibited high success rates, and there were no significant differences in perceived difficulty among the three video laryngoscopes. The incidence of dental injuries was generally comparable among the devices. However, in the cervical spine immobilization model, the AceScope demonstrated a significantly higher rate of dental injuries compared to the McGrath MAC ($p < 0.05$), highlighting a potential concern for clinical practice.

Conclusions The AIRWAY SCOPE was the most efficient video laryngoscope in terms of intubation time, followed by the McGrath MAC and AceScope. However, all devices showed high success rates and no significant differences in perceived difficulty. Further research is needed to validate these findings in clinical settings and investigate the impact of device-specific features on intubation outcomes and dental injury incidence.

Trial registration Registration number: jRCT1030240598 (https://jrct.niph.go.jp/re/reports/detail/91422) The registration date of the clinical trial is January 8, 2025.UMIN000050394.

Keywords Airway management, Video laryngoscopy

*Correspondence:
Musashi Yahagi
musasum0710@yahoo.co.jp
[1]Department of Anesthesiology, Hitachi General Hospital, 2-1-1 Jonan-cho, Hitachi 317-0077, Ibaraki, Japan

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Introduction

Video laryngoscopes have significantly improved tracheal intubation by providing enhanced airway visualization, particularly in difficult airway scenarios. Recent guidelines from the European Society of Anaesthesiology and Intensive Care (ESAIC) emphasize the necessity of thorough airway assessment and the utilization of advanced airway management devices, including video laryngoscopes, to optimize perioperative airway management [1].

While previous studies have evaluated the efficacy of McGrath MAC and AIRWAY SCOPE® (Pentax Corporation, Tokyo, Japan) in various clinical scenarios, limited data exist on their comparative performance when used by novice healthcare providers [2]. Furthermore, the AceScope, a newly developed video laryngoscope integrating design elements from both devices, has not been extensively studied in this population. This study is the first to systematically compare these three video laryngoscopes in novice users, assessing their impact on procedural efficiency, intubation success rates, and ease of use. By focusing on this underexplored aspect, our findings may contribute to optimizing device selection and training strategies in airway management education.

The McGrath MAC (Aircraft Medical Ltd, Scotland, United Kingdom) and are two widely used video laryngoscopes that have demonstrated efficacy in facilitating tracheal intubation across various clinical settings [3, 4, 5, 6]. The McGrath MAC has been shown to provide superior glottic visualization and higher intubation success rates in both routine and difficult airway scenarios, making it a preferred device among both novice and experienced clinicians [3, 4, 5]. Notably, previous studies have reported that the McGrath MAC significantly reduces intubation time and enhances first-attempt success rates compared to direct laryngoscopy, particularly in simulated difficult airways [3, 4, 5]. The AIRWAY SCOPE, incorporating an integrated guide rail system and disposable blade, has been particularly advantageous in scenarios involving limited mouth opening or restricted neck mobility, demonstrating high success rates even in patients with challenging airway anatomy. Clinical studies have reported a first-attempt intubation success rate 100% with the AIRWAY SCOPE in patients with restricted neck movement, outperforming conventional direct laryngoscopy [6]. These devices have established a standard in video laryngoscopy, against which newer devices, such as the AceScope® (IMI Co., Ltd., Seoul, Korea), are now being evaluated [7, 8].

The AceScope is a novel video laryngoscope that integrates the enhanced glottic visualization of the McGrath MAC with the AIRWAY SCOPE's disposable blade and guide rail system [7, 8]. It features an improved angle adjustment mechanism for optimized glottic exposure, a lightweight design to reduce operator fatigue, and an ergonomically positioned monitor to enhance usability. These refinements are intended to improve maneuverability and facilitate intubation, particularly for novice healthcare providers. However, despite its innovative design, limited clinical evidence exists regarding the comparative effectiveness and usability of the AceScope relative to other established video laryngoscopes [7, 8].

Video laryngoscopes are widely utilized for tracheal intubation, particularly among novice healthcare providers, making their usability in this population clinically relevant. Studies indicate that novice users face a steeper learning curve with video laryngoscopy than with direct laryngoscopy, highlighting the need for intuitive device design [9, 10]. This study evaluates whether the AceScope's novel features improve usability, reduce procedural errors, and accelerate proficiency acquisition in airway management, with potential implications for medical education and training [7, 8].

