

A comparison of posterior pharyngeal wall areas between different tongue positions during inhalation

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Clinical Implications

- Optimal intraoral conditions, particularly the tongue position, are required for maximal effectiveness of inhaled antiasthmatic drugs. A larger volume of inhalants can be delivered into the trachea if the tongue is lowered, expanding the back of the throat, during inhalation.

TO THE EDITOR:

Inhalants are not effective unless they are delivered into the airway. Thus, we hypothesized that even if an inhaler was correctly used, the tongue might block the route from the mouthpiece to the trachea. In our previous study, inhalation conditions for 6 healthy volunteers were filmed using an endoscope to examine how different tongue positions would affect the conditions. We reported that a larger volume of placebo powder/particles reached the pharynx and flowed toward the trachea when the tongue was lowered than in other positions, for both fluticasone furoate/vilanterol and fluticasone and formoterol practice inhalers.¹

Our previous study suggested that lowering the tongue might have kept the intraoral inflow route wide open. However, we were unable to observe the posterior pharyngeal wall because of the presence of placebo powder/particles. We assumed that the volume of inflow might differ across different pharyngeal sizes. No previous studies have assessed differences in the pharyngeal area during inhalation. Thus, in the present study, without using placebo, we observed posterior pharyngeal wall conditions, using an endoscope, with and without lowering of the tongue. The wall area was then compared and analyzed.

The present study was approved by the Medical Research Ethics Committee of Fujita Health University (HM16-076). Subjects were healthy volunteers ($n = 9$; age, 28–51 years; 7 men and 2 women). We explained the study to the subjects and obtained their informed consent. We made a paper tube of the same size and shape as the mouthpiece of the fluticasone and formoterol pressurized metered dose inhaler. An endoscope (BF-260, Olympus, Shinjuku, Tokyo, Japan; 4.9 mm diameter) was aligned with the tube's front edge and fixed at the center of its lower side using tape (see Figure E1 in this article's Online Repository at www.jaci-inpractice.org). While filming, all volunteers held the tube in their mouth such that the tube's front edges and bronchoscope were placed 5 mm from their first incisor. When the tongue was not lowered, the tube was held, with the tongue kept free. After a certain amount of expiration, the volunteers inspired deeply. When the tongue was lowered, it was placed under the mouthpiece; the tongue and its root were lowered as much as possible to expand the back of the throat.

The volunteers inspired deeply; inhalation speed and volume were kept constant. The pharyngeal size during inhalation was measured as the area of the posterior pharyngeal wall. Still images were extracted from the filmed video, showing the largest posterior pharyngeal wall area. Because the pharyngeal area varied across volunteers, the percentage of the accessible area without lowering the tongue to the area with lowering the tongue was compared. The posterior pharyngeal wall area was measured from the images using a hypothetical 10-cm long and 10-cm wide region. The area was demarcated using Photoshop CC (Adobe Systems, Inc, San Jose, Calif) and calculated. All results were expressed as mean $\pm$ SD. Statistical analysis was performed using t test, and P value of less than .05 was considered statistically significant. Statistical analyses were performed using Stat View J 5.0 (Brain Power USA, Inc, Fremont, Calif).

Case 1 is shown in Figure 1. When the tongue was lowered (right images), the posterior pharyngeal wall area was 7.0 cm², which was larger than the area measured (1.1 cm²) when the tongue was not lowered (left images).

Table E1 in this article's Online Repository at www.jaci-inpractice.org presents the posterior pharyngeal wall area, measured with and without lowering of the tongue, for all volunteers. Because the oral cavity and pharyngeal sizes varied across volunteers, the posterior pharyngeal wall area when the tongue was not lowered was measured as a percentage of the posterior pharyngeal wall area when the tongue was lowered.

When the posterior pharyngeal wall area was measured and compared in the same manner across all 9 volunteers, the area was significantly larger ($P < .0001$) when the tongue was lowered (100.0% $\pm$ 0.00%) than when it was not (16.17% $\pm$ 10.60%) (Figure 2).

