Master' Thesis of Veterinary Medicine

Modeling and Evaluation of Low-cost 3D-printed Video Laryngoscope with Borescope

산업용 내시경을 장착하도록 **3D** 프린터로 제작한 보급형 후두경의 개발과 평가

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Abstract

To model a low-cost three-dimensional (3D) printed veterinary use video laryngoscope (VL_{VET}) with a commercial borescope and evaluate the VL_{VET} in Beagle dogs.

The VL_{VET} consisted of a Miller-type laryngoscope and a detachable camera holder that could be attached to various locations along the blade and was printed using a black polylactic acid filament through a 3D printer. Each dog was anesthetized using intravenous medetomidine (15 μg kg^{-1}) and alfaxalone (1.5 mg kg^{-1}) in sternal recumbency. The camera was located 2, 4, 6, 8 and 10 cm from the blade tip positioned on the larynx ($distance_{LARYNX\text{-}CAM}$ treatment), and the scores of laryngeal visualization and intubation were evaluated on screen and by the naked eye simultaneously. At 10 cm $distance_{LARYNX\text{-}CAM}$, laryngeal visualization was scored at 10, 8, 6, 4 and 2 cm distances between upper and lower incisors ($distance_{INTER\text{-}INCISOR}$ treatment). The scores were analyzed using a Kruskal–Wallis test.

Six Beagles (11.6 ± 1.1 kg and 3.0 ± 1.0 years) were enrolled in this test, and their maximum inter-incisor distance and the length of the oral cavity were 10.2 ± 0.5 and 12.1 ± 0.7 cm, respectively. The $distance_{LARYNX\text{-}CAM}$ could be adjusted within 5–10 seconds; then the VL_{VET} could be reused immediately without further

reinforcement. At all $\text{distance}_{\text{LARYNX-CAM}}$, whole glottis and intubation were observed on screen and by the naked eye, except for naked eye view at 2 cm $\text{distance}_{\text{LARYNX-CAM}}$ (all $p < 0.005$). On both views, the visualization scores were higher at ≥ 6 cm $\text{distance}_{\text{INTER-INCISOR}}$ than 2 cm $\text{distance}_{\text{INTER-INCISOR}}$ (all $p < 0.005$), and glottis was observed at ≥ 4 $\text{distance}_{\text{INTER-INCISOR}}$ except for one laryngoscopy on naked eye view.

During laryngoscopy and intubation, VL_{VET} enabled both video and direct laryngoscope to be used simultaneously, at various $\text{distance}_{\text{LARYNX-CAM}}$ in Beagles with ≥ 6 cm $\text{distance}_{\text{INTER-INCISOR}}$.

Keywords: canine, detachable camera, inter-incisor, intubation, veterinary use

Student number: 2020-29958

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Introduction

Video laryngoscope (VL), compared with direct laryngoscope, provides benefits to clinical practice and education by recording the process of laryngoscopy or intubation and sharing the view through the screen (Low et al. 2008; Lambert et al. 2020). Especially in human medicine, since VL is mainly used in the management of difficult intubation, it has been established as essential equipment (Frerk et al. 2015; Apfelbaum et al. 2022). However, reports of clinical and educational use of VL in dogs are rare. This may be the result of the relatively high price of equipment for human medicine, the absence of equipment specifically for veterinary use, and/or the easily exposed larynx of dogs. The development of VL exclusively for veterinary medicine at a reasonable cost can facilitate objective evaluation beyond personal experience of limited view during laryngoscopy, and effective training of intubation for novices with real-time supervision.

Three-dimensional (3D) printed laryngoscope for low-cost borescope (approximately US $15 to $100) has been considered as a low-cost option in human medicine because of the much higher price (approximately US $1200 to $5600) of the commercially available VL; the 3D models are available in only one type for adult humans (Huysamen et al. 2020; Lambert et al. 2020; Ataman et al. 2021). With respect to dogs, the 3D modeling of a laryngoscope for borescope is challenging owing to the variations in breed, size, and anatomy. Furthermore, educational use requires the inclusion of not only the function of VL but also the function of a direct laryngoscope providing identical views between the screen and the naked eye. Several criteria have also been suggested for convenient use: 1) similar design with the direct laryngoscope for familiar use, 2) no materials used other than 3D printing filaments for the laryngoscope and a commercial borescope, 3) attachable to various borescopes, 4) movable to adjust the distance between the focused target and the camera for better image quality, 5) minimization of the cross-sectional volume of the laryngoscope blade for less interference in the naked eye view, and 6) design for both left- and right-handed.

