Original Research

A Study Using the Interdental Thickness Discrimination Test at Three Different Degrees of Mouth Opening: Reproducibility and Gender Differences in Young Adults

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Clinical significance
This study confirmed the reproducibility of the interdental thickness discrimination test and the determination of gender differences in the ability of healthy dentate adults to discriminate differences in thickness. The results may provide useful data for evaluating abnormalities in the perception of occlusion and/or mandibular position.

ABSTRACT

Purpose: This study gathered basic information on the ability of healthy dentate individuals to discriminate interdental thicknesses in order to diagnose patients without evident occlusal abnormalities who complain about bite discomfort.

Materials and Methods: Twenty healthy dentate adults participated in the study. The interdental thickness discrimination test was performed at the maxillary and mandibular central incisors with 2-, 5-, and 10-mm thick standard blocks. A test block with a different thickness from that of the corresponding standard block was tested after the application of the standard block. The subjects were then asked to answer whether the test block felt thicker or thinner than the standard block. The number of wrong answers was statistically analyzed. The measurement was repeated three times on different days.

Results: There was no statistical difference in the number of wrong answers among the measurements on three different days. There were statistically significant differences in the number of wrong answers between the 2- and 10-mm, and 5- and 10-mm thicknesses (p<0.05, ANOVA). Significantly more wrong answers were observed for the test blocks that were thicker than the standard block compared to those that were thinner (p<0.05, ANOVA). There were significant differences between females and males in the distribution of wrong answers for the thinner test blocks (2- and 5-mm thicknesses) (p<0.01, ridit analysis).

Conclusion: There was reproducibility of the interdental thickness discrimination test and a gender difference in the thickness discrimination ability in the healthy dentate adults who participated in this study.

Key words
interdental thickness discrimination ability, reproducibility, gender difference, occlusal dysesthesia, muscle spindle

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INTRODUCTION

Most dentists have occasionally treated patients who complain of bite discomfort despite the absence of evident occlusal abnormalities. The possible causes of bite discomfort include periodontitis, premature contact, occlusal interference, psychiatric or psychosomatic problems. It is also possible that the condition is due to abnormalities of sensory mechanisms, such as the recognition of mandibular position. In this regard, the interdental thickness discrimination (ITD) test could be one of the methods for evaluating the status of sensory components that regulate the mandibular position and occlusion.

Several studies have examined the ITD ability of patients. Takagi et al.\(^1\) reported on the ITD ability using a metal plate and reported that it was easier for the subjects to correctly discriminate thinner test blocks than thicker ones compared to the standard block. Christensen and Morimoto\(^3\) reported that anaesthetizing the periodontal ligaments did not diminish the dimension discrimination ability at different degrees of mouth opening. Morimoto et al.\(^5\) also reported that the ITD ability was greater for the thicker test blocks than the thinner ones when vibratory stimulation was interpolated. In another study, Williams et al.\(^6\) reported that there was no difference in the discrimination ability of normal subjects using the ITD test at different degrees of mouth opening, i.e., at 10, 15 and 20 mm. However, the amount of clinically useful information based on scientifically proven data is not sufficient to date.

The purpose of this study was to objectively evaluate the thickness discrimination ability of healthy dentate individuals and patients who complain of occlusal discomfort without evident occlusal abnormalities. In this preliminary study, the thickness discrimination ability of healthy dentate subjects was examined to get fundamental information for future studies.

MATERIALS AND METHODS

Subjects
Twenty healthy dentate young adults (10 females and 10 males; 21–29 years of age) who were recruited from among the students and staff at the Faculty of Dental Science, Kyushu University, participated in this study. They were informed about the experimental procedure and were free to withdraw from the study at any time without reason. The study was approved by the ethics committee at Kyushu University. To be included in this study, the subjects were required to: 1) be over 20 years of age; 2) be in good general health; and 3) have stable intercuspal positions. Subjects were excluded if: 1) they were involved in any ongoing dental treatment; 2) they exhibited malocclusion; 3) they had temporomandibular disorders or related problems; and 4) they were suspected of having neurological or psychiatric disorders. To screen individuals for possible psychiatric or neurological disorders, the Cornell Medical Index (CMI) and the General Health Questionnaire (GHQ 60) were administered to the candidates. Those who exhibited suspected psychiatric disorders based on CMI (categories of 3rd or 4th region) or the GHQ 60 (score of more than 13 points) were excluded. With regard to neurological problems, people who exhibited decreased or exaggerated sensation through the standard cranial nerve examination and neurological examination in the head and face region were also excluded.

