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Influence of experimental palatal plate on mandibular position during continuous [n] phonation and at the physiologic rest position

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Abstract The purpose of this study was to clarify the influence of an experimental palatal plate on the mandibular position during continuous [n] phonation and at the physiologic rest position. Twenty healthy dentulous volunteers (10 males and 10 females, mean age of 24.4 years) were investigated. Three kinds of experimental plate with a thickness of 3 mm, 5 mm, and 8 mm were fabricated and used for each subject. The mandibular position was recorded by a K7 kinesiograph during continuous [n] phonation and at the physiologic rest position under normal conditions and when the three kinds of plate with different thickness were worn separately. The results showed that the mean interocclusal dimensions during continuous [n] phonation were 0.5 mm vertically and 0.4 mm anteroposteriorly under the normal condition. After insertion of an experimental plate, the interocclusal distance increased a little, but the difference was not statistically significant between the normal condition and any of the three experimental conditions. No significant difference was found between the male and female groups. Furthermore, no significant difference in the interocclusal distance at the physiologic rest position was found between the above comparisons. Within the limitations of this study, we concluded that the mandibular position during continuous [n] phonation and at the physiologic rest position was not significantly influenced by the experimental plates.

Key words Mandibular position · Palatal plate · Phonetic method · Physiologic rest position · Occlusal vertical dimension

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Introduction

Several techniques have been reported to be useful in the determination of the occlusal vertical dimension (OVD) in prosthetic treatment, such as phonetics,[1] physiologic rest position,[2] deglutition,[3] and cephalometry.[4] But none of them has been shown to be scientifically more valid than any other.[5] The physiologic rest position remains the commonly used method in the practice of clinical assessment of the OVD, although it is considered as a range affected by a number of factors rather than as a stable parameter.[6,7]

The phonetic method is based upon measurement of the interocclusal dimension (IOD) during speech or the pronunciation of certain sounds, e.g., [s] and [m].[8–13] As a reference position selected to determine the OVD, some researchers suggest that this position would not be influenced by factors such as lips, teeth, and various types of prostheses.[10–12,14] The method of continuous phonation of [n] was recently used by Yamamoto et al.[15,16] and Ohmori et al.[17] Yamamoto et al.[16] reported on the mandibular position during continuous phonation. In the first part of the study, they investigated the stability of the mandibular position in continuous phonation of seven phones ([i], [u], [ʃi], [mi], [su], [mu], and [n]) and determined the effect of the position prior to phonation (the physiologic rest position and the intercuspal position [ICP]) on the stability of this position for 5 healthy dentate subjects. In the second part of the study, they investigated the stability of the mandibular position in continuous phonation of [n] for 20 healthy dentate subjects. The mandibular position was recorded with the aid of a mandibular movement analyzing device. The following results were obtained; that the mandibular position in continuous phonation of the phone [n] was very close to the intercuspal position (mean value 0.4 ± 0.3 mm), and furthermore it was significantly more stable than the physiologic rest position and that in continuous phonation of the other six phones($P < 0.05$). Zhang et al.[14] also found in a small sample (11 subjects) that the mandibular position determined by continuous [n] phonation was not significantly affected by a palatal plate when the thickness of the plate

was less than 5 mm; but they observed that when the thickness was 10 mm, the plate significantly lowered the mandibular position. However, in their study the effect of plates with a thickness of 5–10 mm was not assessed; that is, the ultimate effect of the thickness of experimental plates on the continuous [n] phonation position has not yet been finally determined.

Therefore, the purpose of the present study was to clarify the effect of experimental palatal plates with a thickness of 3.0, 5.0, and 8.0 mm on the IOD during continuous [n] phonation and at the physiologic rest position.

Subjects, materials, and methods

Subjects

Twenty dental students (10 females and 10 males, with a mean age of 24.4 years) voluntarily took part in the study. All participants had intact dentitions, except for preorthodontic extractions or missing third molars. No subjects suffered from any speech defects or had a history or symptoms of temporomandibular joint or muscular dysfunction. Those who had deep overbite relationships of incisal teeth where it would have been difficult to cement the magnet were excluded from this study.

All subjects were informed of the nature and procedure of the investigation, and written informed consent was obtained prior to enrollment. This research protocol was approved by the Ethics Committee of Meikai University School of Dentistry (No. A0603).

