Patients’ preference for acrylic resin major connector analogues formulated for titanium alloy removable partial dentures

Ranjith Wasantha Pallegama, Kumiko Aridome, Kazuyoshi Baba and Takashi Ohyama

Removable Prosthodontics, Masticatory Function Rehabilitation, Tokyo Medical and Dental University

Purpose: Aim of this study was to determine patients’ preference to acrylic resin major connector analogues (MCA) that simulated strengthened major connector designs formulated for Ti-6Al-7Nb alloy. Materials and methods: Four MCA namely wide design (Wide), design with 2 strengthening ridges (2SR), design with 1 strengthening ridge (1SR), and thick design (Thick) were fabricated using light-polymerizing acrylic resin for 10 patients with Kennedy Class I or II partially edentulous maxillary arches. They were asked to wear each MCA in the mouth for 30 seconds in 6 pairs, and to report their preference for each pair. Using these data the 4 MCA were ranked in a descending preference order for each patient. A within-subject comparison of preferences was performed with the Friedman test and multiple comparisons with Wilcoxon Signed Ranks test. Results: A statistically significant preference order was revealed: Wide, 1SR, 2SR, and Thick (P < 0.008). The wide design (P < 0.004) and the 1SR (P < 0.01) were significantly preferred to the thick design. However, individual data showed that the first preference varied depending upon the subject. Conclusion: Thinner designs tended to be preferred to the thicker design by the subjects, while none of the designs tested were consistently selected as the best design.

Key words: Major connector design, patients’ preference, removable partial dentures, titanium alloy, major connectors

Introduction

Titanium possesses several advantageous properties over Co-Cr such as excellent corrosion resistance, biocompatibility, and low density. It has therefore been used for dental prostheses, especially in implantable devices, for several decades. Ti-6Al-7Nb alloy, originally introduced for orthopedic appliances, is recently being considered for removable partial dentures (RPD) owing to its excellent properties such as improved biocompatibility, and excellent wear and corrosion resistance in the biological environment. However, the elastic modulus of this alloy is approximately 60% that of Co-Cr alloy, and renders a lower rigidity diminishing its suitability for major connectors of RPD.

Major connectors of RPD must be adequately rigid, so that occlusal forces are uniformly distributed among components of RPD. Theoretical modeling by means of finite element analysis has shown that only adequately rigid major connectors of removable partial dentures are effective in transmitting applied occlusal forces to the contralateral side of the framework and in decreasing vertical displacement of the distal extension base. Thus, in order to improve the rigidity of the major connectors constructed with Ti-6Al-7Nb alloy, alternative designs with comparable rigidity to the conventional Co-Cr major connectors have been introduced by means of modeling with finite element analysis (Table 1).

However, as shown in Table 1, these strengthening
designs are associated with increased dimensions and complex contours such as strengthening ridges (SR). These altered dimensions may exert diverse influences on patients’ oral sensory receptors giving rise to awkward perceptions. This may potentially influence the patients’ acceptance of the dental prostheses and may explain the observed patients’ preference for certain prosthetic devices. Crossover clinical trials conducted in relation to overdentures and implant dentures provide strong evidence for the presence of such preferences.

In relation to RPD, the thickness of major connector, the area of the palate covered by major connector, and the location of major connector on the palate are found to influence patients’ preference and satisfaction. Further, Sato and colleagues have suggested the use of ‘trial major connector patterns’ made of resin to evaluate suitable designs for individual patients. Thus, it was reasonable to hypothesize that there could be varied degrees of patients’ preference for the four major connector designs formulated for Ti-6Al-7Nb alloy.

The aim of the present study was to evaluate the four major connector designs, formulated for Ti-6Al-7Nb alloy, from the viewpoint of patients’ preference by constructing major connector analogues (MCA) using light polymerizing acrylic resin. The null-hypothesis tested was that there would be no significant difference among patients’ preferences for the four major connector designs.

### Material and Methods

#### Subjects

Ten patients including seven women and three men (mean age, 59.2± 8.9 years) participated in this study. Special prosthodontists screened the patients from those who sought care at the Removable Denture Clinic at Tokyo Medical and Dental University dental hospital. Informed consent was obtained from all patients before enrollment. The study design and the procedure were consistent with the principles of the declaration of Helsinki.

Patients with a Kennedy Class I or II partially edentulous maxillary arch distal to the first premolar were included in the study. They were chosen among patients who were willing to participate, and were required to be within 40 to 75 years and in good general health. Patients with orofacial pain conditions, established or confirmed acute dental diseases, abnormal jaw movement patterns and joint noise, and mobility of remaining teeth equal to or greater than grade II were excluded from the study.

