Occlusal Contacts in Intercuspal Position of Prostheses without Stress Absorbing Elements on Osseointegrated Implants

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Purpose: We evaluated occlusal contacts in the intercuspal position (ICP) of prostheses without stress absorbing elements on osseointegrated implants (the prostheses) and natural teeth.

Materials and methods: We selected 13 subjects who had shown excellent clinical progression for three years or more after placement of the prostheses on either an IMZ implant (5 subjects) or Brånemark implant (8 subjects) in mandibular unilateral free-end cases from whom informed consent had been obtained for the purpose of this research. The registration of occlusal contacts using silicone impression materials was made during clenching in ICP at two levels (10 and 30% MVC) under maximum EMG amplitude (100% MVC). To read the silicone occlusal records quantitatively, we used the add-up picture inspection method which visualized occlusal contacts by digital image processing. We observed variations in the number and area of occlusal contacts between the two occlusal strengths. Statistical analysis was performed using the Wilcoxon test to compare between the two levels.

Results: The number and area of occlusal contacts increased with occlusal strength both on natural teeth and on the prostheses. However, the location of the contacts remained the same in both the healthy dentulous subjects and those with the prostheses. For each tooth, with the increase in occlusal strength, the number of occlusal contacts on natural teeth and the prostheses did not increase significantly, and thus the area of occlusal contacts on natural teeth and the prostheses increased significantly (p<0.05). There was no significant difference between natural teeth and the prostheses in the rate of increase of the area of occlusal contacts with the increase in occlusal strength.

Discussion: The prostheses and the remaining teeth in ICP cooperated with each other, though there were no stress absorbing elements. These results were probably due to displacement of opposing teeth and strain on their supporting tissue.

Conclusion: A harmonious intercuspal position with natural teeth can be established by imparting appropriate occlusal contacts to the prostheses, even if there are no stress absorbing elements.

Key words: occlusal contacts, intercuspal position, prostheses, stress absorbing elements
Introduction

The method of treatment by which the implants were applied has been established as an option for partially and completely edentulous patients. Prostheses and natural teeth with different viscoelastic properties and pressure displacement can coexist in the same oral cavity when functional recovery is achieved by applying osseointegrated implants. It is necessary to clarify the mutual occlusal conditions between the prostheses and natural teeth to maintain the appropriate intercuspal position (ICP) under these conditions and to decide how best to create occlusal contacts on the prostheses with opposing teeth.

We have evaluated the occlusal conditions for each tooth in ICP of the prostheses with stress absorbing elements and of the remaining natural teeth, and concluded that a harmonious ICP with natural teeth can be established by imparting appropriate occlusal contacts to the prostheses.

We evaluated occlusal contacts in ICP of the prostheses without stress absorbing elements and natural teeth in mandibular unilateral free-end cases using the add-picture inspection method.

This research obtained and executed the approval of Ethics Committee at Osaka Dental University (provisional name) (approval number 040636).

Materials and Methods

1. Subjects and prostheses

We selected 13 subjects who had shown excellent clinical progression for three years or more after placement of the prostheses on either an IMZ implant (5 subjects) or Bränemark implant (8 subjects) in mandibular unilateral free-end cases from whom informed consent had been obtained for the purpose of this research (Table 1). Before measurement, in the IMZ implant system, the intramobile element (IME; made of polyoxymethylene) built into the internal element was exchanged for an element made of titanium. The elements and the screw in both the IMZ implant and Bränemark implant systems were fastened with a torque of 145 Nmm using a torque wrench.

The antagonistic teeth of the prostheses in each subject were all natural teeth. The prostheses were connected to each other, but not with mesial natural teeth. The definite guidelines on the prostheses followed the criteria for occlusal contacts in ICP, and the occlusal form that should be considered in crown and bridge prostheses as bucco-lingual width is set to 60–70% of natural teeth and the cusp angle is gentle.

