The aim of the present study was to clarify the difference between the imagination of patients and the reality in regard to the location, the form and the size of the cavity in case of cavity preparation for dental restoration. Firstly, we manufactured the dummy dentition for simulated cavity preparation and the operator intra-orally prepared a cavity on the dummy dentition in subject to confirm its validity. Then, 5 operators intra-orally prepared prescribed cavities at the both sides of maxillary first molars on the dummy dentition in every one of 5 subjects with masking. We compared the location, the form and the area of these prepared cavities with those imagined by subjects, respectively. In 58% of cases, the subjects could accurately recognize the location of prepared teeth. And 34% of cases also determined the Class of cavity form. The imagined area was larger than the actual area and the difference was statistically significant ($p < 0.001$). These results suggested that the perception of the patients regarding the location and the form of the prepared cavity was inaccurate during cavity preparation and patients tended to overestimate amounts of removed tooth substance.

Key words: Patient’s illusion, Size perception, Dental cavity preparation, Patient-dentist relationship, Interventional study

Introduction

“The physician-patient relationship stands as the cornerstone of clinical medicine”\(^1\). For dentistry as well, a good relationship between the patient and oral healthcare professionals is indispensable for the success of any treatment. The traditional paternalistic model of treating patients is based on the assumption that patients share their doctors’ sense of values. However, because of major changes in society, patients and clinicians are now more likely to differ in their sense of health values than before\(^2\). A recent study on dental patients’ attitudes\(^3\) shows that patients find it important to decide whether or not to undergo treatment, but also find it difficult to actually make these decisions themselves\(^2\). Although several studies have demonstrated that many patients want to receive as much information about their conditions as possible\(^4-8\), patients are rather passive when it comes to the situation\(^2\). Though a good patient-healthcare professionals relationship requires common sense of values and information, some discrepancies exist between the patient and the healthcare professionals in the actual clinical scene.

As almost dental treatments are painful, the patient-dentist relationship is fragile. For example, patients’ complaints such as “Though the tooth had a small decay, my dentist drilled a big hole” and “My dentist...
drilled a tooth that didn’t pain me”, are frequently heard. Objects in the mouth, or carious cavity, are often reported to feel larger than they really are. This phenomenon is known as the oral size illusion. And it is known that the diameter of the hole has a strong influence on perception, whereas the depth is not important. Lam et al. reported “Previous studies have shown that normal individuals consistently overestimate the perceived size of small (<10mm) stimulus holes presented to the tongue when using their fingers to select a matching stimulus hole, but they are able to match larger (>10mm) stimulus holes more accurately. The degree of the discrepancy becomes greater as a hole becomes smaller.”11,12 However, there have been no reports on intraoral perception without using tongue, that is, perception of the amount of removed tooth substance and the form of prepared cavity in case of intraoral cavity preparation for the dental restoration. Therefore, the present study was performed to investigate the difference among the imagination of patients, perception with the tongue and the reality in case of simulated cavity preparation.

Materials and Methods

Experiment I—verification of reliability and validity of the dummy dentition

We determined similarity of the perception between the cavity preparation on the dummy dentition as a special device and that in the real situation.

I-1 Subjects and Operators

After giving informed consent, 14 subjects were asked to report on the personal particulars and past dental experience. Obtained profile of subjects was summarized in Table I-1.

Five dentists were recruited for operators who prepared cavity on the special device. Profile of operators was summarized in Table I-2.

I-2 The special device

A maxillary impression was taken in each subject. From this impression, an artificial molar tooth was made from acrylic resin used for denture base (Palapress vario, Heraeus Kulzer Japan Co., Osaka, Japan). A splint was constructed from an acrylic disk of 1.0mm thickness (Yamahachi Dental Co., Aichi, Japan) by the heating vacuum press. Both the splint and artificial tooth were connected with self-polymerizing resin. Thus, a special device for cavity preparation was made for each subject. This device was attached into the mouth of the subject and the artificial tooth was prepared so as to simulate actual cavity preparation.

I-3 Cavity preparation

Each operator prepared a cavity on the special device which was set on the maxillary arch of a subject. Cavity preparation was done using a tapered fissure diamond bur mounted on an air turbine handpiece. These subjects were asked the level of similarity of the cavity preparation between in the experimental procedure using the special device and in the actual procedure in their past experiences of caries treatment. The responses were marked from 0 to 100 on a VAS.

Table I-1. Profile of the subjects in the experiment I

| Number of subjects : 14  male: 11  female: 3 |
| age | mean | SD |
| DT | 28.6 | 4.6 |
| MT | 0.4 | 0.9 |
| FT | 9.8 | 6.0 |
| DMFT | 10.2 | 6.1 |

| number of teeth treated in the past |
| ** | 8.7 | 3.3 |

**based on an oral examination

**based on subjects’ memory

Counted as two when the same tooth had been cut twice.