Experimental plates

Three experimental palatal plates with a thickness of 3.0 mm, 5.0 mm, and 8.0 mm were fabricated with self-curing acrylic resin (Fit Resin; Shofu, Kyoto, Japan) for each subject. The thickness of each plate on the hard palatal area was confirmed by a slide caliper (Matsui Measure; Niigata, Japan). The plates were tried clinically prior to the recording of mandibular movement to ensure adequate retention and stability, and to eliminate occlusal interference at the ICP and during functional movements.

Measurement of mandibular movement

The mandibular positions during continuous phonation of [n] and at the physiologic rest position were measured by using a mandibular kinesiograph (K7 Evaluation System; Myotronics Noromed, Seattle, WA, USA). Within a restricted movement range, this kind of equipment shows considerable reliability for this type of analysis.[18] The subjects were seated in an upright position with the Frankfort plane parallel to the floor and their head supported by a headrest. The subjects were instructed to avoid head movement. A lightweight magnet (3 g) was attached by an adhesive to the labial surface of the mandibular incisors in a position out of contact with the maxillary incisors in ICP and all excursions. The sensor device was firmly fixed to the subject's head. The spatial position of the mandibular incisive point was then recorded and displayed by the K7 evaluation system to the nearest 0.1 mm, in two planes: frontal (vertical) and sagittal (anteroposterior).

When the recording of the mandibular position was undertaken, each subject was asked to pronounce the sound [n], starting from the ICP, for 4 s continuously at a normal conversation pitch and volume, then returning to the ICP. Subsequently, the physiologic rest position was evaluated. After the subject had rested for a while, he or she was asked to swallow and then relax his or her jaw. Once a perfectly steady tracing of the mandibular position for 5 s had been observed on the computer monitor, the rest position was then recorded; and the subject was asked to close to the ICP.[19]

The measurements of the mandibular phonation position and physiologic rest position were performed under four conditions separately: without a plate (control condition) and with a plate of 3.0 mm, 5.0 mm, or 8.0 mm. The recordings were repeated four times under each condition to obtain a mean value. These 16 recordings were performed in a random sequence.

The vertical and anteroposterior interocclusal spaces during continuous phonation of [n] were measured at four points separately (points I, II, III, and IV), where the time intervals from the starting point (SP) were 1 s, 2 s, 3 s, and 4 s, respectively (Fig. 1), and the average value of these four points was calculated to present the IOD of phonation.[14–17] The IOD at the physiologic rest position was also measured, as shown in Fig. 2. In the sagittal plane, positive values represent mandibular retrusion; and negative ones, protrusion.

Statistical analysis

Repeated measures analysis of variance (ANOVA) was used to determine the influence of the experimental plates

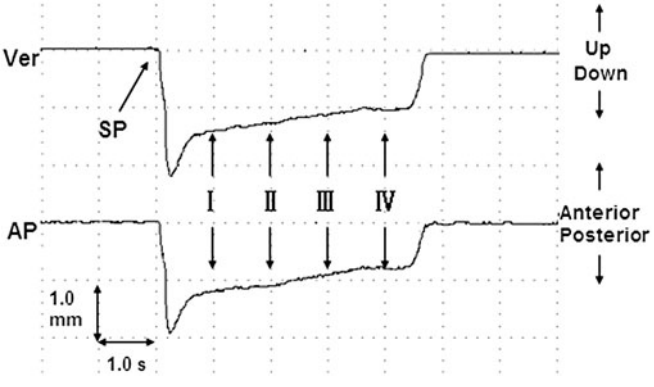

Fig. 1. Representative graph and measurement of the mandibular movement during continuous phonation of [n]. *SP*, Starting point; *Ver*, vertical direction; *AP*, anteroposterior direction; *I*, *II*, *III*, and *IV*, measurement points, where the time intervals from the SP were 1 s, 2 s, 3 s, and 4 s, respectively