2. Clenching condition and maxillomandibular registration

As occlusal contacts are influenced by occlusal strength, occlusal strength was determined by placing a dipole surface electrode in the center part of masseter muscle as described by SAKURAI et al. and with visual feedback. The RMS rectification value of masseter muscle activities during maximum voluntary clenching (MVC) was made to be 100% MVC and occlusal strength was determined at the
RMS rectification values of 10 and 30% MVC under 100% MVC each with visual feedback.

Maxillomandibular registration was made using silicone impression materials (Bite-Checker, GC Co., Japan) during clenching at two levels.

3. Registration of occlusal contacts

The silicon impression material (silicon-black) taken in each measurement was processed by computer according to the block diagram of the add-picture inspection method shown in Fig. 1 and occlusal contacts were quantified and visualized.

Silicon-black was placed so that its occlusal plane was horizontal, and a picture was taken with a CCD TV camera of occlusal contacts shown by the translucent light from the light box. The image signals from the TV camera were A/D and D/A converted and at the same time reproduced on the TV monitor. After various image analyses, measurements of the number, area and position of occlusal contacts were recorded.

The area of occlusal contacts was examined based on 10% MVC according to the increase rate of 30% MVC because of differences among individuals and kinds of teeth.

4. Statistical analysis

Statistical analysis was performed using the Wilcoxon test to compare between the two levels (significance level: p<0.05). When a significant difference was found, the Dunn test was applied as an after-the-fact comparison.

Results

Figure 2 shows one example of an add-picture in subject 11 (the prostheses: 765) during clenching.
ing in ICP at 10 and 30% MVC. The translucent part of the occlusal surface shows the parts showing occlusal contact of 30 μm or less. Occlusal contacts seen at 10% MVC are seen even if occlusal strength is changed to 30% MVC, and their positions have not changed. Further, an increase of the area of occlusal contacts is seen with increase in occlusal strength. These tendencies were similar between subjects who had the prostheses placed by the IMZ implant and those who had the prostheses placed by the Bränemark implant.

Figure 3 shows one example of the number of occlusal contacts seen according to range in subject 4. The upper left row shows the number of occlusal contacts of the entire dentition, and the center shows the total number of occlusal contacts for both natural teeth and the prostheses on the implant side. The right shows the number of occlusal contacts for natural teeth on the non-implant side, and the lower row shows that for each tooth in the dentition. The lower figure represents the dental formula display, but not the right or left side. The figure enclosed with a □ represents the prostheses. The outlined part on the left in each bar chart shows the results in occlusal strength at 10% MVC and the net multiplication part on the right shows the results for occlusal strength at 30% MVC. The number of occlusal contacts for the entire dentition, the implant side and non-implant side seen in the upper row, increased as occlusal strength increased from 10% MVC to 30% MVC for both natural teeth and the prostheses. Examining each tooth in the dentition seen in the lower row, the number of occlusal contacts on the remaining teeth and the prostheses (71) were the same or there was little change. Similar tendencies were shown in subjects who had the prostheses placed either by the IMZ implant or the Bränemark implant.

Figure 4 shows the number of occlusal contacts for each tooth in all subjects. As occlusal strength was increased from 10% MVC to 30% MVC, there was no significant difference in the number of occlusal contacts on natural teeth and the prostheses.

Next, Fig. 5 shows one example (Subject 2) of the area of the occlusal contacts seen according to range at the different occlusal strengths at levels of 10 and 30% MVC. The upper left row shows the area of occlusal contacts of the entire dentition, and the center shows the total area of occlusal contacts for both natural teeth and the prostheses on the implant side. The right shows the area of occlusal contacts for natural teeth on the non-implant side, and the lower row shows that for each tooth in the dentition. The lower figure represents the dental formula display, but not the right or left side. The figure enclosed with a □ represents the prostheses. As occlusal
strength was increased from 10% MVC to 30% MVC, the area of occlusal contacts tended to increase for the entire dentition, the implant side and the non-implant side, seen in the upper row, and for each tooth for both natural teeth and the prostheses, seen in the lower row. Similar tendencies were seen in subjects who had the prostheses placed either by the IMZ implant or the Bränemark implant.

Figure 6 shows the area of occlusal contacts for each tooth in all subjects. The area of occlusal contacts for each tooth of natural teeth and the prostheses seen at a level of 10% MVC increased significantly with an increase of occlusal strength to 30% MVC.