The aim of this study was to develop low-cost 3D-printed veterinary use VL for a commercial borescope with a detachable camera holder that can be attached to various locations along the blade (VL_{VET}). The VL_{VET} was evaluated by visualization score of the larynx and the intubation, on screen and with the naked eye, of different distances from the blade tip located on the larynx to the camera ($distance_{LARYNX-CAM}$ treatment). Since the distance between the upper and lower incisors can restrict the view angle of the naked eye (Nath & Sekar 1997), the visualization score of the larynx was evaluated at different distances ($distance_{INTER-INCISOR}$ treatment) in Beagle dogs.

Materials and Methods

The procedures of this study were approved by the Institute Animal Care and Use Committee of the Seoul National University (SNU-220201-1). This study was designed as a repeated crossover treatment of five $\text{distance}_{\text{LARYNX-CAM}}$ (2, 4, 6, 8 and 10 cm) and five $\text{distance}_{\text{INTER-INCISOR}}$ (2, 4, 6, 8 and 10 cm) in six dogs.

3D modeling and printing of the VL_{VET}

The VL_{VET} was designed based on the Miller-type laryngoscope consisting of two parts: a laryngoscope body (blade and handle) and a detachable holder for the camera of the borescope on the blade (Fig. 1A). The blade part is 14 cm long and 1 cm wide. The 2 cm tip of the blade is designed with an inclined surface with a slope of 15 degrees so as not to interfere with the camera view angle. There are 11 hemispherical protrusions with a diameter of 0.5 cm on the bottom surface of the blade with intervals of 1 cm each and three holes on the bottom of the camera holder, which fits the diameter of the protrusion of the blade. Further, the camera holder can be moved by 1 cm on the blade so that the camera can be adjusted to the desired location.

The handle, 17 cm long and 1.5 cm wide, has three holes to firmly hold the rigid cable of the borescope. The camera holders come in various designs to correspond to multiple borescopes (Fig. 1A), and in this study a holder for a camera of 0.4 cm diameter (Fig. 1Aa) was used.

The 3D modeling was developed with a computer-aided design software (Fusion 360; Autodesk Inc., USA), and printed using a black polylactic acid (PLA) filament through a fused-deposition modeling 3D printer (DP-200; Sindoh [Qingdao] Co. Ltd, China). When printing, a 100% infill density was used for the stability of the laryngoscope body and the side without the blade was facing the floor (Fig. 1B).

Borescope

The borescope (Oiiwak® 4.3-inch Screen Endoscope 5FT red; Shenzhen Haisi Zhichuang Technology Co., Ltd, China) consisted of 3 parts: a camera (0.4 cm diameter), a rigid cable (150 cm) and a screen (4.3-inch) (Fig. 1C). The camera was waterproof and had the best focus range of 3–10 cm, a view angle of 70 degrees, and six light-emitting diodes of a total of 10 lux. The in-plane switching screen showed 1080-pixel high-definition video, and stored video resolution was 1280×720 pixel.

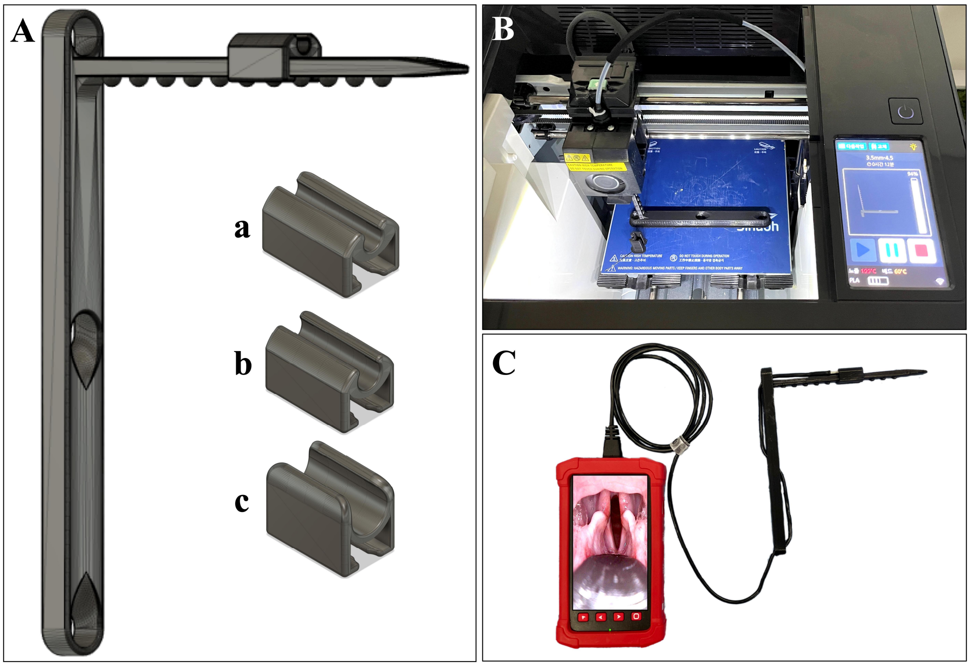

Figure 1. Three-dimensional (3D) printed video laryngoscope for borescope with adjustable location of camera (VL_{VET}). A, computer-aided design drawing of VL_{VET} with a camera holder attached to the blade, and three different sized camera holders for 0.4, 0.6 and 1 cm (a, b and c, respectively); 'a' is used in this study. B, VL_{VET} being printed through the fused deposition modeling 3D printer. C, actual VL_{VET} with a borescope.