Interdental Thickness Discrimination Test
For the ITD test, standard blocks made of stainless steel (2, 5 and 10 mm thick), and 12 test blocks (with thicknesses that were ±0.25, 0.50,
0.75, 1.00, 1.25 and 1.50 mm greater than the standard block) were used (Fig. 1). The tests were performed in a quiet room with the subjects seated in a chair in the upright position. In order to avoid the influence of as much extraneous sensory perceptions as possible, the subjects were asked to wear an eye mask, earplugs and a cheek retractor. The standard block was first placed between the subject’s upper and lower central incisors and was held between the maxillary and mandibular central incisors for 2 seconds by the investigator. Two seconds after the removal of the standard block, one of the test blocks was placed in the same position. The subjects were then asked to indicate using a predetermined hand movement whether the test block felt “thicker” or “thinner” than the standard block. When the subject indicated “thicker” for a test block that was actually thinner than the standard block or vice versa, the response was recorded as a wrong answer. The order of the standard block and the test blocks was randomly assigned to eliminate systematic error. These procedures were performed twice in a single trial for all test blocks. The trial was repeated three times on three different days for each subject.

**Fig. 1** Standard block and test blocks
The blocks were made of stainless steel. The figure shows a 2-mm thick standard block and 12 test blocks, which differed in thickness from the standard block by ±0.25, 0.50, 0.75, 1.00, 1.25, and 1.50 mm. The standard blocks were 2, 5 and 10 mm

**Analysis**

The number of wrong answers was statistically analyzed. Repeated measures ANOVA was used to analyze the data obtained on the 1st, 2nd and 3rd day to confirm the reproducibility of the ITD test. For each thickness (i.e., 2, 5, 10 mm), the data were compared between test blocks that were thicker and thinner than the corresponding standard block (unpaired t-test). The data were also compared among the 2-, 5- and 10-mm thicknesses (ANOVA: Scheffé’s test). Finally, ridit analysis was used to test for any gender differences in the ITD ability. Ridit (relative to an identified distribution) analysis is commonly used to detect the difference in the order category data. In this study, this method was applied using the order of the test block, in which the thickness was different by increments of 0.25 mm, as the order category.

**RESULTS**

There were no significant differences in the number of wrong answers for any of the standard block thicknesses (repeated measures ANOVA) (Table 1).

Significantly more wrong answers were observed for the thicker test blocks compared to the thinner blocks (p<0.05, unpaired t-test) (Fig. 2). There was a statistically significant difference in the number of wrong answers among the thicknesses of the standard blocks (p<0.05, repeated measures ANOVA). Post-hoc multiple comparisons revealed that there were significant differ-

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Reproducibility of the thickness discrimination test</th>
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<tr>
<td></td>
<td>2 mm</td>
</tr>
<tr>
<td>Thinner test blocks</td>
<td>0.678</td>
</tr>
<tr>
<td>Thicker test blocks</td>
<td>0.076</td>
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</table>

p-values for 2-, 5-, and 10-mm thick standard blocks (repeated measures ANOVA, N=20)
Fig. 2 Comparison of the number of wrong answers between test blocks thinner than the standard block and those thicker than the standard block. *: p<0.05, unpaired t-test. N=20. Error bar: standard deviation.

Fig. 3 Comparison of the number of wrong answers among 2-, 5-, 10-mm thicknesses. *: p<0.05, repeated measures ANOVA, Scheffé’s test. N=20. Error bar: standard deviation.

Fig. 4 Distribution of the number of wrong answers in females (N=10) and males (N=10); pooled data.

Interdental Thickness Discrimination Test at Different Degrees of Mouth Opening

Significant differences between the 2- and 10-mm, and 5- and 10-mm thicknesses (p<0.05, Scheffé’s test) (Fig. 3).

The distribution of the number of wrong answers according to gender is shown in Fig. 4. A similar distribution was observed for the thicker test blocks for the 2- and 5-mm standard blocks, and both thinner and thicker test blocks for the 10-mm standard block in both groups of subjects. However, a clear difference in the distribution was observed for the thinner test blocks for the 2- and 5-mm standard blocks, i.e., females showed a broader distribution pattern than males. The ridit analysis of these data sets indicated that there were statistically significant differences in gender for the thinner test blocks for the 2- and 5-mm standard blocks (p<0.01, ridit analysis, Table 2).

Table 2 Comparison of gender

<table>
<thead>
<tr>
<th></th>
<th>2 mm</th>
<th>5 mm</th>
<th>10 mm</th>
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<tr>
<td>Thinner test blocks</td>
<td>2.693*</td>
<td>5.243*</td>
<td>0.918</td>
</tr>
<tr>
<td>Thicker test blocks</td>
<td>0.810</td>
<td>1.649</td>
<td>0.231</td>
</tr>
</tbody>
</table>

Ridit values for 2-, 5-, and 10-mm thick standard blocks (10 females and 10 males). *: p<0.01, ridit analysis.
DISCUSSION

There are reports in which sensory mechanisms that regulate the ITD ability and position of the mandible were investigated\(^1\)\(^{-8}\) using blocks\(^1\)\(^{-3}\), sliding calipers\(^6\) or round wires\(^8\). In the present study, we elected to use stainless-steel blocks that were precisely manufactured in the designated thickness. Since the blocks could be sterilized, and deformation throughout the experiment was negligible, safe and precise experiments could be carried out throughout this study. We also elected to use the number of wrong answers from this test to obtain an objective evaluation, rather than using thickness discrimination as the criterion, which might be biased by the examiner’s judgment.