This study aims to evaluate and compare the performance of the AceScope, McGrath MAC, and AIRWAY SCOPE in terms of intubation success rate and time to intubation in simulated tracheal intubation scenarios performed by novice healthcare providers using a manikin model. Additionally, user preferences and device usability will be assessed as secondary outcomes in both simulated normal and difficult airway conditions. Given the increasing reliance on video laryngoscopy in contemporary airway management, this study seeks to provide valuable insights into whether the AceScope offers distinct advantages over established video laryngoscopes, potentially influencing future clinical practice and airway management training protocols [7, 8].

Materials and methods

After obtaining approval from the Ethics Committee of Hitachi General Hospital (Approval No. 2023-22, Clinical Research Registry No. jRCT1030240598), written informed consent was secured from 60 nurses and pharmacists lacking prior tracheal intubation experience to participate in this randomized crossover study. The novices received verbal and demonstrative instruction from a board-certified anesthesiologist in Japan on the utilization of three types of video laryngoscopes (McGrath MAC, AIRWAY SCOPE, and AceScope). A malleable stylet was inserted into the endotracheal tube (ETT) and bent into a "field hockey stick" shape for intubation with the McGrath MAC [9, 10]. In this study, two types of airway management simulators, the Laerdal Airway Management Trainer (Laerdal Medical, Stavanger, Norway), were prepared: a "normal airway model" that allowed subjects to freely and arbitrarily adjust the simulator's inherent head extension angle, and a "Cervical Spine Immobilization Model," which was a custom-made

difficult airway version created by the principal investigator [11, 12]. The latter involved modifying the Laerdal Airway Management Trainer by securing an adult-sized cervical spine protection collar (Philadelphia Collar, Ossur, Reykjavík, Iceland) tightly around the simulator's neck, thereby completely restricting head extension. This modification simulated a difficult airway scenario where manual in-line stabilization was applied, mimicking clinical conditions in patients with cervical spine injuries. Subsequently, participants were provided with five minutes of free training time for each device. Previous research has established that a brief training period, such as five minutes, is adequate for novice operators to attain fundamental proficiency in video laryngoscopy [13, 14]. This timeframe was selected due to its practicality in clinical settings and its prior validation in comparable studies. Following the five minutes training session, participants were required to perform tracheal intubation within two minutes using each device. Each participant was allowed up to three attempts per device. Failure to achieve successful tracheal intubation with at least one device within three attempts resulted in exclusion from the study. A randomized sequence of the six intubation scenarios was generated using a web-based randomization tool (https://www.random.org), ensuring that each value appeared once without duplication. An independent physician, uninvolved in the tracheal intubation demonstrations, conducted the randomization to ensure unbiased allocation and enhance study reproducibility. The scenarios included: (1) intubation with McGrath MAC in a normal airway model, (2) intubation with McGrath MAC in a cervical immobilization model, (3) intubation with AIRWAY SCOPE in a normal airway model, (4) intubation with AIRWAY SCOPE in a cervical immobilization model, (5) tracheal intubation using AceScope in a normal airway model, and (6) tracheal intubation using AceScope in a cervical immobilization model. During tracheal intubation scenarios, participants were allowed to request assistance from a supervising anesthesiologist at their discretion, beginning 30 s after initiating the procedure [15].

In this study, intubation assistance was defined as any external intervention provided by the supervising anesthesiologist to facilitate tracheal intubation. Assistance was classified into three categories based on the nature and degree of intervention:

Device Hold: The anesthesiologist stabilized the video laryngoscope alongside the participant to optimize glottic visualization and improve device control.

Device Replacement: If the participant failed to obtain an adequate glottic view, the anesthesiologist removed and reinserted the device, after which the participant resumed control and continued the intubation attempt.

Head Repositioning: The anesthesiologist manually adjusted the participant's head position (e.g., head extension) to optimize airway alignment while the participant continued to manipulate the video laryngoscope independently.

Participants who were unable to complete tracheal intubation within two minutes were permitted to request assistance. This structured assistance framework was designed to evaluate the usability and clinical applicability of each video laryngoscope under simulated conditions. All instances of intubation assistance were systematically recorded by independent observers. The frequency and type of assistance provided were analyzed to assess device usability, operator performance, and procedural efficiency. The number of instances in which the assistant provided aid was recorded. However, assistants were not allowed to touch the ETT. Upon completing all six scenarios, participants rated the ease of tracheal intubation for each device on a visual analog scale, with 0 signifying "extremely easy" and 10 denoting "extremely difficult."