#### Study protocol

A maxillary impression was made for each patient using irreversible hydrocolloid impression material (Algiace Z; Dentsply-Sankin K.K., Tokyo, Japan) and then a definitive cast was fabricated using dental stone (Cristobalite PF; Shofu Inc., Kyoto, Japan). The four designs were fabricated on the cast using light-polymerizing acrylic resin (Base Plate LC; Molten corporation, Hiroshima, Japan) and inlay wax (Inlay Wax Soft; GC Corporation, Tokyo, Japan) (Table 1 and Fig. 1). On a subsequent visit after two weeks, the patients underwent a preference test in a blind to the physical appearance of MCA manner. They were also given a brief questionnaire to check whether they had any problems such as misfit of MCA and to affirm that the blindness was successfully kept during the experiment.

#### Construction of MCA

The aim of the present study was to evaluate the four major connector designs, formulated for Ti-6Al-7Nb alloy, from the viewpoint of patients’ preference by constructing major connector analogues (MCA) using light polymerizing acrylic resin. The null-hypothesis tested was that there would be no significant difference among patients’ preferences for the four major connector designs.

<table>
<thead>
<tr>
<th>Ti-6Al-7Nb design</th>
<th>Thickness (mm)</th>
<th>Width at center (mm)</th>
<th>Specifications of SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide design</td>
<td>0.8</td>
<td>16</td>
<td>No SR</td>
</tr>
<tr>
<td>2SR design</td>
<td>0.8</td>
<td>10</td>
<td>2 SR at the anterior</td>
</tr>
<tr>
<td>1SR design</td>
<td>0.8</td>
<td>10</td>
<td>1 SR in the middle</td>
</tr>
<tr>
<td>Thick design</td>
<td>1.0</td>
<td>10</td>
<td>No SR</td>
</tr>
<tr>
<td>Co-Cr design</td>
<td>0.8</td>
<td>10</td>
<td>No SR</td>
</tr>
</tbody>
</table>

SR= Strengthening ridge.

drawn on the cast. This resin base was light cured for 10 minutes using a light-polymerizing machine (Labolight LV II, GC Corporation). The thickness throughout the base was measured using a caliper and adjusted to the predetermined size by grinding (Table 1). The specified width was maintained from the midline of the resin base to 10 mm on either side of the base. The resin base was smoothed by number '0' sand paper and then polished with polishing paste. The undercut areas were filled with paraffin wax (GC Paraffin Wax; GC Corporation) for better retention and convenient insertion. The special strengthening ridges (SR) were constructed with inlay wax (Inlay Wax Soft; GC Corporation) on the polished surface of the resin base (Table 1 and Fig. 1). These were extended from the midline of the resin base to a distance of 10mm on either side of the base. The principal investigator performed the construction of all MCA following a standard protocol.

In a preliminary study, the investigator, who was trained to construct the MCA accurately, fabricated 12

Figure 1. Four major connector analogues constructed for a patient with Kennedy Class I partially edentulous maxillary arch. Wide (wide design), 2SR (design with 2 strengthening ridges), 1SR (design with 1 strengthening ridge) and Thick (thick design).

Figure 2. Designed major connector analogue for a patient with Kennedy Class II partially edentulous maxillary arch. The width was maintained from the midline of the resin base to 10 mm on either side of the base (until the dotted lines on both sides).
MCA twice in order to test the reproducibility of fabrication procedure. An independent person, who was blinded to the study objectives and MCA design specifications, measured the thickness and widths of each MCA at predetermined positions. The measurements of all 24 MCA were done in a random order thrice and then averaged. Inter-class correlations calculated using these data measured from the two sets of MCA resulted to be 0.99 for both the thickness and the width, and were considered excellent.

Preference test procedure
The patients were seated in a dental chair and given a detailed explanation of the study procedure. The MCA were tested in the oral cavity of each patient to ascertain the degree of fit and retention to the residual ridge and remaining teeth. The 4 MCA were placed in the oral cavity of each patient in 6 combinations of pairs in random order. The patients were asked to “just retain” and feel each MCA of each pair for 30 seconds, and answer to the question “which one is the preferred design of this pair?” If they were unable to report a difference, both designs were judged to be equally preferred. The patients were given no opportunity to see and identify the appearances of the MCA. Two investigators performed the procedure on every patient following a standard protocol.