With regard to the degree of mouth opening investigated in previous studies, a variety of inter-incisal distances of the ITD test was found. Although 10– to 20-mm mouth openings were used in most studies\(^1\)\(^{-6,7}\), some researchers investigated openings of less than 10 mm\(^6,8\). Williams and colleagues\(^8\) compared the ITD ability among 10–, 15–, and 20-mm mouth openings in healthy dentate subjects and reported no statistical differences. On the other hand, Siirilä and Laine\(^6\) investigated the ITD ability in 0.03–, 0.5–, 6–, 10–, and 20-mm, and maximal openings minus 10 mm. They reported that the absolute value of the thickness discrimination threshold was smaller in the smaller degrees of mouth opening. However, no statistical analysis was performed in their study. Therefore, in the present study, we focused on the mouth opening of 10 mm or less, and the data were statistically analyzed.

There is no report to date in which the reproducibility of the ITD test was systematically examined. Since there was no significant difference in the results of the ITD test measured on three different days, the reproducibility of the test used in this study was confirmed. Therefore, it was suggested that the ITD ability could be evaluated by a one-time measurement using our technique. However, the ANOVA results revealed that the P-values were low in some data sets. Thus, the data should be carefully handled, especially for the thicker (2 mm) test blocks.

Our results generally showed the same tendency as the report of Takagi et al.\(^1\) and Christensen and Morimoto\(^3\), even though the degree of mouth opening investigated in their studies was different from ours. It was suggested that the muscle spindles in the jaw elevator muscles are predominantly involved in the ITD ability. On the other hand, Hasegawa\(^9\) reported that anesthetizing the periodontal ligaments diminished the discriminatory ability at 1-4 mm. However, it is difficult to compare our results with those in his study due to the difference in the experimental procedure.

The number of wrong answers for the thicker test blocks was significantly higher than that for the thinner test blocks. This result was in complete agreement with previous studies\(^6,7\). Furthermore, with regard to the effect of the degree of mouth opening on the ITD ability, the number of wrong answers increased as the thickness of the standard block increased. These results could be reasonably explained by the theory that muscle spindles play a dominant role in the ITD test.

The information on the length of the muscle spindles in the jaw elevator muscles is mainly sent to the central nervous system by the group Ia fibers. The frequency of firing of the group Ia fibers increases with the degree of mouth opening. However, the rate of increase is not proportional but gradually decreases with the degree of mouth opening. Therefore, for instance, it is considered that the difference in the information from the muscle spindles between the 0.50-mm thick test block and the standard block was
smaller than that between the 0.50-mm thinner test block and the standard block. This finding may explain why the ITD ability was higher for the thinner test blocks. It may also be the reason for the increased number of wrong answers as the thickness of the standard block increased.

When the data in our study were analyzed only on the basis of the number of wrong answers, there was no gender difference in the ITD ability. This observation agreed with a prior study by Watanabe9. However, when the data in the present study were analyzed with respect to the distribution of wrong answers, the ridit analysis revealed that there were significant differences between females and males for the thinner 2- and 5-mm thick test blocks. These results are interesting and clinically important because temporomandibular disorders and dysesthesia in the orofacial region were reported to be more dominant in females than in males9–11).

This gender difference might be partly attributed to the above described theory on the frequency of firing of the group Ia fibers in the muscle spindle. Since the size of the jaw is relatively smaller in females than in males, female subjects had to open their jaws wider than did males to bite blocks of the same thickness. Consequently, the difference between the information from the muscle spindles in response to biting the test block and the standard block could be smaller in females than in males. Therefore, the female subjects gave wrong answers, even for the test blocks with thicknesses that were very different from the standard block. Further investigation is required because the underlying mechanisms are still unclear due to the limited results of this study.

Although the results obtained in this study are only preliminary, the confirmation of the reproducibility of the ITD test can be applied to future studies. Moreover, it was very interesting to find a gender difference in the ITD ability, even in healthy dentate young adults. This information might be useful for understanding the mechanisms of the condition called “occlusal dysesthesia.” Future studies should examine changes in ITD ability related to phenomena such as aging and the condition of occlusal dysesthesia.

CONCLUSION

1. The reproducibility of the interdental thickness discrimination test was confirmed in the 2-, 5- and 10-mm mouth openings.
2. The interdental thickness discrimination ability decreased as the degree of mouth opening increased.
3. There was a gender difference found for the interdental thickness discrimination ability in the healthy dentate adults who participated in this study.
4. This test might be applied to the evaluation of occlusal dysesthesia patients in future studies.

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REFERENCES


