Comparison of the Contact Force Exerted on Teeth by Conventional Macintosh Laryngoscope Versus Video Laryngoscopes

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During laryngoscopy, the laryngoscope blade sometimes comes in contact with the teeth, fracturing or dislocating them. However, no studies have compared the effects of newly marketed video laryngoscopes and the Macintosh laryngoscope (Mac) on teeth. In this study, we measured and compared the force exerted on the teeth of an intubating manikin by the Mac, the Airway Scope (Pentax), and the McGrath MAC (Covidien). The mean force exerted was 141.1 ± 15.7 kg by the Mac, 39.2 ± 10.3 kg by the Airway Scope, and 48.7 ± 6.7 kg by the McGrath MAC. No significant difference was observed between the Airway Scope and the McGrath MAC. When the Mac is inserted, the glottis has to be visually located from outside the oral cavity. However, a significant force is not necessary when inserting video laryngoscopes because a camera is mounted on the blade tip. In this laboratory model, the lower force exerted by the video laryngoscopes should contribute to a reduction in their impact on fracture or dislocation of teeth.

Key Words: Contact force, Airway Scope, McGrath MAC, Macintosh laryngoscope.

During laryngoscopy, the laryngoscope blade can come in contact with the maxillary incisors and damage them. According to one study, oral injury due to anesthesia occurs in approximately 1 in every 2073 cases (0.05%), and the maxillary central incisor has a particularly high risk of injury.¹ Another study demonstrated that the incidence of tooth injury associated with intubation is approximately 0.4%.² Various studies on laryngoscope blades have analyzed their usability, incidence of tooth damage, and other aspects.^{3–5} However, to our knowledge, no studies have evaluated the force exerted by the blades on the anterior teeth.

With recent technological advances in charge-coupled device cameras and portable monitors, various video laryngoscopes have been developed and used in clinical practice. Although they reportedly allow for relatively easy visualization of the larynx, no studies have investigated the incidence of tooth damage caused by these laryngoscopes or the force exerted by them on

teeth. In the present study, we compared the contact force exerted on the maxillary anterior teeth by the blades of the Macintosh laryngoscope (Mac), the Airway Scope AWS-S100L (AWS; Pentax), and the McGrath MAC (MM; Covidien) using a manikin model.

METHODS

Experiments were performed using an intubation training manikin (Laerdal Airway Management Trainer; Laerdal) (Figure 1). The laryngoscope blades used were a Macintosh No. 3 manufactured by Acoma Medical Industry for the Mac, a standard Intlock for the AWS, and a No. 3 blade for the MM (Figure 2). The mouth of the manikin had an opening dimension between the incisal edges of the upper and lower central incisors of 13 mm at rest and 51 mm when fully opened. The width of the laryngoscope blade contact point was 17 mm for the Mac, 18 mm for the AWS, and 12 mm for the MM. The contact force was measured using an occlusal force meter (MPM-3000; Nihon Kohden). The MPM-3000 is connected to a 14-mm-diameter, 3-mm-thick sensor via a cord. When force is applied to the sensor, the force

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Figure 1. The manikin used for this study.

measurement (kilograms) instantly appears on the display (Figure 3). The maximal force between the start and end times of the measurement is also displayed. In the present study, the measurements of maximal force were used.

To ensure that the laryngoscopes would all contact the tooth area under the same conditions, we developed a mouthpiece with a thickness of 0.8 mm that was attached to the manikin during visualization of the larynx (Figure 4). Five anesthesiologists with 1 to 26 years of experience in conventional and video laryngoscopy performed the experiment 5 times using each laryngoscope. The Mac was used first, followed by the AWS and then the MM. The maximal contact force (kilograms) exerted on the anterior teeth by the blade was measured when a grade 1 laryngeal view was

obtained according to the Cormack and Lehane⁶ classification of laryngeal view (Figure 5). As soon as the anesthesiologist achieved the grade 1 laryngeal view, the force was released. The determination of the grade 1 laryngeal view for all laryngoscopies was made by each anesthesiologist. An independent reviewer did not confirm that a grade 1 view was obtained with each visualization. No head manipulation, such as cervical extension, was performed.

The sample size was calculated using G* Power (Ver. 3.1.9.2, Heinrich-Heine-Universität). For a significance level of $\alpha = .05$, an effect size of $f = 0.4$, and a statistical power of 0.8, the necessary total sample size was 66, which suggested that the sample size of 75 used in this study was adequate. One-way analysis of variance was performed for statistical analysis. We also calculated the

Figure 2. Three laryngoscopes used in this study.

Figure 3. The load measurement system used for laryngoscopes.

Figure 4. The mouthpiece ensured that the laryngoscopes would all contact the teeth.

correlation coefficient between the experience of the operator and the contact force.

A *p* value of less than .05 was considered to indicate a significant difference.