The National Asthma Education and Prevention Program² and the 2018 guidelines of the Global Initiative for Asthma³ indicate that the basis of bronchial asthma treatment is inhaled corticosteroids, and that regular inhaled therapy is essential.² Various studies worldwide have promoted correct inhaler use.^{4–6} Although correct inhaler use is essential, no clinical studies have been conducted on delivery of inhaled drugs from the mouthpiece to the trachea. We previously investigated the most efficient and preferable intraoral condition for inhalation. Although the tongue is not considered in *in vitro* studies, we assumed that drugs might be trapped depending on tongue positions in *in vivo* studies. Therefore, we filmed inhalation conditions, using an endoscope, to examine the effect of different tongue positions. We reported that a larger volume of placebo reached the pharynx and flowed toward the trachea when the tongue was lowered than when it was not,¹ suggesting that lowering the tongue expanded the pharynx, and kept the inflow route open. In the present study, we examined the pharyngeal conditions without using placebo. Consequently, the posterior pharyngeal wall area during inhalation was significantly larger when the tongue was lowered than when it was not. In other words, the results suggested that by lowering the tongue, the inflow route from the mouthpiece to the pharynx is kept wide open so that a larger volume of drugs could pass by without being trapped by the tongue, flow into the pharynx, and reach the trachea, confirming our previous

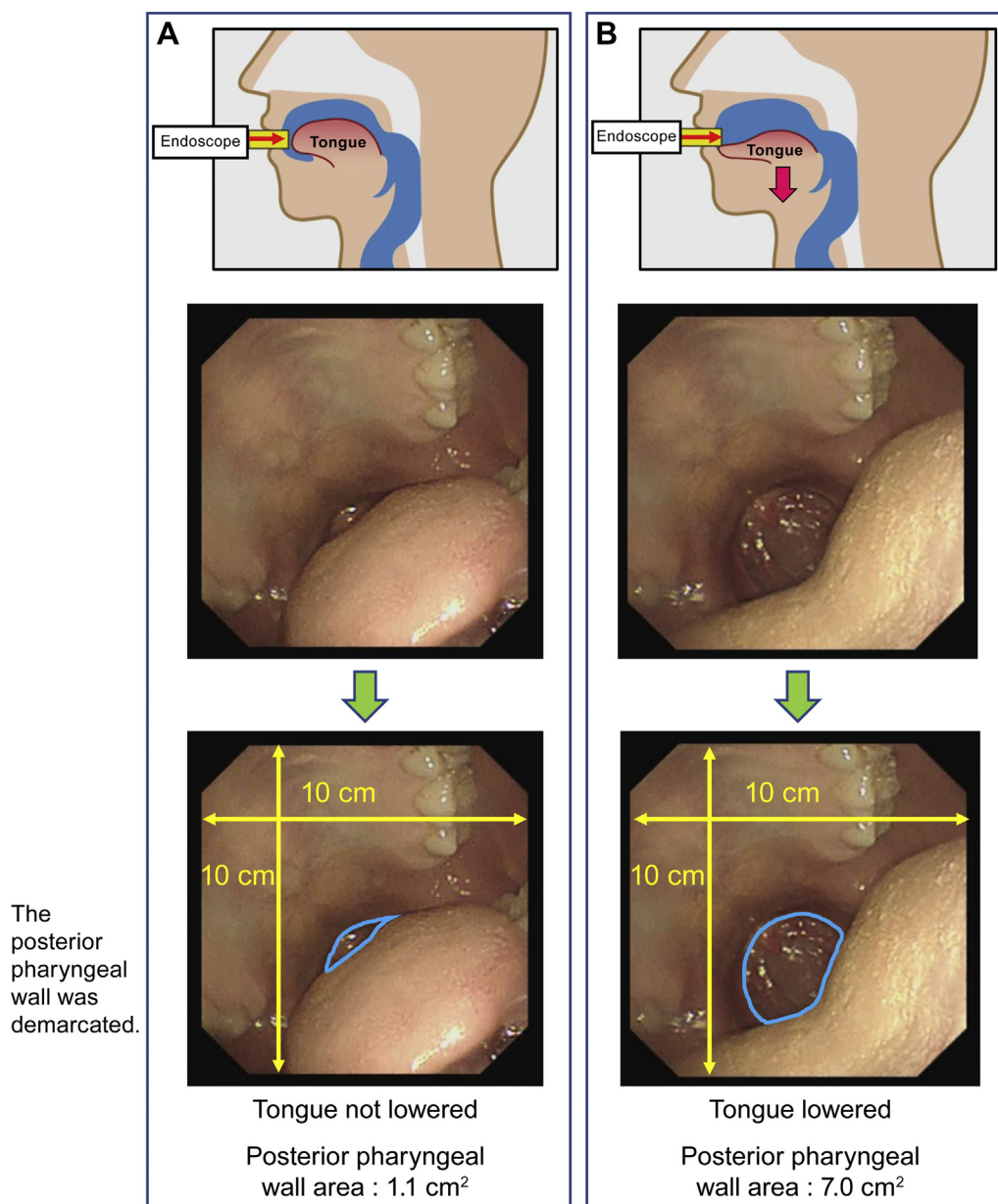


FIGURE 1. Case 1: Area of the posterior pharyngeal wall according to the tongue position. The posterior pharyngeal wall area was (A) smaller when the tongue was not lowered (1.1 cm²) than (B) when the tongue was lowered (7.0 cm²).

results. If drugs are efficiently delivered to the trachea, their effects can be maximized, and unnecessary stepping-up of treatment can be avoided. Lowering the tongue is a common technique that can be applied for all inhalants without increasing medical costs.