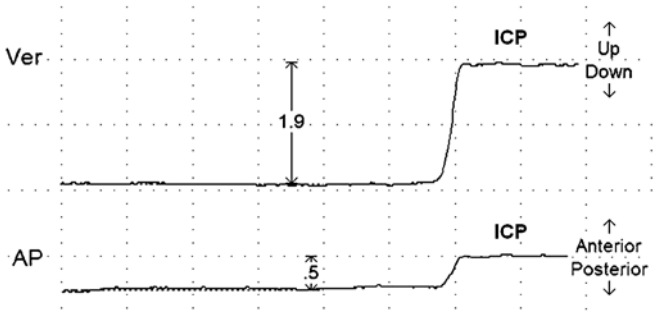

Fig. 2. Measurement of interocclusal dimensions at the physiologic rest position. *Ver*, Vertical direction; *AP*, anteroposterior direction; *ICP*, intercuspal position

Table 1. Interocclusal dimensions (mm) during continuous [n] phonation and at the physiologic rest position under the control condition for male ($n = 10$) and female ($n = 10$) groups

		Continuous [n] Phonation			Physiologic rest position		
		Mean	SD	Range	Mean	SD	Range
Male	Vertical	0.5	0.4	0.0–1.1	1.2	0.3	0.4–1.5
	Anteroposterior	0.4	0.3	0.0–0.9	0.8	0.4	0.2–1.5
Female	Vertical	0.5	0.3	0.1–1.2	1.2	0.7	0.4–2.5
	Anteroposterior	0.4	0.3	0.0–0.9	0.9	0.7	–0.2–2.2

of three different thicknesses (3.0, 5.0, and 8.0 mm) on the mandibular phonation position and physiologic rest position. The Bonferroni test was performed for post-hoc comparisons. Differences in position between male and female subjects were compared by means of independent samples *t*-test, and the comparison between the IODs of phonation and at the physiologic rest position was done by the paired *t*-test. The significance level was set at $P < 0.05$. All statistical analyses were performed with statistical software SPSS 11.0 for Windows (SPSS, Chicago, IL, USA).

Results

Under the control condition without the wearing of a plate, the mean values of IODs during continuous [n] phonation were 0.5 ± 0.3 mm vertically and 0.4 ± 0.3 mm anteroposteriorly, and the mean IODs at the physiologic rest position in these two directions were 1.2 ± 0.5 mm and 0.8 ± 0.6 mm, respectively. There was a significant difference in the IODs between these two positions (vertical t = –6.285, $P < 0.001$; anteroposterior t = –3.691, $P = 0.002$).

The IODs during continuous [n] phonation and at the physiologic rest position under the normal condition are shown in Table 1 with respect to gender. No significant difference was found between the male and female groups.

After insertion of the experimental plates, there was a little increase in the IODs during continuous [n] phonation (Fig. 3), but this difference from the normal condition was not statistically significant. The mean IODs under the different experimental conditions were as follows: with the 3.0-mm plate, 0.7 ± 0.5 mm vertically and 0.5 ± 0.4 mm anteroposteriorly; with the 5.0-mm plate, 0.8 ± 0.5 mm vertically and 0.6 ± 0.4 mm anteroposteriorly; and with the 8.0-mm plate, 0.8 ± 0.5 mm vertically and 0.5 ± 0.4 mm anteroposteriorly.

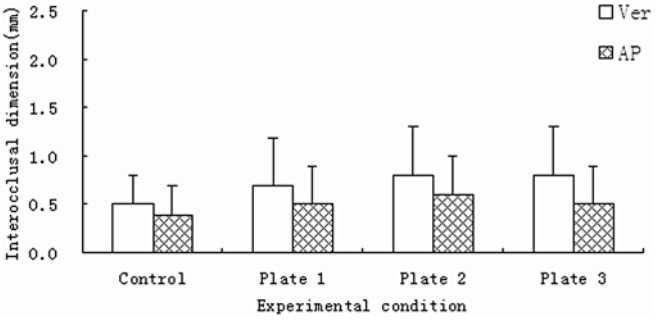

Fig. 3. Vertical and anteroposterior interocclusal dimensions during continuous phonation of [n] under four conditions. *Control*, normal condition (without a plate); *plates 1, 2, and 3*, wearing of plates with a thickness of 3.0 mm, 5.0 mm, and 8.0 mm, respectively; *Ver*, vertical; *AP*, anteroposterior

