Influence of experimental loss of occlusal support on tongue movement during swallowing

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We attempted to clarify how stable occlusal positioning in the molar region influence tongue movement during swallowing. M-mode ultrasonography was used to measure the tongue movement of eight healthy dentulous subjects when they swallowed 10 grams of a gel style pudding. Time-course changes in vertical tongue movement were recorded in the mediodorsal region of the tongue at the position of the mandibular first molars. Measurements were done with no splint (NS), a full-jaw splint (FS), a splint maintaining molar occlusion (MS) and a splint maintaining occlusion only on the anterior teeth (AS). The duration the tongue contacted the palate was measured between the time it touched the roof of the palate and the time it disengaged.

Since the time of contact for the NS subjects was not significantly different from that of the FS subjects, we concluded that changes in vertical dimension caused by wearing the splint did not affect the duration of contact. However, when compared with NS, the FS, and the MS, the AS did reduce contact time ($p<0.05$). This is probably because when the AS was in place the mandible was unstable because of loss of occlusal support in the molar region. This seemed to make it more difficult with the AS to maintain the tongue pressed to the palate as compared with NS, the FS and the MS. (J Osaka Dent Univ 2007; 41: 169-172)

Key words: Occlusal support; Deglutition (Swallowing); Tongue movement; Ultrasonography

INTRODUCTION

There have been many studies on the movement of the tongue during swallowing. Most previous studies have focused on handicapped children with developmental retardation and rehabilitation of patients who have undergone glossectomy because of tongue cancer or cerebral apoplexy. Recently, considerable attention has been directed at how occlusion affects movement of the tongue during swallowing. Quantitative studies have researched the effect of anterior open bite, tongue-thrusting during swallowing,¹ and how alteration in mandibular position affect tongue movement during swallowing.² Stability of the mandible is considered an important factor for swallowing. However, how partial loss of occlusal support influences tongue movement during swallowing has not been clarified. We studied this issue.

MATERIALS AND METHODS

Measurement procedures

Eight healthy dentulous students with no functional disorder in the stomatognathic system were chosen as the subjects from undergraduate and graduate students at Osaka Dental University. They were between 21 and 35 years of age, with a median of 22 years. The nature of the study was fully explained and written consent was obtained. This research was approved by the Ethics Committee at Osaka
Dental University (approval number 050149). Ten grams of gel style pudding (Big Putchin Pudding; Glico, Tokyo, Japan) was used as the test food. M-mode ultrasound diagnostic equipment (SSA-250 A; Toshiba, Tokyo, Japan) was used to measure movement of the tongue dorsum at the midpoint between the bilateral mandibular first molars. At the start of this study, the subjects were instructed to place a spoonful of pudding in the anterior of the oral cavity and swallow it when instructed. We asked the subjects to visualize moving the tongue dorsum from the front to the back of the oral cavity as they swallowed, and to consciously maintain their usual swallowing speed. We also instructed the subject to maintain the rest position of the mandible after swallowing, even if some pudding remained in his mouth.

We used photopolymerizable resin (Photo CMO-21; Kuraray Medical Inc., Tokyo, Japan) and the indirect technique to prepare splints that allowed experimental changes in the area of occlusal support. Pressure-molding of the resin paste was done maintaining a space of 1-mm in the molar region to make the splint as thin as possible. The splints were prepared to maintain contact with either the anterior or posterior teeth at the time of occlusion.

Measurements were carried out with no splint (NS), a full-jaw splint (FS), a splint that maintained occlusion only in the molar region with the anterior portion removed (MS), and a splint that maintained occlusion only in the anterior region (AS).

**Analysis**

Time points for analysis and measurement parameters are shown in Fig. 1. First, the time is determined when the tongue reaches its lowest point (A). Then the time is determined when movement stops and it touches the roof of the palate (B). Next, the time is determined when the tongue disengages the palate (C). The intervals between these three time points are the measurement parameters, i.e., the duration of transfer movement and the duration of contact with the palate. A digital caliper (951-101 MAX-15 P; NSK, Tokyo, Japan) was used for measuring the parameters.

The mean from three trials was calculated as the individual value. Statistical analysis for comparison among the different conditions was made by Friedman analysis. If significant differences were found on Friedman analysis, Dunn analysis was used for multiple comparison. The level for significance was 5%.

