

# The effects of mouth opening on changes in the thickness of deep cervical flexors in normal adults

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**Abstract.** [Purpose] The purpose of this study was to identify changes in the thickness of the deep cervical flexors (DCF) according to the degree of mouth opening (MO) in normal adults. [Subjects] The study's subjects were 50 normal adults (30 men, 20 women). [Methods] Ultrasound was used to obtain images of muscles, and the NIH ImageJ software was used to measure the thickness of each muscle. [Results] An increase in MO resulted in a corresponding increase in the thickness of the DCFs, and in isometric exercises (IEs), the thickness of the DCFs further increased during MO. [Conclusion] During MO, the thickness of the DCFs increased. This may be due to correlations between mandibular movements and DCFs. Therefore, the results are likely to be utilized as new clinical research data.

**Key words:** Deep cervical flexors, Mouth opening, Temporomandibular joint

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## INTRODUCTION

Muscles around the neck have associative correlations with the muscles of the stomatognathic system, and they play a mutually complementary role in maintaining each other's balance. Eventually, changes in head posture will influence the movement of the temporomandibular joint (TMJ) by changing the activation of masticatory muscles, and this can cause muscular diseases such as myofascial pain syndrome due to use of bad postures<sup>1)</sup>.

Zafar et al.<sup>2)</sup> reported that mouth and neck movements are harmonized, particularly in fast movements. In addition, a higher level of functional correspondence between head and mouth movements leads to a larger degree of mouth opening (MO), and extension of the head enables a larger degree of MO<sup>3)</sup>.

A number of studies have reported that the mouth's functional movements influence the head and neck bones<sup>3-5)</sup>. Armijo-Olivo and Magge<sup>6)</sup> presented clear correlations between disabilities in the neck and TMJ and revealed a reduction in the neck extensors and flexors when a muscular endurance test was conducted on the two muscle groups. This

may suggest that mechanical correlations exist between the neck and TMJ and that the degrees of MO and pain vary according to changes in head and neck postures<sup>7)</sup>. Eventually, the neck bone and TMJ can either share risk factors between their conditions or influence each other<sup>8)</sup>. As this shows, assertions about the relationship between the alignment of the neck bone and TMJ have been generalized, but clear evidence is still lacking. In addition, direct measurements have not been taken for the changes in the stabilizer muscles of the neck bone according to mouth movements.

In this regard, this study aimed to confirm kinematic correlations between the neck and TMJ by measuring changes in the thickness of the deep cervical flexors (DCF), stabilizer muscles of the neck bone, during MO.

## SUBJECTS AND METHODS

This study's subjects included 50 students (30 men, 20 women) at D College located in Daegu City, Republic of Korea. In terms of the mean±standard deviation, the subjects were 26.8±4.7 years of age, 169.75±9.2 cm in height, and 65.4±15.1 kg in weight. Those who had muscular, skeletal, or neurological problems, felt pain in the neck, shoulder, or TMJ, or had limitations in movement in daily life were excluded from the study. This study was approved by Korea Nazarene University's Institutional Review Board (2014-0417-10). Participants in the study submitted a written consent form for participation based on the ethical standards of the Declaration of Helsinki after fully understanding the study's purpose and the test's overall contents.

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To identify changes in the thickness of the DCFs according to mouth movements, changes in the thickness of the DCFs were measured during 50% MO and 100% MO and during isometric exercises (IEs) with mouth closing (MC) and MO from 50% MO. To this end, before the experiment, the maximum degree of MO for every subject was measured in terms of the distance between the upper and lower teeth using vernier calipers (China).

To measure the thickness of muscles during MO, each subject had his/her head, back, and waist fixed against a wall while seated on a chair. To have the neck fit into a standardized location, the forehead and jaw were aligned with a vertical line, and a pressure biofeedback unit (PBU) was placed on the back of the neck and expanded at a basic pressure level of 20 mmHg. During 50% MO and 100% MO, all subjects were instructed to perform MO in a comfortable manner. The performance for each phase was maintained for ten seconds. In evaluating the IEs of MO and MC, each subject was instructed to open his/her mouth 50% while the research assistant applied resistance to the jaw's lower part during MO. During MC, resistance was applied to the subject's lower teeth for ten seconds. A two-minute break was provided between tests. In every measurement, caution was taken not to cause head and neck movements during MO. When a change in PBU pressure occurred, measurement was stopped, and it was resumed after reeducating the subject.