The primary endpoint in this study was the duration of successful tracheal intubation. Intubation time was defined as the interval from the blade's entry between the teeth until the ETT was connected to the bag-valve mask and the model lung inflated [13, 16]. The tracheal intubation procedures were recorded laterally, focusing on the participants' hand movements. A high-resolution video recording was conducted using an iPhone 13 Pro (Apple Inc., Cupertino, CA, USA) to ensure precise documentation of the intubation process. The position of the ETT tip was verified by the principal investigator following each intubation. Failure of intubation was defined as a time delay exceeding 120 s or inflation of the model stomach without inflating the model lung when utilizing the bag-valve mask. Secondary endpoints included the frequency of assistance required for successful intubation and the incidence of dental injuries (audible maxillary teeth clicking sounds) [17].

Sample size calculations for this study were based on previous research comparing video laryngoscopes [13, 16, 18]. Assuming an average intubation time of 40 s with a standard deviation of 10 s, a sample size of 7 participants per group was determined to be necessary for detecting a minimum difference of 10 s in intubation time between groups, with a statistical power of 0.80 and an alpha level of 0.05. To account for potential dropouts and ensure an adequate sample size for each of the three devices, the study aimed to enroll 60 novice healthcare providers, comprising both nurses and pharmacists.

Statistical analysis

Statistical analyses were conducted using Stata version 17.1 (StataCorp, College Station, TX, USA). Data

normality was assessed using the Shapiro-Wilk test. As intubation time data were normally distributed, they were presented as means ± standard deviations. Differences in intubation time among devices were analyzed using repeated measures analysis of variance (ANOVA), followed by post-hoc tests with Bonferroni correction. Primary outcome measures included intubation times for each device in every scenario. Secondary outcome measures encompassed user preferences and ease of use for each device based on visual analog scale scores, the incidence of dental injuries, and the frequency of assistance required during intubation procedures. These outcomes were analyzed using descriptive statistics, such as means and standard deviations for continuous variables and proportions for categorical variables. The statistical significance of differences in outcomes among devices was determined using ANOVA or chi-square tests, as appropriate. Post-hoc comparisons were performed using Bonferroni-corrected pairwise comparisons, with a significance level set at $p < 0.05$. All statistical tests were two-tailed.

Results

The study involved 60 healthcare professionals with a median age of 32 years (interquartile range: 26–42 years), consisting of 35% males and 65% females, and including 71.7% nurses and 28.3% pharmacists. Novice operators performed tracheal intubation with each device, and a repeated measures ANOVA was conducted on the intubation times for the three groups among 55 participants. Prior to the study, all fifty-five participants successfully completed tracheal intubation in all six scenarios after receiving a 5-minute demonstration and 15 min of hands-on training (5 min per device). Five participants were excluded due to difficulties handling the devices in the cervical spine immobilization model: three were unable to independently perform tracheal intubation using AceScope, and two were unable to independently perform tracheal intubation using McGrath MAC.

In the normal airway model, the analysis revealed a significant effect of the device on intubation time ($F(2, 54) = 8.358$, $p = 0.0002$). The mean intubation times (SD) for the McGrath MAC, AIRWAY SCOPE, and AceScope groups were 18.67 (1.44), 14.90 (1.76), and 24.16 (2.49) seconds, respectively. Post-hoc comparisons using the Bonferroni correction demonstrated significant differences in intubation time between the McGrath MAC and AIRWAY SCOPE groups ($p < 0.05$), and between the AIRWAY SCOPE and AceScope groups ($p < 0.05$), but not between the McGrath MAC and AceScope groups ($p > 0.05$). In the cervical spine immobilization model, the repeated measures ANOVA indicated a significant effect of the device on intubation time ($F(2, 57) = 7.04$, $p = 0.0007$). The mean intubation times (SD) for the McGrath MAC, AIRWAY SCOPE, and AceScope groups were 26.33 (2.06), 23.80 (2.43), and 33.38 (2.50) seconds, respectively, with significant differences in intubation time among all three groups (McGrath MAC vs. AIRWAY SCOPE: $p < 0.05$, McGrath MAC vs. AceScope: $p < 0.05$, AIRWAY SCOPE vs. AceScope: $p < 0.05$) (Fig. 1 and 2).