Because the area of occlusal contacts shows individual variations, Fig. 7 shows the results of calculating the rate of increase of the occlusal contacts when occlusal strength was increased to 30% MVC based on occlusal strength at a level of 10% MVC. When occlusal strength was increased, the rate of increase of occlusal contacts was 1.0 or more in 69 of 71 natural teeth and in all 33 prostheses. A significant difference was not seen in the rate of increase of the area of occlusal contacts for each tooth in natural teeth and the prostheses.

Figure 8 shows the results regarding each rate of increase for natural teeth separated into implant side and non-implant side.
ral teeth was separated into the implant side and non-implant side. A significant difference was not seen in the rate of increase between natural teeth on the implant side and natural teeth on the non-implant side, or between natural teeth on the implant side and the prostheses.

Discussion

Widely recommended endosteal implants were used as so-called osseointegrated implants, connecting to surrounding bone without mediation by soft tissue, and there was little pressure displacement of the implant supported prostheses. On the other hand, natural teeth with physiological mobilities due to supportive tissue such as periodontal membrane had surrounding mechanoreceptors and pressure displacement was larger than that of the implants.

To enable implant-supported prostheses to coexist and harmonize functionally with natural teeth in the same oral cavity, it is thought that some countermeasures are necessary with regard to implants and the prostheses for providing artificial periodontal membranes, improvement of materials, placement of stress absorbing elements, connection between remaining teeth and the prostheses, occlusal surfaces and their materials, and occlusal contacts.

Since there have been few reports to date on the influence on the stomatognathic system function of the difference of internal elements composing the prostheses, the presence or absence of connection between natural teeth and the prostheses, occlusal contacts of the prostheses, and the height of the occlusal contacts, clinical and research guidelines remain inadequate.

Regarding occlusal contacts on the prostheses, one view is that because of a difference of pressure displacement between natural teeth and the implant and other factors there should be no occlusal contacts on the prostheses. Another view is that, from the perspective of masticatory function, occlusal contacts should be imparted. Though both views and ideas have been accepted, there are few original papers that prove them and a conclusion has not been reached.

Our present research, which uses such methods as occlusal examination and electromyographic examination, has shown that the prostheses and natural teeth cooperate due to the effect of IME, which has viscoelasticity near that of natural teeth, when occlusal contacts are imparted to the prostheses with stress absorbing elements to obtain ICP. Therefore, when stress absorbing elements are included, to maintain and stabilize stomatognathic system function, occlusal contacts should be imparted.

However, stress absorbing elements are not placed in the implant systems being marketed now. MATSUTANI et al. suggested that occlusal contact height should be equalized in both molar regions, which could lead to stability of masticatory movements for implant-supported prostheses without stress absorbing elements, as it might affect masticatory function.

Therefore, the purpose of this research was to identify the ideal way of imparting occlusal contacts to the prostheses without stress absorbing elements in ICP.

1. Subjects and implants

There are many factors that affect occlusal contacts. It is necessary to avoid factors such as uncomfortableness, sense of something wrong and problems with habituation accompanying placement of the prostheses. Therefore, patients who had had the prostheses placed three years or more earlier and who were supposed to be well accustomed to the prostheses were selected as subjects for this research.

The two types of implant used were the IMZ implant system installed with an element made of titanium without stress absorbing elements and the Bränemark implant system, which originally had no stress absorbing element.
2. Examination of occlusal contacts

The silicon-black method using silicon impression material is the best method for examining conditions such as the position and area of occlusal contacts, since it is not influenced by the materials and surface properties of the prostheses, intervention of saliva, and oral environment such as humidity and temperature, and does not change the heights of occlusal contacts\(^4\). In our department\(^14\text{--}17\), the add-picture inspection method has been developed for examining occlusal contacts in the silicon-black method in a more detailed and quantitative manner, which has been used widely clinically and in studies on healthy dentulous subjects, temporomandibular joint dysfunction patients, and occlusal examination methods before and after placement of the prostheses.