Animals

Six adult male Beagle dogs were included of weight and age (mean ± standard deviation) 11.6 ± 1.1 kg and 3.0 ± 1.0 years, respectively. All dogs were considered clinically healthy based on pre-anesthetic physical examination, complete blood count, serum chemistry analysis, and thoracic radiographs.

Anesthetic procedures

After 6 hours of withholding food with free access to drinking water, a cephalic venous catheterization was performed with over-the-needle polyurethane 22-gauge catheter (Becton Dickinson Medical(S) Pte Ltd, Sindistanceore). Medetomidine (15 μg kg^{-1}, Domitor; Pfizer Ltd, UK) was administered intravenously (IV) for sedation. Alfaxalone (1.5 mg kg^{-1}, Alfaxan; Jurox Pty Ltd, Australia) was administered IV up to 1 mg kg^{-1} until the jaw tone disappeared, and when required 0.5 mg kg^{-1} was supplemented. Endotracheal tube size was selected measuring the internal tracheal diameter from a thoracic radiographic image in a right lateral recumbent position (Shin et al, 2018).

Laryngoscopy and intubation

The whole process was performed in sternal recumbency. After the jaw tone disappeared, the upper jaw and tongue were each held with one hand and the mouth was opened as widely as possible. Then the inter-incisor distance, the height from the upper incisor to the tongue, and the length of the oral cavity from the tip of the epiglottis to the lower incisor, were measured. The VL_{VET} was prepared with a borescope, and the camera located at 2, 4, 6, 8 and 10 cm ($distance_{LARYNX\text{-}CAM}$

treatment) from the blade tip positioned at the larynx, using the detachable camera holder. Laryngoscopy was performed from each distance by directly and gently depressing the epiglottis (Fig. 2), followed by intubation.

The distance$_{INTER\text{-}INCISOR}$ treatment was performed at 10 cm of the distance from the blade tip to the camera. The distance$_{INTER\text{-}INCISOR}$ was controlled from 10 to 2 cm with 2 cm intervals, and the naked eye view and screen view were evaluated in the same way.

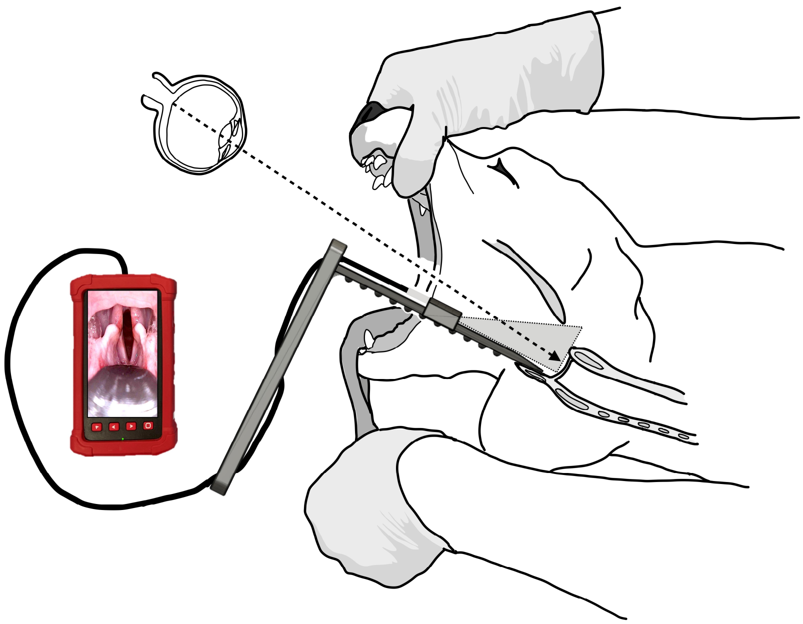

Figure 2. Schematic diagram of use of three-dimensional printed video laryngoscope with a borescope with adjustable location of camera. The distance between the borescope camera and larynx is 6 cm. The dotted arrow represents the direction of naked eye view to glottis during laryngoscopy, and the gray area within dotted triangle is view angle of camera.