RESULTS

For all laryngoscopes, the mean force exerted on the maxillary anterior teeth was not significantly different among anesthesiologists. There was no correlation between operator experience and contact force. There was no significant difference among the measurement times of the laryngoscopies. The mean force exerted on the maxillary anterior teeth was 141.1 ± 15.7 kg by the Mac, 39.2 ± 10.4 kg by the AWS, and 48.7 ± 6.7 kg by the MM. The force exerted on the teeth by the AWS and the MM was significantly lower than that exerted by the Mac. However, no significant difference was observed between the force exerted by the AWS and that exerted by the MM (Figure 6).

DISCUSSION

In this study, the force exerted on the maxillary anterior teeth by the AWS and the MM was significantly lower than that exerted by the Mac during the visualization of the larynx. This confirms the clinical impression of many anesthesiologists. Video laryngoscopes, such as the AWS and the MM, are reportedly more useful for intubation even in difficult cases, including those of trismus.^{7,8} The fact that the larynx can be visualized using the video laryngoscopes in patients with limited opening of the mouth allows for the insertion of the laryngoscopes with little contact with teeth. In the present study, the grade 1 Cormack and Lehane laryngeal view, which indicates the achievement of full visualization of the laryngeal structures, was used as the main end point. In the United Kingdom, the Difficult Airway Society guidelines limit the number of attempts with a laryngoscope or a laryngeal mask.⁸ An excessive number of attempts at intubation is associated with an

Figure 5. Ideal position of the laryngoscope handle to achieve grade 1 laryngeal view of the vocal cords.

increased risk of damage to oral/pharyngeal structures and laryngeal soft tissue edema due to repeated external force. Airway edema is a direct risk factor for airway obstruction. Because of these risks, an in vivo experiment was not considered ethically acceptable, and a training manikin was used for the present study.

During conventional laryngoscopy, tissue in the oral cavity and the pharynx is physically displaced with a laryngoscope to obtain a laryngeal view. In this process, the pharyngeal and oral axes are aligned. When the Mac is inserted, a straight line of sight must be obtained between the eyes of an operator and the glottis of a patient, because the pharynx of the patient needs to be visually located from outside the oral cavity.⁹ However, such a line of sight is not required for the AWS and the MM, because a camera is mounted on the blade tip. If the blade is slid up to the base of the tongue, the larynx

Figure 6. Comparison of contact load for teeth in the Macintosh laryngoscope, the Airway scope, and the McGrath MAC.

can be visualized with little effort. This likely contributed to the reduction in force exerted on the teeth by the AWS and the MM. The difference in contact force is reflected in the motion of the cervical spine. Hirabayashi et al⁹ radiologically analyzed the motion of the cervical spine during intubation and reported that, although the cervical spine significantly moved from the baseline position during intubation with the AWS, the amount of motion was significantly smaller during intubation with the AWS than with the Mac. Head manipulation was not used for any of the laryngoscopic techniques in this study. As the manikin utilized in this study has an extendable neck, different results might have been obtained if the operators had also manipulated the head.

No significant difference was observed between the AWS and the MM in the force exerted on the teeth. The blade of the MM is less curved than that of the AWS and resembles that of the Mac in shape. However, because both the MM and the AWS have a camera mounted on the blade tip, this common basic structure might have contributed to the lack of significant difference between the 2 laryngoscopes.

Helkimo et al¹⁰ reported that the mean maximal bite force in the anterior teeth of people aged between 15 and 65 years is 18 kg in men and 11 kg in women. Although the results of the present study cannot be directly compared with those of their study because we used a manikin, our study indicates that the anterior teeth bear a force approximately 10 times greater than the maximal bite force exerted by the Mac and approximately 3 times greater than the force exerted by the AWS or the MM. The force vector of the occlusal force sensor is not perpendicular to the long axis of the tooth. If the force

exerted by the operator on the laryngoscope blade is on a lingual force vector, measurement values different from the force perpendicular to the long axis of the incisors may be obtained. In addition, although teeth are known to be resilient to downward pressure, patients with damaged periodontal tissue are presumably at a higher risk of tooth dislocation during intubation.

Limitations of the present study include the lack of tissue distensibility in the manikin and the lack of head movement, which may have helped limit Mac tooth forces. The measuring device did have a thickness that might have affected force measurements. Of possible importance, the blade of the Mac in our study was made of metal, whereas the blades of the AWS and the MM are made of plastic. Considering the hardness properties of the 2 different materials, the impact of the plastic blade on teeth might have been somewhat weaker than that of the metal blade. Lastly, a full grade 1 view is not necessary for intubation to be successful, as a grade 2 view is also acceptable.

Future studies should evaluate the tooth force on patients using this force meter to determine the force of different laryngoscopes during actual intubation. In order to obtain an adequate sample size, because repeated laryngoscopies in the same patient would not be appropriate, data would need to be collected over an extended period of time. Plastic Mac blades could also be used to eliminate the potential bias between metal and plastic blades.

The present study demonstrated that video laryngoscopes exert less force on the anterior teeth than conventional laryngoscopes in a manikin model.

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