Statistical analysis
Six responses were available for 6 pairs of the MCA for each patient. Logical comparison of these 6 answers (placing the preferred design on top) allowed the four designs to be placed in a descending rank order of preference for each patient. (Rank 1 was assigned to the most preferred design of each patient.) Three responses out of 60 were excluded as those did not fit into the rank orders established by other responses. This procedure was performed by a person who was blind to the MCA designs. A within-subject comparison of rank orders was performed using the Friedman test, which compared the distribution of preference ranks of each design. The Wilcoxon Signed Ranks test was used for multiple comparisons among designs. A statistically significant difference was reported when the $P$ value was less than 0.05. All analyses were performed using Statistical Package for Social Sciences version 11, designed for windows (SPSS Inc., Chicago, IL, USA).

Results
Average time spent by a patient to complete the series of tests including the administration of questionnaire was approximately 25 minutes. None of the subjects complained of lack of retention of MCA, nausea, or any other problems resulting from misfit of MCA. No one of them had seen the MCA during the test, verifying that they have been satisfactorily blinded.

As shown in Fig. 3 the Friedman test placed the mean preference ranks of four MCA in the following order: wide design (1.8), 1SR design (2.0), 2SR design (2.6), and thick design (3.6) ($\chi^2 = 11.76, P=0.008$). Multiple comparisons revealed that the wide design was significantly ($P=0.004$) and the 1SR design was marginally ($P=0.01$) preferred to the thick design by this cohort of subjects (Fig. 3). No obvious difference was found between the preferences to wide design and 1SR design. The preference to 2SR design did not show statistically significant difference to any other design although it was placed third in the rank order. Looking at the individual data, the wide design was ranked as the most preferred design in four sub-

![Figure 3](image-url)
Patients had a tendency to prefer thinner designs to traditionally published related studies. Sufficient control of such study projects for his ability to fabricate MCA precisely. Moreover, the MCA were fabricated by a single trained investigator, who was tested arbitrarily selecting the test designs. The MCA were selected and investigated exclusively, than arbitrarily. The strengths of this study are that the major connector designs of theoretically comparable rigidity were selected and investigated exclusively, than arbitrarily. These findings are in general agreement with widely accepted concept by clinicians and also with previous studies that thinner major connectors are more comfortable to patients, and cause less disturbance during speech. On the other hand, the observed individual variation in preference among these three thinner major connector designs suggests that it is not possible to find a best preferred design common to all patients. Consequently, these results suggest that the application of acrylic resin MCA to clinical settings is useful for the final selection of the best design for each patient.

The strengths of this study are that the major connector designs of theoretically comparable rigidity were selected and investigated exclusively, than arbitrarily. Furthermore, results drawn would be less warranted, as a high individual variation in preference is expected as reported by this short-term study; and hence, the present design could be considered as a realistic compromise.

Within the limitations of this study, the results suggest that there is a general tendency for patients to prefer thinner major connector designs to thicker designs. As a significant variability in preference was found within the thinner designs, it is reasonable to suggest that the most preferred design should be selected among the thinner major connector designs by patients with a similar method described in this study. Use of such modified designs may allow the application of Ti-6Al-7Nb alloy to the major connectors, thereby overcoming the lower rigidity of this alloy, while securing the advantages of its other properties for RPD.

**Discussion**

These data allowed us to reject the null-hypothesis that there would be no significant difference among the patients’ preference to four major connector designs. Patients had a tendency to prefer thinner designs to thicker one as a group. This tendency was fairly consistent when a middle-strengthening ridge was added, while the design with anterior and posterior strengthening ridges was not significantly preferred to the thicker type. The latter finding was probably because the two strengthening ridges left only a 4mm width of thin resin base between them, and therefore, proprioceptors of the tongue may have perceived it as being a thick MCA. These findings are in general agreement with widely accepted concept by clinicians and also with previous studies that thinner major connectors are more comfortable to patients, and cause less disturbance during speech. On the other hand, the observed individual variation in preference among these three thinner major connector designs suggests that it is not possible to find a best preferred design common to all patients. Consequently, these results suggest that the application of acrylic resin MCA to clinical settings is useful for the final selection of the best design for each patient.

The strengths of this study are that the major connector designs of theoretically comparable rigidity were selected and investigated exclusively, than arbitrarily. Moreover, the patients’ preference to MCA was tested by offering the preference to four major connector designs. This study, to observe a significant difference in the preference between wide design and thick design, which was the most expected outcome of this study, resulted to be 0.84 (a post-hoc power analysis).

**References**