Laryngeal visualization scoring system

In the process of laryngoscopy and intubation, the naked eye view was photographed with a smartphone (iPhone 12 Pro; Apple Inc., USA) camera to capture a view that is as similar as possible to that with the naked eye. In addition, the whole process was recorded simultaneously with the borescope camera and analyzed later. The laryngeal visualization was scored based on the Cormack and Lehane system, which is one of the laryngeal visualization evaluation criteria for intubation in human medicine, modified for canines (Molina & García 2017). The laryngeal visualization score (LVS) was defined as four points: LVS 0, invisible glottis; LVS 1, only the epiglottis is visible; LVS 2, part of the glottis is visible; LVS 3, the whole glottis is visible (Fig. 3). In addition, when the endotracheal tube passed the laryngeal cartilage or vocal folds, we identified whether the intubation process was visible or not, and the visualization of the intubation through the camera was evaluated the same way using the recorded video.

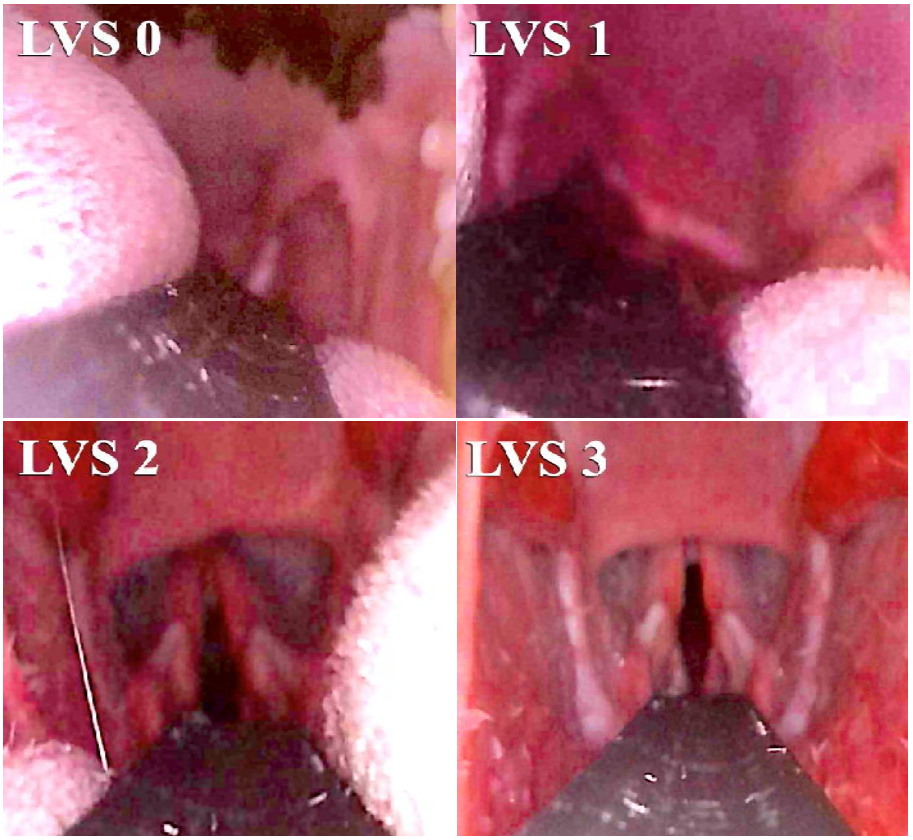

Figure 3. Example images of laryngeal visualization score (LVS). LVS 0, neither glottis nor epiglottis is visible; LVS 1, only epiglottis is visible; LVS 2, partial view of glottis; LVS 3, full view of glottis.

Statistics

Statistical analysis was performed using the SPSS 26 statistical program for MAC (IBM SPSS Statistic; IBM Corp., NY, USA), and all tests used a significance level of 5%. Differences of visualization score on the screen and to the naked eye during laryngoscopy or intubation at $\text{distance}_{\text{LARYNX-CAM}}$ and $\text{distance}_{\text{INTER-INCISOR}}$ were analyzed by one-way Kruskal–Wallis analysis of variance (ANOVA). Post hoc analysis of 10 pairwise comparisons among five treatments (laryngeal visualization score for each $\text{distance}_{\text{LARYNX-CAM}}$ and $\text{distance}_{\text{INTER-INCISOR}}$) was performed using Mann–Whitney test for multiple comparisons.

Results

Single VL_{VET} was used in a total of 60 episodes of laryngoscopy, and there was no dysfunction of the device during manipulation. The mean of Beagles' maximum inter-incisor distance and the length of the oral cavity were 10.2 ± 0.5 and 12.1 ± 0.7 cm, respectively. There was no remarkable dysmorphism of the larynx, and no injury related to the VL_{VET} of the oral cavity was observed in any of the dogs.