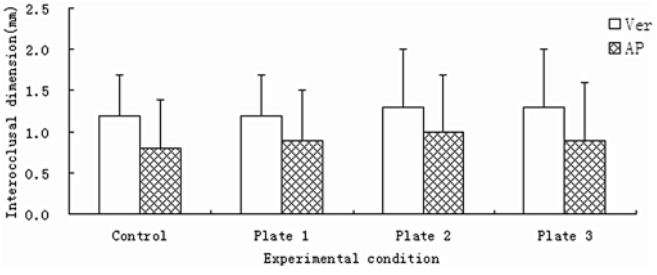

Fig. 4. Vertical and anteroposterior interocclusal dimensions at the physiologic rest position under four conditions. *Control*, normal condition (without a plate); *plates 1, 2, and 3*, wearing of plates with a thickness of 3.0 mm, 5.0 mm and 8.0 mm, respectively; *Ver*, vertical; *AP*, anteroposterior

The IODs at the physiologic rest position did not change greatly after the wearing of the experimental plates, and also no significant differences were found between the control and the three experimental conditions (Fig. 4).

Discussion

The present study examined the effect of experimental palatal plates of different thicknesses on the mandibular position during continuous [n] phonation and at the physiologic rest position. The results showed that the IOD during continuous [n] phonation and at the physiologic rest position were not significantly influenced by the inserted experimental plates.

Several sounds have been recommended as guides to determining the OVD. Ohmori et al.[17] documented that the mandibular position during continuous [n] phonation in complete denture wearers was significantly affected by the starting position. When the phonation was started from the

ICP, the interocclusal phonation space was 0.2–0.3 mm, very close to the ICP, and also it was more stable than that started from the physiologic rest position. Moreover, Yamamoto et al.[16] verified the reproducibility of this phonation position in dentate subjects by taking several measurements on the same day and on different days. In the present study, the mean vertical IOD of continuous [n] phonation was 0.5 mm, with a range from 0 to 1.2 mm, in the normal condition without plate insertion, which was very similar to the values stated by Yamamoto et al.[16] and Zhang et al.[14] The mean value and range of this IOD are less than those for the [s] sound, with the mean value reported to be 2.0 mm, ranging from 0.1 mm to 4.1 mm,[8] and for the [m] sound (range, 2-4 mm).[20]

In the present study, in the control condition with no plate, the IODs during continuous [n] phonation and at the physiologic rest position were both demonstrated to show no significant gender-specific difference, which is in agreement with other previous studies.[12,19]

Rothman[21] pointed out that the tongue contacts a specific part of the teeth, alveolar ridge, or hard palate during the pronunciation of each consonant. When the shape and thickness of these areas are changed due to the insertion of new prostheses, disturbed pronunciation may occur, and the mandibular position of speech can also be altered because of oro-sensory feedback.[22] However, Rodrigues Garcia et al.[10] stated that the mandibular speech position for the nasal consonant [m] did not change immediately after insertion of a new denture, but progressively changed with adaptation over several months. Zhang et al.[14] also found that the mandibular position during continuous [n] phonation did not significantly change immediately after insertion of an experimental plate with a thickness less than 5 mm. In the present study, the same phenomenon was confirmed even when the experimental plate was as thick as 8 mm. These results would imply that a conventional palatal plate of a prosthesis, of which the thickness is mostly 2–3 mm, has no obvious influence on the determination of the OVD by means of continuous phonation of [n]. Moreover, a palatal plate of up to 8 mm thick will not affect the mandibular position of pronouncing [n] continuously, and this could also mean that even if the patient was given an unreasonably thick palatal plate the patient could still pronounce [n] without any difficulty. However, the result of this study is probably limited to Japanese people. Further study of people in another country is still needed, including the influence of adaptation to palatal plates.

Recording of the IOD at the physiologic rest position is one of the commonly used clinical methods for determining the OVD, although it is not an exactly defined jaw position but a range with great interindividual variation and can be affected by a number of factors.[6,7,12] In the present investigation, the mean value of the IOD at the physiologic rest position was 1.2 mm (SD 0.5 mm) vertically and 0.8 mm (SD 0.6 mm) anteroposteriorly in the control condition (without a plate), which were significantly larger than those during the continuous [n] phonation. Although the physiologic rest position varied from individual to individual, no significant influence of the experimental palatal plates on it was detected in this study. This result was confirmed by Souza et al.[11] who also reported no influence of new dentures on the interocclusal physiologic rest position.

Conclusions

Within the limitations of the present study and the sample population investigated, the following conclusions may be drawn:

1. The vertical and anteroposterior IODs during continuous phonation of [n] were not significantly influenced by the experimental palatal plates with thicknesses of 3.0 mm, 5.0 mm, and 8.0 mm.
2. The IOD at the physiologic rest position was also not significantly affected by the experimental palatal plates.

