

Research letter

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Forces applied to maxillary incisors with different laryngoscopes

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The most common legal claims related to orotracheal intubation in England, USA and South Australia were related to dental injuries [1]. The forces applied during the intubation of critically ill patients in the emergency department (ED) may not only cause local trauma to different oropharyngeal structures but have systemic effects.

The aim of this manikin study is to compare the peak-force applied onto the maxillary incisors during tracheal intubation using six different laryngoscopes/blades in normal and difficult airway scenarios. This study was carried out between June 2017 and February 2019 in the simulation center of a university hospital ED. The ethical committee and research project unit approved and supported the study (TTU-2018-2384). Cervical spine immobilization was used to simulate a difficult airway situation. In this study Macintosh laryngoscope #3, Glidescope MAC T3 (Verathon Inc., Bothell, Washington, USA), McGrath MAC #3 and X blade (Aircraft Medical Ltd., Edinburgh, UK), C-MAC # 3 and d-blade (Karl Storz, Tuttlingen, Germany) were used. The sequence of airway devices was randomized to each participant in the normal airway scenario and then the difficult

airway scenario by a researcher who was blinded to the study's aim and outcome. Three different sensors were attached to the convex surface of the blades to measure the exerted forces. The forces applied by each participant to the maxillary incisors during the intubation of two different scenarios were measured and recorded continuously by the program designed for this study by Arduino. A Kruskal–Wallis H test was conducted to examine the difference of applied forces on sensors according to the airway scenarios. A total of 45 ED residents from different postgraduate years (PGY 1-4s) attempted orotracheal intubation with three different laryngoscopes and six different blades in normal and difficult airway scenarios. The study group consisted of 32 (71%) males, 13 (29%) females with a mean age of 27 ± 2 .

The lowest exerted forces to maxillary incisors were with the McGrath MAC #3 and X blade, followed by the Glidescope and CMAC-d (Table 1). The forces applied on maxillary teeth were higher with the CMAC #2 and Macintosh Laryngoscope in both airway scenarios (Table 1). There was a difference in the forces generated when we compared different laryngoscopes across different airway scenarios. We also divided the resident cohort into beginners (PGY 1 and 2) and advanced (PGY 3 and 4). There were no differences in force generated between resident cohorts across all blade types.

According to our results, the mean peak forces exerted by McGrath MAC and X blade were lower than other blades in both airway scenarios. CMAC-d and Glidescope T3 had similar measurements and the Macintosh and the CMAC #3 blades had exerted the highest forces to the maxillary incisors in both airway scenarios.

Table 1 The peak forces applied by the laryngoscopes in normal and difficult airway scenario

		Normal Airway			Difficult Airway		
		Sensor 1	Sensor 2	Sensor 3	Sensor 1	Sensor 2	Sensor 3
Glidescope T3	Mean \pm SD	271 \pm 296	265 \pm 264	248 \pm 280	277 \pm 279	324 \pm 289	304 \pm 338
	Median (IQR)	143 (59–368)	126 (73–424)	133 (61–342)	176 (67–390)	233 (79–523)	125 (64–490)
Macintosh	Mean \pm SD	362 \pm 250	326 \pm 259	268 \pm 211	493 \pm 254	432 \pm 235	427 \pm 278
	Median (IQR)	371 (91–501)	290 (91–521)	213 (96–422)	523 (325–647)	464 (292–590)	371 (212–537)
McGrath X	Mean \pm SD	159 \pm 175	119 \pm 126	155 \pm 156	279 \pm 267	176 \pm 201	282 \pm 218
	Median (IQR)	73 (61–194)	69 (55–108)	79 (56–207)	148 (61–502)	69 (46–271)	231 (77–432)
McGrath 3	Mean \pm SD	190 \pm 197	85 \pm 137	231 \pm 202	230 \pm 248	105 \pm 148	272 \pm 221
	Median (IQR)	73 (58–386)	40 (15–74)	140 (62–389)	78 (63–478)	48 (16–88)	229 (60–455)
CMAC#3	Mean \pm SD	314 \pm 251	245 \pm 214	396 \pm 243	393 \pm 274	310 \pm 243	472 \pm 229
	Median (IQR)	293 (79–498)	155 (85–424)	417 (129–601)	397 (127–581)	280 (90–243)	510 (332–622)
CMAC-D	Mean \pm SD	255 \pm 202	209 \pm 214	122 \pm 113	301 \pm 222	268 \pm 258	221 \pm 223
	Median (IQR)	161 (76–412)	96 (64–412)	78 (65–121)	241 (84–524)	112 (78–448)	86 (63–397)

In a manikin study by Schieren *et al.*, forces applied to the maxillary incisors were compared in both normal and difficult airways by anesthetists. In both scenarios, hyperangulated blades (Glidescope AVL and Kingvision) caused lower median peak forces compared to Macintosh Blade [2]. Our study showed that all video laryngoscopes had similar forces and were lower than the Macintosh, except for the Glidescope which had similar force to the Macintosh laryngoscope. One explanation for the lower amount of force needed could be that a hyperangulated blade does not require a direct line of sight, therefore, intubating patients with these blades might need less head and neck manipulation and reduce the force needed.

Furthermore, our study results showed that the Glidescope T3 was found to cause less force when compared with the Macintosh laryngoscope, as well as the C-MAC having higher median peak forces than other video laryngoscopes. This could be due to the slimmer design of the T3 as opposed to the bulky design that the C-MAC video laryngoscope shares with the classical Macintosh laryngoscope. Furthermore, we found that the CMAC-d had applied lower forces than C-MAC #3 which could point out that the laryngoscope blade design and shape may have a bigger impact than the video technology in terms of dental forces.

Unlike Ueshima *et al.* [3] who found that the force received at the upper teeth was significantly less for the X blade than for size 3 blade [#3 blade: 47.5 (0–70.0) N, X blade: 15.0 (0–35.0) N; $P = 0.0036$). In our study, however, we could not find a difference in terms of force applied between the McGrath MAC size 3 and X blade, This is probably due to the fact that the X-blade has a greater curvature resembling the d-blade of CMAC, but it has a slimmer design.

Finally, in accordance with a study by Lee *et al.* [4,5] who found that experience was not associated with the force applied, we did not find any difference in force generated across all laryngoscope types.

This study has several limitations. First, this is a manikin study. The participants were not blinded to the devices and as such, the results can be affected by personal biases towards specific laryngoscopes.

In this manikin study, the shape of the blade and to a lesser extent the video camera applied to laryngoscope seems to decrease the force applied to maxillary incisors.

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Conflicts of interest

There are no conflicts of interest.

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