While the subjects performed each phase, a 7.5 MHz transducer of a Mysono U5 (Samsung Medison, Seoul, Republic of Korea) was placed in such a way that it could measure the DCFs in the front of the neck in a longitudinal direction and parallel to the trachea's central part at a distance of 5 cm. Therefore, images were photographed while the transducer was in place to show clear shapes of the muscle, carotid artery (CA), and vertebra lamina (VL)<sup>9</sup>. For every subject, his/her left-side DCFs were measured, and the better image after two measurements was selected.

The thickness of the DCFs was measured from images obtained by ultrasound using the NIH ImageJ software (version 1.44 for Windows). During measurement of the thickness, a standard line was drawn through the center of each image, and vertical lines were drawn from the central line to the right with lengths of 0.5 cm, 1 cm, and 1.5 cm. On each line, the thickness of the DCFs was measured based on the distance of the boundary part between the CA and the VL<sup>10</sup>. Average values were employed for the thickness of measured muscles.

The data collected in this study were analyzed using SPSS 17.0, and the collected data are presented as averages and standard deviations. A repeated measures ANOVA was conducted to examine changes in the thickness of each muscle according to pressure, and paired t-tests were employed to identify changes in the thickness of muscles during the IEs of MO and MC. The statistical significance level was set at  $\alpha=0.05$ .

## RESULTS

While performing MO, an increase in MO led to a statistically significant increase in changes in the thickness of the

**Table 1.** Change in muscle thickness during mouth opening (unit: cm)

DCFs*	Muscle thickness (mean±SD)		
	MC	50% MO	100% MO
	0.83±0.21	0.86±0.22	0.95±0.25

\*  $p<0.05$ . DCF: deep cervical flexors, MO: mouth opening, MC: mouth closing

**Table 2.** Muscle thickness changes during isometric exercises (unit: cm)

DCFs*	Muscle thickness (mean±SD)	
	MO	MC
	0.95±0.23	0.85±0.21

\*  $p<0.05$ . DCFs: deep cervical flexors, MO: mouth opening, MC: mouth closing

DCFs ( $p>0.05$ ) (Table 1). During the IEs with MC and MO, changes in the thickness of the DCFs also showed statistical significance ( $p>0.05$ ) (Table 2).

## DISCUSSION

Eriksson et al.<sup>11</sup> reported that MO involves extension of the head and neck and that MC is exhibited simultaneously to flexion of the head and neck. The head's extension during MO could reduce the shortening of the length of the muscle plate of the jaw's opening muscles. As a result, the jaw's opening muscles produce torque values to further open the jaw during the head's backward extension<sup>3</sup>. This motion of extension may require the co-contraction of DCFs to stabilize the neck bone.

This study showed that an increase in MO led to a corresponding increase in the thickness of the DCFs, and even in IEs, a larger increase in the thickness of the DCFs was confirmed during MO compared with during MC. This indicates that the motion of MO requires the stability of the neck bone and that the neck muscles are associated with the masticatory muscles.

Moreover, this study was designed and performed to prevent the extension of the neck bone that occurs during MO. Therefore, the activation of the DCFs may have increased to suppress this extension.

Forward head posture (FHP) can be accompanied by disabilities in the TMJ and, at times, become the cause of their occurrence<sup>12</sup>. Gong et al.<sup>13</sup> reported that an increase in FHP leads to a reduction in the ROM of the extension of the neck and in the endurance of the DCFs. Armijo-Olivo and Magge<sup>6</sup> noted that regarding correlations between disabilities in the neck and TMJ, the muscle endurance of the neck extensors and flexors was reduced. Ultimately, this study enabled direct observation of changes in DCFs according to the degree of MO; thus, the neck and TMJ may have kinematic correlations. This result can be suggested as new evidence for the relationship between the two joints, and the results of the present study can likely be utilized as new data in future studies regarding the therapeutic relationship between diseases in the TMJ and diseases related

to back pain.

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