The $distance_{LARYNX\text{-}CAM}$ could be adjusted within 5-15 seconds, then the VL_{VET} could be reused immediately without further reinforcement. On the screen and naked eye views, as the light source of the camera was further away from the larynx, both views were darker, but the different anatomy of the larynx was visible.

Full view of the glottis was accomplished through the screen from all $distance_{LARYNX\text{-}CAM}$ (Fig. 4 & Table 1). On the naked eye view, the 2 cm $distance_{LARYNX\text{-}CAM}$'s visualization score was significantly lower compared to other distances (all $p < 0.005$). The 2 cm $distance_{LARYNX\text{-}CAM}$ showed partial glottis (LVS 2) owing to visual obstruction of the naked eye view because of the camera holder being too close to the larynx, but intubation was possible without any difficulty. In addition, successful intubation from all $distance_{LARYNX\text{-}CAM}$ was also confirmed on both views.

The ≥ 6 cm $distance_{INTER\text{-}INCISOR}$ allowed full view of the glottis with both the naked eye and the screen (Table 2), and the 2 cm $distance_{INTER\text{-}INCISOR}$ had a lower visualization score because of the tongue volume in the oral cavity, compared to ≥ 6 cm $distance_{INTER\text{-}INCISOR}$ (all $p < 0.005$).

On the naked eye view, 4 cm distance$_{INTER-INCISOR}$ had a lower visualization score compared to ≥ 8 cm distance$_{INTER-INCISOR}$ (all $p < 0.005$). However, 4 cm distance$_{INTER-INCISOR}$ showed partial glottis in all but one dog, whereas the glottis was not observed at 2 cm distance$_{INTER-INCISOR}$. In addition, 4 cm distance$_{INTER-INCISOR}$ showed the glottis on the screen view in all laryngoscopies.

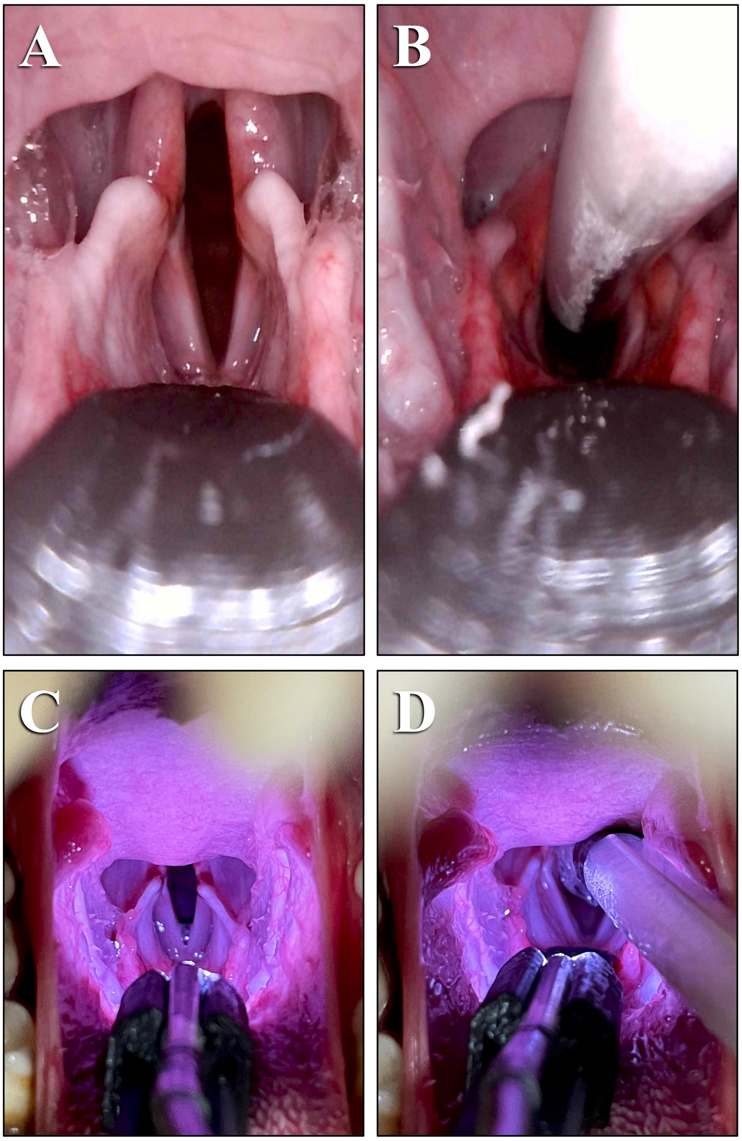

Figure 4. Comparison of view with the screen and the naked eye during laryngoscopy and intubation. Images of glottis during laryngoscopy and endotracheal tube passing through the larynx during intubation on borescope screens (A and B, respectively) and on naked eye views (C and D, respectively).