References

1. Silverman MM. The speaking method in measuring vertical dimension. J Prosthet Dent 1953;3:193–9.
2. Thompson JR. The rest position of the mandible and its significance to dental science. J Am Dent Assoc 1946;33:151–80.
3. Millet C, Jeannin C, Vincent B, Malquarti G. Report on the determination of occlusal vertical dimension and centric relation using swallowing in edentulous patients. J Oral Rehabil 2003;30: 1118–22.
4. Pyott JE. Centric relation and vertical dimension by cephalometric roentgenograms. J Prosthet Dent 1954;4:35–41.
5. Rivera-Morales WC, Mohl ND. Variability of closest speaking space compared with interocclusal distance in dentulous subjects. J Prosthet Dent 1991;65:228–32.
6. Darling DW, Kraus S, Glasheen-Wray MB. Relationship of head posture and the rest position of the mandible. J Prosthet Dent 1984;52:111–5.
7. McKay Tingey E, Buschang PH, Throckmorton GS. Mandibular rest position:a reliable position influenced by head support and body posture. Am J Orthod Dentofacial Orthop 2001;120:614–22.
8. Burnett CA, Clifford TJ. Closest speaking space during the production of sibilant sounds and its value in establishing the vertical dimension of occlusion. J Dent Res 1993;72:964–7.
9. Meier B, Luck O, Harzer W. Interocclusal clearance during speech and in mandibular physiologic rest position. A comparison between different measuring methods. J Orofac Orthop 2003;64:121–34.
10. Rodrigues Garcia RC, Oliveira VM, Del Bel Cury AA. Effect of new dentures on interocclusal distance during speech. Int J Prosthodont 2003;16:533–7.
11. Souza RF, Marra J, Pero AC, Compagnoni MA. Effect of denture fabrication and wear on closest speaking space and interocclusal distance during deglutition. J Prosthet Dent 2007;97:381–8.
12. Burnett CA. Clinical rest and closest speech positions in the determination of occlusal vertical dimension. J Oral Rehabil 2000;27: 714–9.
13. Rivera-Morales WC, Goldman BM. Are speech-based techniques for deter-mination of occlusal vertical dimension reliable? Compend Contin Educ Dent 1997;18:1214–5, 1219–23.
14. Zhang H, Sone M, Yamamoto H, Ohmori K, Yaka T, Ohkawa S. Influence of experimental palatal plate on mandibular position during continuous phonation of [n]. J Prosthodont Res 2009;53: 38–40.
15. Yamamoto H, Yaka T, Naka T, Ikawa T, Ohkawa S. Stability of mandibular position during continuous phonation of [i], [u], [mi], [mu] and [n]. Meikai Univ Dent J 2004;33:209–14 (in Japanese).
16. Yamamoto H, Ohmori K, Kurihara M, Shimokawara S, Sone M, Yaka T, Fujisawa M, Ohkawa S. Studies on mandibular reference

position for determining occlusal vertical dimension-stability of mandibular position in continuous phonation. J Meikai Dent Med 2008;37:8–19 (in Japanese).
17. Ohmori K, Yamamoto H, Kurihara M, Shimokawara S, Yaka T, Nakazato H, Fujisawa M, Ohkawa S. Mandibular positions during continuous phonation of the sound [n] by complete denture wearers. J Meikai Dent Med 2007;36:148–52 (in Japanese).
18. Balkhi KM, Tallents RH, Goldin B, Catania JA. Error analysis of a magnetic jaw-tracking device. J Craniomandib Disord 1991;5: 51–6.
19. Burnett CA. Reproducibility of the speech envelope and interocclusal dimensions in dentate subjects. Int J Prosthodont 1994;7: 543–8.
20. Mehringer EJ. The use of speech patterns as an aid in prosthodontic reconstruction. J Prosthet Dent 1963;13:825–36.
21. Rothman R. Phonetic considerations in denture prosthesis. J Prosthet Dent 1961;11:214–23.
22. Schierano G, Mozzati M, Bassi F, Preti G. Influence of the thickness of the resin palatal vault on the closest speaking space with complete dentures. J Oral Rehabil 2001;28:903–8.