Table I-2. Profile of the operators in the experiment I

<table>
<thead>
<tr>
<th>operators</th>
<th>sex</th>
<th>age</th>
<th>Clinical experience (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>male</td>
<td>33</td>
<td>7.3</td>
</tr>
<tr>
<td>B</td>
<td>male</td>
<td>41</td>
<td>15.3</td>
</tr>
<tr>
<td>C</td>
<td>male</td>
<td>30</td>
<td>5.3</td>
</tr>
<tr>
<td>D</td>
<td>male</td>
<td>41</td>
<td>15.3</td>
</tr>
<tr>
<td>E</td>
<td>male</td>
<td>39</td>
<td>15.3</td>
</tr>
</tbody>
</table>

| mean | 36.8 | 11.7 |
Experiment II—patient’s perception of cavity preparation

The aim of the second experiment was to clarify the differences about the location, the form and the size of the cavity between the imagination of patients and the reality in case of intraoral cavity preparation.

II-1 Settings

We hypothesized that a patient would overestimate the cavity size in case of cavity preparation under the effects of infiltration anesthesia. This experiment was designed based on the following situations in which patients often experience.

- A patient meets the dentist for the first time, and has no knowledge of the character or expertise of the attending dentist.
- No precise information is given regarding the region, number and degree of the decayed tooth. The patient is only informed by the dentist that there is a decayed tooth in the upper molar, which will be prepared and treated appropriately.
- An infiltration anesthesia has been administered effectively. The loss of pain sensation and diminution of tactile sensation occur without fail.

II-2 Subjects and operators

Five dentists, who had no problem in opening their mouths, volunteered to participate as subjects in this experiment. After explanation of the experimental protocol, they gave informed consents. Prior to the experiment, each subject was asked to report on the personal particulars and past dental experience. Obtained profile of subjects was summarized in Table II-1.

Table II-1. Profile of the subjects in the experiment II

<table>
<thead>
<tr>
<th></th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>26.6</td>
<td>2.3</td>
</tr>
<tr>
<td>DT</td>
<td>0.4</td>
<td>0.9</td>
</tr>
<tr>
<td>MT</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FT</td>
<td>11.6</td>
<td>8.4</td>
</tr>
<tr>
<td>DMFT</td>
<td>12.0</td>
<td>8.4</td>
</tr>
<tr>
<td>number of teeth treated in the past</td>
<td>9.6</td>
<td>3.4</td>
</tr>
<tr>
<td>past treatment experience (VAS scale)</td>
<td>29.7</td>
<td>20.7</td>
</tr>
<tr>
<td>worst pain experienced during past treatment (VAS scale)</td>
<td>40.3</td>
<td>10.8</td>
</tr>
</tbody>
</table>

*based on an oral examination
**based on subjects’ memory

Counted as two when the same tooth had been cut twice.

Another five dentists were recruited for operators who prepared cavity on the special device. Profile of operators was summarized in Table II-2.

Table II-2. Profile of the operators in the experiment II

<table>
<thead>
<tr>
<th>operators</th>
<th>sex</th>
<th>age</th>
<th>Clinical experience (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>male</td>
<td>33</td>
<td>7.5</td>
</tr>
<tr>
<td>B</td>
<td>male</td>
<td>41</td>
<td>15.5</td>
</tr>
<tr>
<td>C</td>
<td>male</td>
<td>30</td>
<td>5.5</td>
</tr>
<tr>
<td>D</td>
<td>male</td>
<td>42</td>
<td>15.5</td>
</tr>
<tr>
<td>E</td>
<td>male</td>
<td>39</td>
<td>15.5</td>
</tr>
<tr>
<td>mean</td>
<td></td>
<td>37</td>
<td>11.9</td>
</tr>
</tbody>
</table>

II-3 Cavity preparation

Each operator prepared Class I inlay cavity on the first molar of the special device which was set on the maxillary arch of the subject. Cavity preparation was done using a tapered fissure diamond bur mounted on an air turbine handpiece to a depth of 2.0 ± 0.5 mm (Fig 1). Each operator prepared cavities on the left and right sides in every subject. Thus, one subject used 5 special devices and the number of the cavity samples was 50.

II-4 Experimental procedure

Prior to commencement of the experiment, each subject was instructed to get accustomed to wear the special device for a few minutes. The operator ought not to have faced the subjects in this study. The experiment was conducted in the following order.

1) The subject was only informed by the assistant that a tooth would be prepared and had no knowledge about which tooth, the number of teeth or the kind of treatment.
2) The special device for cavity preparation was
inserted into the mouth and the operator prepared the cavity.