This time, the conditions of occlusal contacts during clenching in 10 and 30\% MVC were examined\(^10\). Additionally, it is possible to visually feed back the required occlusal strength, such as 5, 20, 40 and 50\% MVC. However, if this examination method is used, it is always necessary to use silicon impression materials with different occlusal strength as shown in the reports by TANAKA\(^10\) and YANAGIDA et al\(^17\). Evaluations should be performed by comparing and discussing the position and area of each occlusal contact: All molar teeth should be in contact irrespective of the occlusal strength, and the positions of occlusal contact should show a pattern of no change with varying occlusal strength.

3. Results of the experiment

Previously, with regard to occlusal contacts in ICP of patients with the prostheses placed, we have compared and discussed the number and area of occlusal contacts of the entire dentition or natural teeth side and implant side in order mainly to investigate whether the prostheses affect the stomatognathic system\(^4,5\). As a result\(^1,6,12\), we have reported that a harmonious ICP with natural teeth can be established by placing the prostheses with stress absorbing elements built in.

In this report, from the viewpoint of how to impart occlusal contacts to the prostheses without stress absorbing elements, occlusal contacts were evaluated between the prostheses and individual natural teeth.

As shown in the report by YANAGIDA et al\(^17\), the criteria of normal occlusions\(^10\), even if the silicon-black was observed by the naked eye, all molar teeth were in contact whether at light or moderate occlusal strength and coincided with a pattern in which there was no change in position of occlusal contacts with varying occlusal strength, showing the same tendency as that of healthy dentulous subjects.

No significant difference in the number of occlusal contacts was observed between occlusal strength at 10 and 30\% MVC in the prostheses and natural teeth. However, the area of occlusal contacts increased significantly for both the prostheses and natural teeth, but no significant difference in the rate of increase was observed between them.

The displacements of the implants themselves were smaller than for natural teeth. It is thought that this result was obtained even though there were no stress absorbing elements because of displacement of upper molar teeth (opposing teeth)\(^18,19\), strain on their supporting tissues such as periodontal membranes and alveolar bones, and deformation of the mandibles, among other factors. Additionally, as in the unilateral free-end cases with fewer implants and more remaining natural teeth, it is thought that the prostheses and the remaining teeth in ICP are likely to cooperate with each other irrespective of the presence or absence of stress absorbing elements if the occlusal support by the remaining natural teeth is strong.

Therefore, it has been suggested that a harmonious ICP with natural teeth can be established for a long period of time as in healthy dentulous subjects by imparting appropriate occlusal contacts even to an implant system without stress absorbing elements if the opposing teeth are natural teeth.
Conclusions

1. An appropriate intercuspal position was established even if the prostheses without stress absorbing elements were placed.

2. Occlusal contacts were observed for both occlusal strengths of 10 and 30% MVC.

3. The positions of occlusal contacts did not change among occlusal strengths.

4. The number of occlusal contacts for each tooth observed at 10% MVC did not increase significantly for both the prostheses and natural teeth when the occlusal strength was increased to 30% MVC.

5. The area of occlusal contacts for each tooth observed at 10% MVC significantly increased for both the prostheses and natural teeth when the occlusal strength was increased to 30% MVC.

6. No significant difference in the rate of increase of the area of occlusal contacts was observed for the prostheses or natural teeth.

Therefore, it is suggested that a harmonious intercuspal position with natural teeth can be established by imparting appropriate occlusal contacts to individual prostheses without stress absorbing elements.

We would like to express our gratitude to Dr. Iwata, Dr. Matsutani and Dr. Nishikawa of Osaka Dental University who greatly supported us in performing this research. We would also like to thank the department staff, postgraduate students and subjects for their support and guidance.

A part of this report was presented at the 35th Annual Meeting of Japanese Society of Oral Implantology (September 10, 2005, Hirosaki, Aomori, Japan). A summary was presented at the 500th Regular Meeting of the Osaka Odontological Society (October 15, 2005, Hirakata, Osaka, Japan).

This study was supported in part by Oral Implant Grant at Osaka Dental University (Tamaki Foundation).

References