Table 1 presents the outcomes of the study, examining the success rates for intubation, the necessity for intubation assistance, and the incidence of dental injuries (quantified by the number of clicks) for each scenario. In this study, all three video laryngoscopes—McGrath MAC, AIRWAY SCOPE, and AceScope—were utilized for tracheal intubation in both normal airway and

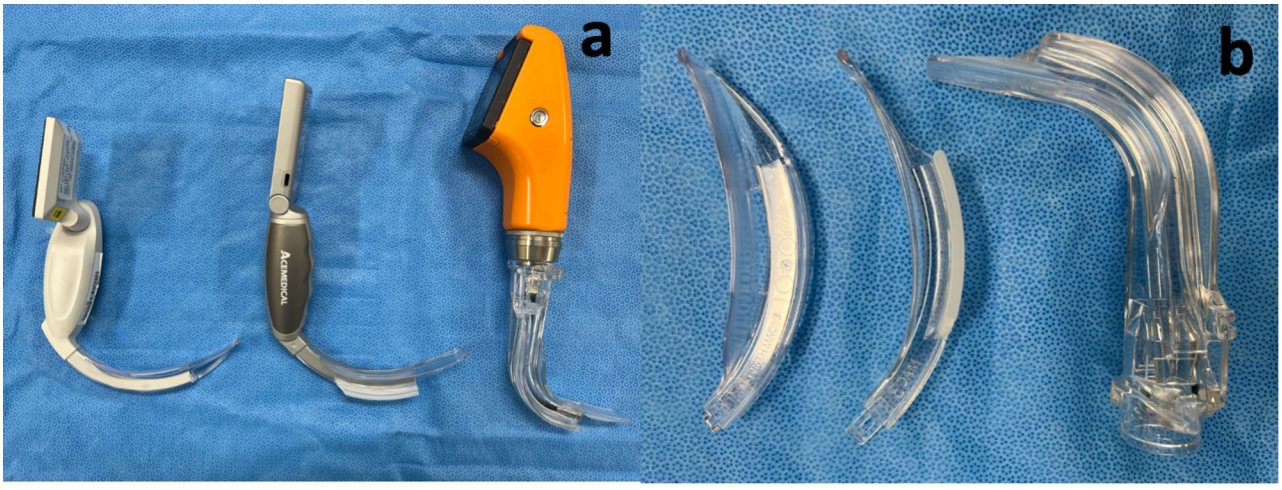

Fig. 1 Comparison of three video laryngoscope models and their corresponding disposable plastic blades. **a**: A collective view of the three video laryngoscopes, arranged from left to right: McGrath MAC, AceScope, and AIRWAY SCOPE. **b**: The disposable plastic blades compatible with each of the three video laryngoscopes, displayed from left to right: McGrath MAC blade (size #3, blade effective length 114 mm), AceScope blade (size #3, blade effective length 133.4 mm), and AIRWAY SCOPE blade (Depth 95 mm, Height 134 mm, Width 52 mm)