3) After preparation, the operator removed the special device immediately and the subject was instructed to draw an imaginary figure of the prepared cavity on a photograph of the subject’s maxillary arch.

4) In addition, the following items were recorded.
   - Actual preparation time: AT (sec.)
   - Time of cavity preparation imagined by the subject: IT (sec.)
   - Subjects’ feelings about IT longer or shorter: VT (VAS scale)
   - Pain and discomfort experienced by the subject during the preparation: VP (VAS scale)

5) After the above steps were completed, the special device was inserted into the mouth again. Then the subject was allowed to touch the devices with the tongue. After recognizing the cavity, subject was asked to draw figures of the cavities on their photographs of the maxillary arch.

Randomization and masking procedures were used as follows:
   - The order of preparation was assigned randomly.
   - The subject was blindfolded during preparation.
   - The operator was asked to keep silence during the entire procedure, and all instructions and guidance were given by an assistant.
   - No subject was allowed to see the special device or touch it with the tongue.

II-5 Measurement of area

The areas of actual cavity (AS), imagined cavity (IS) and perceived cavity with tongue (TS) were measured as follows:

Margin of the cavity was marked with pencil. Photographs of the special device used for cavity preparation were taken with a digital still camera (Nikon E995, Nikon Corporation, Tokyo, Japan) from a direction perpendicular to the occlusal plane (Fig 2). Specifics of the photographic method was: macro-mode, ISO400, shutter speed 1/60, F value 4.9, distance 35 cm, the quality of output mode FINE and image size SXGA.

An image was taken by the computer, the outline of the cavity was traced over with the mouse pointer on the screen, and the area of the cavity was calculated. Photo retouching software (Adobe Photoshop Elements, Adobe Systems Inc., CA, U. S. A.) and image analytic software (Scion Image Beta 4.0.2, Scion Corporation, MD, U. S. A.) were used for the above process (Fig 3). For the measurement of IS and TS, the figure drawn by the subject was also analyzed in the same way.

II-6 Data Analysis

Normality test of the measured variables were done using Shapiro-Wilk’s W-test with the number of interval=10. In order to investigate the effects of operators, subjects and their interaction on the measured variables, we used repeated measures multi-variable analysis of variance. The seven measured parameters (AT, IT, VT, VP, AS, IS and TS) were considered as dependent variables and the factors were operators, subjects and their interaction. Mean values of the three variables related to size were compared using contrast test of dependent variables in MANOVA.

The level of significance was set at 0.05. Statistical analyses were conducted using SPSS version 11.0J (SPSS Inc., IL, U. S. A.) and STATISTICA version 6 (StatSoft, Inc., OK, U. S. A.) on a Windows-operating system.
Results

Experiment I
A cavity preparation could be performed without the handpiece hitting the mandibular teeth in spite of decrease in vertical dimension due to using the special device. Similarity of 14 subjects’ feelings between past real cavity preparations and this experimental condition using special device expressed with VAS scale was 67.0 ± 13.4.

Experiment II
II-1 The location and the cavity form of prepared teeth
The figures of the cavities perceived by the subjects were divided into four groups based on location of the prepared teeth and the Class of cavity.

Contingency tables based on the location and the cavity form of prepared tooth are shown in Table II-3 and Table II-4. In 58% (29 of 50) cases, the subject imagined the maxillary first molar as the prepared tooth. In 34% (17 of 50) cases, the subjects drew the cavity form as Class I. Both location of prepared tooth and cavity form were imagined correctly in 22% (11 of 50) (Table II-3).

When the subjects were allowed to touch the tooth with the tongue, they were able to identify the maxillary first molar as prepared tooth in 90% (45 of 50) cases, and perceived cavity form correctly in 98% (49 of 50) cases. Both location of prepared tooth and cavity form were identified correctly in 90% (45 of 50) cases (Table II-4).

II-2 The cavity area
The distribution of the area related variables was considered as log-normal distribution. The hypothesis of normality of log (AS), log (IS) and log (TS) was not dismissed by Shapiro-Wilk’s W-test. There were no statistically significant differences in the cavity preparation between left and right sides in each subject in terms of log (AS), log (IS), log (TS), AT, IT, VT and VP. From the results of repeated measures MANOVA, an interaction effect between operators and subjects was not observed in any of the parameters examined. Log (IS) had an effect of operator while log (AS) had significant effects of operator and subject. In addition, the cavity form and preparation time depends on the operator, and the subject had no information about them. However, AT did not differ between operators. On the other hand, IT, VT, and VP were decided only by the subject, and were not influenced by the operator.