**RESULTS**

**Duration of transfer movement** (Fig. 2) The median time for each subject was 0.20 sec for NS, 0.22 sec for FS, 0.35 sec for MS, and 0.25 sec for AS. The median time was significantly greater for the MS than for NS or the FS (p<0.05).

**Duration of contact with the palate** (Fig. 3) The median duration for the subjects was 0.96 sec for NS, 1.01 sec for FS, 1.18 sec for MS, and 0.72 sec for AS. Compared with NS, the FS, and the MS, the time of contact was significantly less for the AS (p<0.05).

![Fig. 1 Measurement points and durations. (A) The tongue reaches its lowest point. (B) Movement stops as the tongue presses against the palate. (C) The tongue disengages the palate.](image)

![Fig. 2 Duration of transfer movement under various measurement conditions (*p<0.05).](image)
DISCUSSION

The first step of mastication is intake of food into the oral cavity. The food is then transferred onto the tongue, which presses it to the palate to determine such properties as hardness and temperature. If the food is soft enough, it is immediately crushed to be swallowed. However, if it is judged to be hard, it is transferred to the molar region for mastication. After the food is softened through mastication and mixed with saliva, it is transferred into the back of the oral cavity for swallowing. Because it is difficult to masticate with the splint in place, we chose a pudding as the test food. It does not require mastication, and it allows accurate recording of physiological tongue movements during swallowing.

It is difficult to measure tongue movement when the amount of test food is small, because the movement is not necessarily accompanied by swallowing. However, when the amount is too large, bracing activity by the teeth may sometimes be poor. If this happens, experimental results may not accurately reflect the experimental loss of occlusal support that we created. Ten grams of pudding is about one teaspoonful. This amount was easy for the subjects to swallow at one time and yet was large enough to show up on the recording apparatus during swallowing. In addition, the subjects could be aware of bracing activity by teeth during swallowing.

Occlusal splints for mandibular stabilization usually maintain a space of 1–2 mm in the molar region. However, the splints used in this study were made as thin as possible so that changes in vertical dimension could be minimized. In addition, the splint was placed in the mandible so that foreign body sensations would not interfere during the tongue’s contact with the palate.

The difference in transfer time was not significant between NS and the FS, indicating that the change in vertical dimension caused by wearing the splint did not affect the duration of food transfer. The duration for transfer was significantly longer in the subjects wearing the MS than in those wearing NS or the FS. This might be because of the difficulty in pressing the tip of the tongue to the anterior teeth and the forward part of palate. Moreover, there was no significant difference in the transfer duration between the subjects wearing the AS and those wearing NS.

Since the duration of contact for the subjects wearing NS was not significantly different from that for those wearing the FS, it was concluded that changes in vertical dimension caused by wearing a splint do not affect the duration of contact. The duration of contact was shorter for the AS than for NS, the FS or the MS. The differences were significant when the AS was compared with the others. This is probably because the mandible was unstable owing to loss of occlusal support in the molar region with the AS. This seemed to make it more difficult with the AS to maintain the tongue pressed to the palate as compared with NS, the FS or the MS. As a result, the duration that the tongue is pressed against the palate would be terminated sooner. This would make it more difficult to swallow the pudding.

A quantitative study on the pharyngeal phase of swallowing by Longemann pointed out that the most elevated level of the hyoid bone and larynx was decreased in the elderly, whereas in younger adults, the elevation was much greater than that required to prevent aspiration. The difference between the necessary movement and that of actual
movement is called the “reserve”. It is thought that the reserve of neural and muscular functions are decreased in the elderly. These results suggest that there is reserve in various functions of the oral phase of swallowing. As is the case with the hyoid bone and the larynx, a large reserve in the oral cavity facilitates swallowing. The reserve in the oral cavity is large enough that food transfer from the oral cavity to the pharynx is carried out smoothly by the tongue cooperating with various pharyngeal functions.

We are deeply grateful to the subjects of this study and the staff of our department for their cooperation and support. A summary of this study was presented at the Annual Meeting of the Japan Prosthodontic Society, Kansai Chapter, January 28, 2006, Kyoto, Japan.

REFERENCES