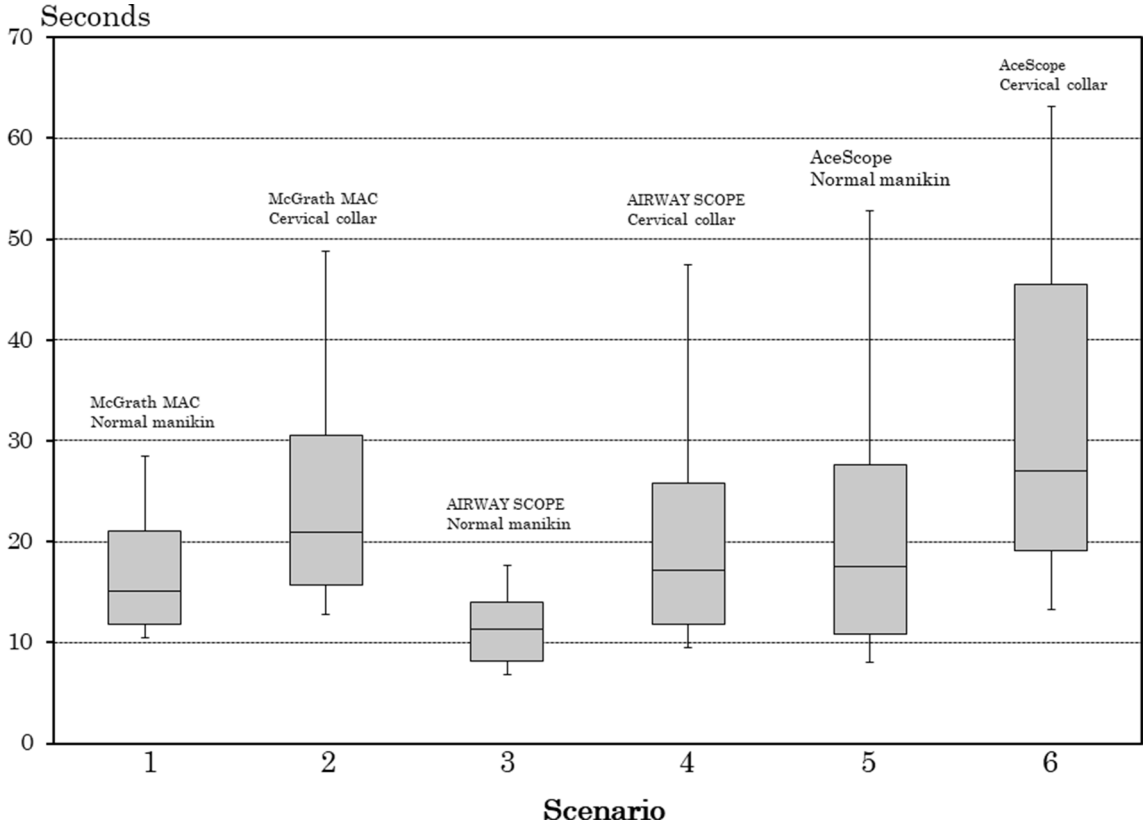

Fig. 2 Six box-and-whisker plots illustrating intubation times in seconds for six scenarios involving McGrath MAC, AIRWAY SCOPE, and AceScope video laryngoscope in normal airway and cervical immobilization models. Scenario (1) intubation with McGrath MAC in a normal airway model, (2) intubation with McGrath MAC in a cervical immobilization model, (3) intubation with AIRWAY SCOPE in a normal airway model, (4) intubation with AIRWAY SCOPE in a cervical immobilization model, (5) tracheal intubation using AceScope in a normal airway model, and (6) tracheal intubation using AceScope in a cervical immobilization model. In the normal airway model, significant differences were observed between McGrath MAC and AIRWAY SCOPE ($p < 0.05$) and AIRWAY SCOPE and AceScope ($p < 0.05$), but not between McGrath MAC and AceScope ($p > 0.05$). In the cervical spine immobilization model, significant differences in intubation time were found among all three groups (McGrath MAC vs. AIRWAY SCOPE: $p < 0.05$, McGrath MAC vs. AceScope: $p < 0.05$, AIRWAY SCOPE vs. AceScope: $p < 0.05$)

Table 1 Outcomes of a study investigating endotracheal intubation scenarios utilizing various videolaryngoscopes

Scenario	Failed / Success (Success rate)	Intubation Assistance Required	Dental Injuries (number of clicks)			
			No injury	1	2	3
1 (McGrath MAC normal)	0 / 55 (100%)	3 (device hold)	55	0	0	0
2 (McGrath MAC difficult)	0 / 55 (100%)	7 (device hold)	48	4	1	2
3 (AIRWAY SCOPE normal)	0 / 55 (100%)	2 (one head repositioning, one device hold)	54	1	0	0
4 (AIRWAY SCOPE difficult)	1† / 54 (98.2%)	12 (six device hold, six device repositioning)	46	4	4	1
5 (AceScope normal)	0 / 55 (100%)	10 (five head repositioning, four device hold, one device repositioning)	52	2	0	1
6 (AceScope difficult)	2† / 53 (96.3%)	18 (sixteen device hold, two device repositioning)	42*	4	6	3

Table 1 presents the outcomes of a study evaluating six distinct endotracheal intubation scenarios using three video laryngoscopes. The analysis included intubation success rates, the necessity of assistance, and the incidence of dental injuries (measured by the number of audible clicks). The McGrath MAC, AIRWAY SCOPE, and AceScope were each tested in both normal airway and cervical spine immobilization models. In scenario 4, one case of esophageal intubation was recorded, while in scenario 6, two cases of esophageal intubation and failure to intubate within the time limit were observed. Abbreviations:†, esophageal intubation or time up; *, significant difference in dental injury rate between AceScope and McGrath MAC ($p = 0.04$).