Log (IS) were significantly larger than log (AS) from the results of the contrast in MANOVA (p < 0.001). There was no statistically significant difference between log (AS) and log (TS) (Fig 4). No statistical
correlation was found between each parameter measured in this experiment and each subject’s past dental history shown in Table II-1.

**Discussion**

This study was performed to clarify experimentally the possibility of misunderstanding due to the patient’s perception during dental treatment. We paid much attention in making experimental design to exclude confounding factors affecting the results.

1. The reliability and validity of the experimental method used

As the special device was used, the whole situation was similar to that under the effects of infiltration anesthesia, even though an anesthetic was not actual-ly administrated. Thus the patient experiences loss of pain sensation and diminution of tactile sensation, whereas the sense of the tongue, cheeks and skin and also of the tension applied by the operator to the face and head is retained.

Based on the results of the experiment I, we assumed that the special device used for cavity preparation in this study could be applied as a model for actual cavity preparation.

In experiment II, we designed the procedure to minimize the influence of the subject’s bias concerned with operators, expectation of the next operators and memories of the previous steps.

The maxillary teeth were chosen because they had less possibility to be touched with tongue. In addition, we supposed that the cavity on the special device attached in the maxillary arch could be perceived more naturally than attached in the mandibular when the subjects were asked to touch the special device with tongue.

2. The reliability and validity of the techniques used to measure area

In this experiment, no subject was excluded from the study due to malalignment of teeth. Two types of error, the distortion of occlusal plane and the inclination of tooth axis, occurred during the measurement can be calculated geometrically. As to the former type, for example, even though margin of the cavity was raised by 4 mm from the surface of the photographic plane due to the curved occlusal plane of the special device, this would result in errors of 1.1% in photographic distance, 1.1% in measured length, and 2.2% in the

---

**Table II-3. Contingency table based on subjects’ imagination**

<table>
<thead>
<tr>
<th>Location</th>
<th>The first molar only</th>
<th>Other teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavity form</td>
<td>Class I cavity</td>
<td>11 (22%)</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>18 (36%)</td>
</tr>
</tbody>
</table>

*One case of abutment for full crown was included.

**Table II-4. Contingency table based on subjects’ perception with the tongue**

<table>
<thead>
<tr>
<th>Location</th>
<th>The first molar only</th>
<th>Other teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavity form</td>
<td>Class I cavity</td>
<td>45 (90%)</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

---

**Fig. 4.** The comparison of the areas of actual cavity (AS), imagined cavity (IS) and perceived cavity with tongue (TS).
measured area. The latter type of error was more prone to occur when an artificial tooth was fixed obliquely during the construction of the special device. For example, even though the tooth axis inclines an angle of 10°, the errors in measured area and length would be both 1.6%. Moreover the angulation increased to 15°, they would be increased to 3.4%. It was ensured that the bur was positioned perpendicular to the occlusal plane.

3. Other considerations

Dentists were selected as study subjects in the present experiments because they have a higher level of knowledge and fewer illusions regarding dental treatment than patients. They have also less probability to describe deviated cavity shape which could not be measured. Even though the study subject was a dentist, the location, the form and the size of the cavity could not be identified correctly (Table II-3, Fig 4).

However, when they touched the prepared cavity with their tongues, there was no statistically significant difference between AS and TS. Our findings do not agree with those of previous studies which demonstrated that the tongue overestimates the size of objects in the mouth. However, it is inappropriate to compare our results with those of previous studies. This is because the subjects were dentists and they knew their own teeth size in our methods. The subjects could identify form and size of cavity with tongue by means of reference points such as a cusp or fissure on the tooth. Moreover, the subjects answered in drawing relative size on the photographs of teeth. Therefore they were able to draw an almost accurate outline on the photograph. A patient could not have adequate time to understand and identify the details of a prepared cavity in a daily dental practice. Though there were no overestimations of cavity area perceived with tongue in our experiments, several studies demonstrated that the size illusion became greater as a diameter became smaller. We could not exclude the possibility that patients, who had less knowledge about the form of cavity and tooth, tend to overestimate the size of the cavity when they probe around with the tongue even for a short time.

Existence of this possibility suggests that dentists always face the risk of patients’ misunderstanding regarding ordinary operative dental treatment. If patients have additionally postoperative pain or hypersensitivity, they may not confide their dentists. Therefore it is important to prevent such misunderstanding and to build up a desirable patient-healthcare professionals relationship. One of the useful methods is to use proper visual information such as illustrations, models, intraoral photographs, radiographs, and so on.

Further studies are required to understand the oral size illusion in other cases of daily dental treatments.

Acknowledgements

We are grateful to all participants in this study. We would like to thank Dr. Tonami, Dr. Kinoshita and Dr. Koshy for their critical reading of the manuscript.

References