Table 1. Median of laryngeal visualization scores for laryngoscopy and intubation visibility by distance from the larynx of the borescope mounted on blade

$\text{Distance}_{\text{LARYNX-CAM}}$ (cm)	**Laryngoscopy**		**Intubation**	
	Screen	**Naked eye**	**Screen**	**Naked eye**
2	3 (3-3)	2 (2-2)	Visible	Visible
4	3 (3-3)	3 (3-3)*	Visible	Visible
6	3 (3-3)	3 (3-3)*	Visible	Visible
8	3 (3-3)	3 (3-3)*	Visible	Visible
10	3 (3-3)	3 (3-3)*	Visible	Visible

$\text{Distance}_{\text{LARYNX-CAM}}$, distances from the blade tip located at the larynx to the camera. Laryngeal visualization score (LVS) was defined as four scores, which were 0; invisible glottis, 1; only the epiglottis is visible, 2; part of the glottis is visible, 3; the whole glottis is visible. Intubation visualization was evaluated whether the endotracheal tube passed through the vocal fold. *Statistically different visualization score from focus distance 2 cm ($p < 0.005$).

Table 2. Median of laryngeal visualization scores through the naked eye and the screen during laryngoscopy by reducing the inter-incisor gap by 2 cm from 10 cm.

$Distance_{INTER-INCISOR}$ (cm)	Screen	Naked eye
2	1.5 (0-2)	1 (0-1)
4	2 (2-3)	2 (1-2)
6	3 (2-3)*	3 (2-3)*
8	3 (3-3)*	3 (3-3)*,†
10	3 (3-3)*	3 (3-3)*,†

$Distance_{INTER-INCISOR}$. the gap between upper and lower incisors. Laryngeal visualization score (LVS) was defined as four scores, which were 0; invisible glottis, 1; only the epiglottis is visible, 2; part of the glottis is visible, 3; the whole glottis is visible. *Statistically different from inter-incisor gap 2 cm ($p < 0.005$). †Statistically different from inter-incisor gap 4 cm ($p < 0.005$).

Discussion

The VL_{VET} enabled both video and direct laryngoscope to be used simultaneously, during laryngoscopy and intubation, at various $distance_{LARYNX\text{-}CAM}$ in Beagle dogs with ≥ 6 cm $distance_{INTER\text{-}INCISOR}$. The VL_{VET} was designed not only for the synchronization of laryngeal visualization between the screen and naked eye views using similar manipulation with the direct laryngoscope, but also for adjustment of the $distance_{LARYNX\text{-}CAM}$ through introduction of the camera holder. Fortunately, there was no remarkably difficult visualization on both views in Beagles with > 10 cm $distance_{INTER\text{-}INCISOR}$. However, if the camera holder is too close to the larynx, the naked eye view can be obstructed, and the obstruction is aggravated at less $distance_{INTER\text{-}INCISOR}$ which is one of the major factors for difficult intubation due to inadequate laryngeal visualization (Nath & Sekar 1997). Therefore, LVS of the longest $distance_{LARYNX\text{-}CAM}$ (10 cm) was additionally evaluated at limited mouth opening, and the VL_{VET} required ≥ 4 cm $distance_{INTER\text{-}INCISOR}$ at least for glottis visualization in Beagles with 12.1 ± 0.7 cm length of oral cavity.

VL is used to obtain screen images of the larynx. For this reason, most low-cost 3D printed VLs have been used with a commercial borescope whose camera has restrictive and various specifications including diameter, resolution, light source, focus distance, and view angle (Lambert et al. 2020, Ataman et al. 2021). The VL_{VET} adopted a detachable camera holder for stable attachment, and its design can be varied corresponding to diverse camera sizes of various borescopes with one size of laryngoscopic body. In addition, the detachable camera holder allowed adjustment of the location of the camera on the laryngoscope blade to record detailed images despite the restrictive camera specification. The straight blade of the VL_{VET} was considered to maintain the viewing angle of the attached camera at different locations. Moreover, prolonged use of borescope causes warming of the camera, but the camera holder covers the camera and prevents direct contact between the camera and the patient. The VL_{VET} also functions as a direct laryngoscope with the support of the light source of the camera. The blade volume of VL_{VET} was minimized through pilot tests of various prototypes, and the 2 cm inclined blade tip is designed for minimal visual obstruction.