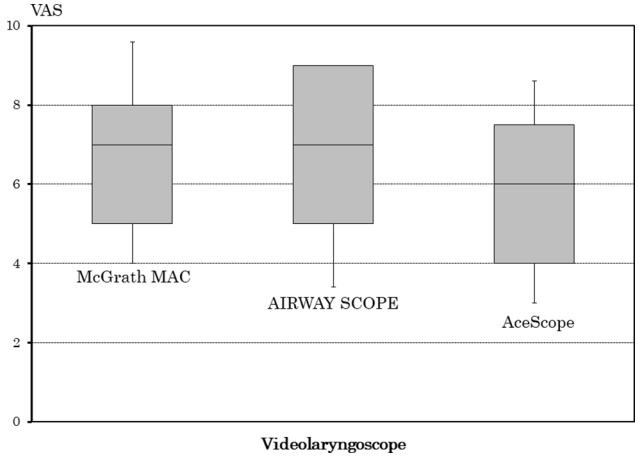

Fig. 3 the box-and-whisker plots delineating the perceived ease of use for the McGrath MAC, AIRWAY SCOPE, AceScope video laryngoscopes, as assessed by 60 participants employing a Visual Analog Scale (VAS). Upon completion of all six scenarios, the participants evaluated the facility of tracheal intubation for each of the three devices utilizing a VAS, where a score of 0 signified "extremely easy" and 10 indicated "highly challenging". The comparative analysis revealed no statistically significant differences among the three devices concerning their ease of use. McGrath MAC: Median VAS score = 6 (IQR: 4–8), AIRWAY SCOPE: Median VAS score = 7 (IQR: 5–9), AceScope: Median VAS score = 6 (IQR: 4–8)

cervical spine immobilization models. In scenario 4, a single case of esophageal intubation occurred, while in scenario 6, there were two instances of esophageal intubation and time up.

Participants assessed the difficulty of tracheal intubation using each device on a visual analog scale (VAS), and no significant differences in VAS ratings were observed among the devices (Fig. 3). No significant differences in dental injury incidence were found among the McGrath MAC, AIRWAY SCOPE and AceScope in both normal and cervical spine immobilization models, except for a notable difference in dental injury rate between the AceScope and McGrath MAC in scenario 6 (23.6%, $p = 0.04$) (Table 1).

Discussion

This study aimed to compare the effectiveness and usability of McGrath MAC, AIRWAY SCOPE, and AceScope video laryngoscopes during simulated tracheal intubation scenarios in novice healthcare providers. Our results demonstrated significant differences in intubation times among the three devices in both normal and cervical spine immobilization models. In the normal airway model, the AIRWAY SCOPE had the shortest intubation time, followed by the McGrath MAC and AceScope. In the cervical spine immobilization model, intubation times were significantly longer, with the AIRWAY SCOPE remaining the fastest, followed by the McGrath MAC and AceScope.

These findings suggest that the AIRWAY SCOPE may be more efficient than the other two devices, particularly in challenging airway situations. This could be attributed to the AIRWAY SCOPE's unique design, which features a disposable blade and guide rail system that facilitates smooth endotracheal tube insertion [19, 20]. Previous studies have also reported the AIRWAY SCOPE's superiority in terms of intubation time compared to other video laryngoscopes [21, 22, 23, 24]. While the AIRWAY SCOPE demonstrated the shortest intubation time, the differences, although statistically significant, may not necessarily impact clinical outcomes in scenarios where rapid intubation is not critical. Previous studies have also indicated that differences in intubation time of less than 10–15 s may not translate into clinically relevant benefits, particularly in controlled settings [25, 26, 27]. However, in emergent situations requiring immediate airway management, even small differences in intubation time may contribute to improved patient safety, particularly in cases of hypoxia or hemodynamic instability. Further studies evaluating these factors in real-world clinical settings are warranted.

In terms of secondary outcomes, our study found that novice users reported similar levels of difficulty using three different video laryngoscopes based on their assessments using a visual analog scale (VAS). However, it should be noted that healthcare providers with varying levels of experience may have different experiences with these devices. Notably, the AceScope's user-friendly design may make it easier to use, underscoring the importance of appropriate training and practical experience in increasing healthcare providers' confidence and comfort when using these devices [28, 29].