One limitation of this study is the use of artificial conditions, which was crucial and unavoidable because it was important to film the intraoral conditions (distance from the right and left sides, height, and depth) from the same point as where an inhaler containing an active drug is held to accurately measure the tongue position and posterior pharyngeal wall area. Nonetheless, in the future, we would like to report clinical effects based on the present study. In our future study, we will instruct patients with bronchial asthma to lower their tongue on the basis of findings of

the present study and will assess the effectiveness of this technique. We also intend to report its clinical effects.

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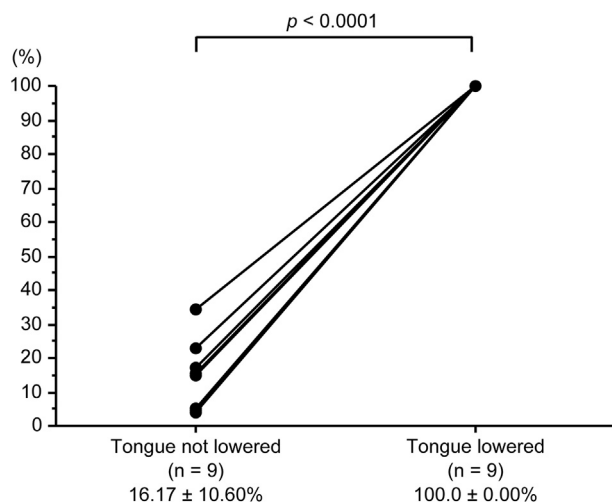


FIGURE 2. Percentage of the accessible posterior pharyngeal wall area according to the tongue position. In all 9 volunteers, the area of the posterior pharyngeal wall was significantly larger when the tongue was lowered than when it was not ($P < .0001$).

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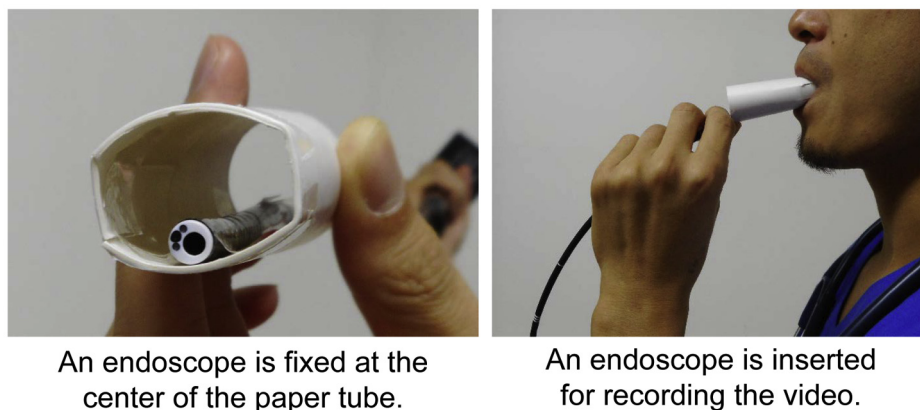


FIGURE E1. Video recording method. Using paper, we made a tube that was of the same size and shape as the mouthpiece of the pressurized metered dose inhaler for fluticasone and formoterol. The front edge of an endoscope was aligned with that of the tube, and firmly fixed at the center of the lower side of the tube using tape.

TABLE E1. Percentage of the posterior pharyngeal wall area (N = 9)

Case no.	Age (y)	Sex	Posterior pharyngeal wall area (cm ²)		Posterior pharyngeal wall area (tongue not lowered)/posterior pharyngeal wall area (tongue lowered) (%)
			Tongue not lowered	Tongue lowered	
1	28	Male	1.1	7.0	15.7
2	51	Female	4.5	13.0	34.6
3	49	Male	0.34	7.8	4.4
4	28	Female	0.4	7.6	5.3
5	34	Male	2.0	8.7	23.0
6	30	Male	1.9	11.0	17.3
7	42	Male	1.0	6.6	15.1
8	31	Male	0.37	9.5	3.9
9	29	Male	1.5	5.7	26.3

The posterior pharyngeal wall area, with or without lowering the tongue, was measured from images using a hypothetical 10 cm × 10 cm region. For each volunteer, the percentage of the posterior pharyngeal wall area on not lowering the tongue to that on lowering the tongue was calculated.