Borescopes are commonly priced from US $60 to $150, and the borescope used in the present study was purchased for approximately US $100. When using VL_{VET}, the diameter of the camera that is attached above the blade is the most critical factor in securing visibility to the naked eye. Though the borescopes sold online offer a wide range of diameters between 0.4 cm and 1 cm, the borescope with the smallest diameter is recommended considering the design and function of VL_{VET}. Although the 0.4 cm diameter borescope was used for this experiment, the camera holder was manufactured for 3 different diameters (0.4, 0.6 and 1 cm) to support the variety of diameters of borescope cameras.

The 3D printing of medical devices requires consideration of materials and printing methods. PLA filaments are eco-friendly, reasonably priced, biocompatible, and non-carcinogenic (DeStefano et al. 2020), and therefore used in many medical devices including stents and surgical instruments in human medicine (Farah et al. 2016). Further, PLA filament-made objects could be sterilized using plasma or ethylene oxide (Rynio et al. 2022).

At the VL_{VET}, the color of filament affects the auto brightness balance of the borescope camera and secondarily the screen image, because the blade tip is always closer to the camera that is being automatically focused rather than the larynx. Comparing between black and white colored filaments, the use of black filament resulted in a clearer image of the larynx (Fig. 5). The fused-deposition modeling technique of 3D printers requires a structure supporter on the area that touches the floor surface for structural stability during printing, and the VL_{VET}'s area where the structure supporter is attached comes out rough and uneven. Therefore, when printing, the blade area that comes in contact with the patient should not face the floor.

Manipulation of the VL_{VET} was also a major consideration at its design for user preference. In particular, when relocation of the camera is required during the anesthetic induction period, a rapid, easy, and stable manipulation of the VL_{VET} should be available. For these, the fixation strength of the borescope to the VL_{VET} should be stable enough without further reinforcement, but the rigid cable and heavy screen of the borescope increased the difficulty of the design. As a solution, three holes on the handle are made for the cable to pass through, and then the rigidity of the cable is used to fasten the borescope firmly to the handle. In addition, while the common laryngoscope is designed to be either left-handed or right-handed, the VL_{VET} can be used interchangeably (in both hands) as the camera is located in the center of the blade.

Suitable conditions for the VL_{VET} can be different in other situations. This study was performed on only Beagle dogs with normal airways, and further study is needed in patients of various breeds, sizes, and disease states in clinical environments. In addition, the results of this study performed using only a specific borescope should not be generalized to other commercial borescopes with different camera diameters or specifications. Although the camera holders can be separately designed for various diameter of camera, in theory, minimal diameter is recommended for better naked eye view. In this study, unfortunately, there was no evaluation of the exact strength that caused structural degeneration or destruction, while it was verified that the VL_{VET} has more than the strength required for laryngoscopy and intubation through the repeated test with a single VL_{VET}. The purpose of the VL_{VET} is different with existing direct laryngoscopes, and preparation of other laryngoscopes is recommended as backup, if necessary.