The incidence of dental injuries was comparable among the McGrath MAC, AIRWAY SCOPE, and AceScope in both normal airway and cervical spine immobilization models, with the exception of a significant difference between the AceScope and McGrath MAC in scenario 6. The higher dental injury incidence associated with the AceScope in scenario 6 may be attributed to its blade design, which requires a more pronounced lifting force for adequate glottic visualization [17]. Additionally, novice users unfamiliar with the device's handling may have applied excessive force, leading to unintended maxillary contact. Previous studies have reported similar trends with video laryngoscopes featuring rigid blades and unfamiliar handling mechanics [30, 31]. Strategies such as extended training, alternative insertion angles, or modified blade designs may help mitigate this risk. Future investigations assessing the impact of operator experience on dental injury rates will be valuable in further clarifying this issue. While the differences in dental injury rates observed in this study were minimal, further investigation into the factors contributing to these

discrepancies may help identify strategies to reduce dental injury risk during intubation [32].

The AceScope is a novel video laryngoscope that combines the most advantageous features of the McGrath MAC and AIRWAY SCOPE, providing a lightweight design that facilitates ease of use and maneuverability [7, 8]. Although the AceScope demonstrated longer intubation times in both normal and cervical spine immobilization models compared to the other devices, it is crucial to consider that the differences may not be clinically significant, given that all devices achieved high first-attempt success rates exceeding 90% in both models (Fig. 2). This finding suggests that, despite variations in intubation time, all three video laryngoscopes are effective for airway management in novice users. Notably, the AIRWAY SCOPE demonstrated the highest first-attempt success rate across all scenarios, aligning with its previously reported advantages in glottic visualization and guided endotracheal tube insertion. Future studies should further explore how device-specific features influence success rates, particularly in challenging airway conditions. The AceScope's blade shape is similar to that of the McGrath MAC, and its guide rail system is reminiscent of the unique feature of the AIRWAY SCOPE. These design features may potentially facilitate smooth endotracheal tube insertion and optimal glottic visualization. However, additional investigation is necessary to assess the effects of these characteristics on intubation outcomes. It is worth noting that the AceScope's longer intubation times may result from its unique design, which may require novices to adjust to a new technique, leading to longer intubation times. Subsequent studies should evaluate the effectiveness of the AceScope among providers with varying levels of experience to determine whether it offers any distinct advantages over the other two video laryngoscopes. Overall, the AceScope's innovative design warrants further investigation to determine its potential role in airway management strategies.

This study has some limitations that should be acknowledged. Firstly, the use of a manikin model may not fully represent the complexities and challenges of intubating human subjects, particularly in difficult airway scenarios [12, 17, 19, 22, 24, 33, 34]. Therefore, the generalizability of our findings to clinical practice should be approached cautiously. Secondly, the study only involved novice healthcare providers, and the results may not be applicable to experienced providers [12, 35]. Future studies should examine the performance of these devices among providers with varying levels of experience to determine their effectiveness across a broader spectrum of healthcare professionals.

In conclusion, our findings demonstrate that the AIRWAY SCOPE was the most efficient video laryngoscope in terms of intubation time, both in normal airway and cervical spine immobilization models, followed by the McGrath MAC and AceScope. However, all devices exhibited high success rates, and there were no significant differences in perceived difficulty among the three video laryngoscopes. Further research is needed to validate these findings in clinical settings and investigate the impact of device-specific features on intubation outcomes, as well as dental injury incidence.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-025-03094-y.

Supplementary Material 1

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Author contributions

Y.Y. and M.Y. designed the study. Y.Y. and K.O. performed the data collection and analysis. M.Y. wrote the manuscript draft. Both authors reviewed and approved the final manuscript.

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Data availability

The data that support the findings of this study are not publicly available due to restrictions related to patient privacy and confidentiality. However, de-identified data supporting the results of this manuscript is available from the corresponding author (Musashi Yahagi, musasum0710@yahoo.co.jp) upon reasonable request and with the approval of the institutional ethics review board of Hitachi General Hospital.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Hitachi General Hospital (approval number 2023-22) and registered as a clinical trial with the registration number jRCT1030240598 (https://jrct.niph.go.jp/re/reports/detail/91422) The registration date of the clinical trial is January 8, 2025. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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