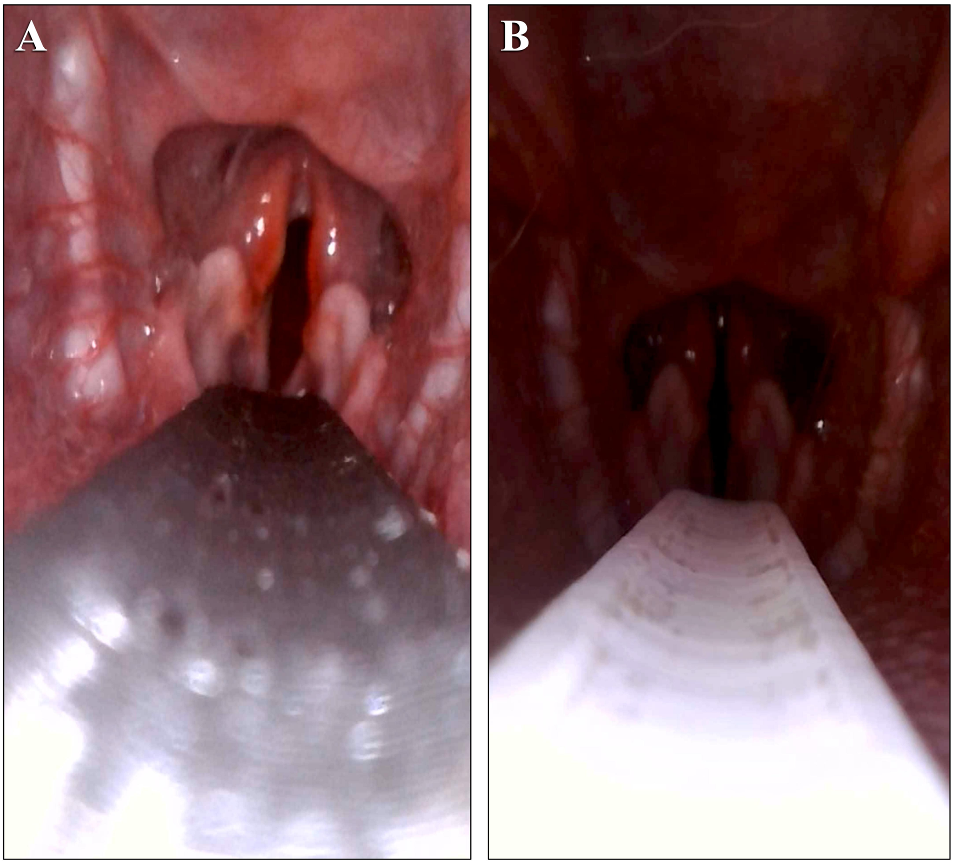

Figure 5. Brightness comparison of images, including the tip of laryngoscopic blade and larynx, according to the colors of three-dimensional printed video laryngoscope with a borescope. The larynx around the blade tip made of black filament is well differentiated (A) compared to with white filament (B).

Conclusions

The VL_{VET} facilitated the function of both video and direct laryngoscope to be used simultaneously at a reasonable price. The use of camera holder facilitated laryngoscopy at various $distance_{LARYNX\text{-}CAM}$, but glottic visualization on naked eye view required above a certain $distance_{INTER\text{-}INCISOR}$. Further investigation should focus on whether the performance of VL_{VET} is enough in other situations.

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국 문 초 록

산업용 내시경을 장착하도록 3D 프린터로 제작한 보급형 후두경의 개발과 평가

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수의학과 임상수의학 전공

본 연구의 목적은 시판되는 borescope 를 장착할 수 있는 3D 프린팅 을 이용한 비디오 후두경 (VL_{VET})을 제작하고, 이를 비글견에서 평가하기 위함이다.

VL_{VET} 은 검정색 polylactic acid 로 3D 프린터를 통해 인쇄된 Miller 형 후두경 본체와 블레이드 위 다양한 위치에 카메라를 부착할 수 있는 분리 가능한 카메라 홀더부로 구성되어있다. 각각의 비글견들은 복와위에서 정맥주사를 통해 medetomidine (15 μg kg^{-1}) 과 alfaxalone (1.5 mg kg^{-1}) 로 마취되었다. 카메라의 위치는 후두에 닿는 블레이드 끝으로부터 2, 4, 6, 8, 10 cm 거리 ($distance_{LARYNX-CAM}$) 에 장착하여 각

거리별로 맨눈 시야와 화면을 통한 시야로 후두 가시화 점수와 삽관 가시화 정도를 평가했다. 10 cm $\text{distance}_{\text{LARYNX-CAM}}$ 에 카메라를 위치시킨 뒤, 입을 벌려 위아래 앞니 사이의 거리 ($\text{distance}_{\text{INTER-INCISOR}}$) 를 10, 8, 6, 4, 2 cm 로 2 cm 간격으로 줄이며 각각의 거리에서 후두 가시화 점수를 측정하였다. 각 점수는 Kruskal-wallis test 를 통해 통계적으로 분석되었다.

평균 체중 11.6 ± 1.1 kg, 평균 나이 3.0 ± 1.0 년 령의 6 마리 비글을 이용하여 실험을 진행하였다. 블레이드 위에서의 카메라의 위치는 5-10 초 이내에 조정 가능했고, 위치 이동 후에는 다른 고정 장치 없이 즉시 VL_{VET} 를 사용할 수 있었다. 2 cm 를 제외한 모든 $\text{distance}_{\text{LARYNX-CAM}}$ 에서 맨눈과 화면 모두를 통해 성문 전체와 삽관이 되는 것을 확인할 수 있었다. 맨눈과 화면 시야 모두에서 $\text{distance}_{\text{INTER-INCISOR}}$ 가 6 cm 이상일때 2 cm 에 비해 더 높은 가시화 점수를 보였으며 4 cm 이상에서는 한 마리를 제외하고는 모두 맨눈으로 성문을 확인할 수 있었다. 비글에서 후두 검사와 삽관을 진행하는 과정에서, VL_{VET} 은 다양한 $\text{distance}_{\text{LARYNX-CAM}}$ 에서와 6 cm 이상의 $\text{distance}_{\text{INTER-INCISOR}}$ 에서 비디오 후두경과 직접 후두경의 기능을 동시에 수행할 수 있었다.

주요어: 개, 탈부착 카메라, 앞니사이 거리, 삽관, 수의학용

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