# Discrimination ability in patients with extensive fixed partial dentures on mandibular canine teeth

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To study discrimination ability under different test situations, a psychophysiologic test was performed in a group of patients with 12-unit mandibular fixed partial dentures supported on the 2 canines. The cantilever segments were exchangeable. Analyses of discrimination ability were performed with regard to periodontal and endodontic status of the abutment teeth and to type of mucosal contact in cantilever regions. Discrimination ability was markedly reduced with a strongly reduced periodontal bone contact area. The endodontic status did not affect discrimination ability. A tendency towards better discrimination ability was seen when the cantilever sections without mucosal contacts were compared with those with mucosal contacts through pontics or saddles. □ *Dental prosthesis; endodontics; oral rehabilitation; psychophysiology; sensory receptors*

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One of the clinical variables affecting the long-term prognosis of a fixed partial denture is the load or force exerted during function (1). The sensory receptors necessary for reflexly modulating muscular activity are situated not only in, for example, the teeth and their surrounding tissues but also in the mucosa, muscles, and the temporomandibular joint (2).

Discrimination of forces or loading applied on a tooth varies among different teeth (3). The front teeth are more sensitive than the molars. Natural dentition has a more discriminative capacity than a prosthodontically restored one (4). When single teeth are compared, a pulpless tooth has a significantly higher pressure threshold (4) and pain-loading level (5) than a vital one. When a cap is put over a vital tooth, the pressure threshold increases more than 100%. On the other hand, when denervated teeth with and without a cap are studied, no differences were found (4). This indicates the presence of intradental receptors more sensitive than the periodontal ones.

There are differences in ability to discriminate and in exerting load or forces with regard to type of dentition. A fully dentate person can exert maximal chewing forces of more than 500 N, but complete denture wearers can for different reasons only use a third or fourth of this (6). Persons with complete dentures are able to discriminate particles between their teeth (7, 8) even though their threshold of oral tactile sensibility is significantly higher than that of persons with natural dentitions or fixed dentures on osseointegrated implants (7, 9). In spite of severe loss of periodontal tissue, patients with extensive bridgework can achieve bite force values that are almost comparable to those in individuals with natural teeth (10).

Subjects with periodontal bone loss without inflammation are shown to have impaired bite force discriminatory ability compared with normal controls (11). Still more impaired tactile function is seen in subjects with periodontal bone loss and pathologically altered periodontium (12).

The role of the periodontal ligaments in perception of external forces applied to the teeth has been widely studied (5, 7, 11–13). It is suggested that the sensory input from

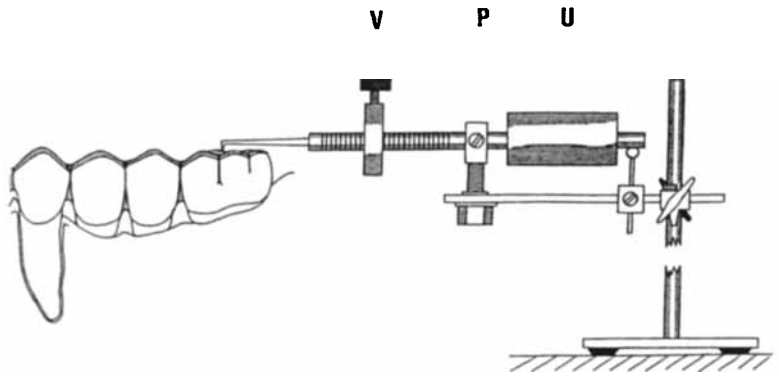


Fig. 1. Apparatus for loading cantilever units. V = variable weight; P = center of rotation; U = counterbalance.

the periodontal ligaments provides adequate feedback for the control of different levels of biting force. During chewing, however, the information from periodontal sensory receptors is of less importance for the occlusal tactility than during conscious biting (2, 7).

As discrimination ability may be one of the regulating factors in mastication, the aims of this study were 1) to investigate discriminating abilities in subjects with an extensive fixed prosthesis on two abutments and with different types of cantilever constructions; 2) to study whether the vitality of the abutments influences discrimination abilities; and 3) to study the role of the periodontal surfaces of the abutments with regard to discrimination abilities.

## Materials and methods

The test group consisted of 9 persons, 8 men and 1 woman, with an average age of 62 years. They were selected from those referred to the Department of Prosthetic Dentistry, Faculty of Odontology, University of Göteborg, for treatment of a severely compromised dentition. The treatment consisted of a new complete maxillary denture or an adjustment of the old one and a mandibular 12-unit fixed partial denture (FPD), including 3 cantilever extensions bilaterally on the 2 canines as abutments.

The cantilever segments, consisting of two premolars and one molar, were removable and exchangeable with extension bases described in detail in a previous presentation (14). There were three different test situations: a) FPD retained only on the abutments; b) FPD retained on the abutments and in mucosal contact through pontics; and c) FPD retained on the abutments and in mucosal contact through saddles.

The measurements were performed with the apparatus shown in Fig. 1, consisting of a lever with a movable weight. The lever is calibrated and marked, and when the weight is moved along the scale, varying pressure will be exerted at the point. The apparatus was mounted on a mobile stand.

During the test the persons sat in a dental chair with a neck rest, in a calm and relaxed environment. They were asked to concentrate on the task and close their eyes. Several breaks for rest were taken. The upper denture was removed during the test, to give enough space for the point of the lever. All measurements were made on the occlusal surface of the first left lower molar. The applied forces were directed along the vertical axis of the first molar pontic.

The test technique used in these psychophysiologic measurements is called 'the method of constant stimulus differences' (15). With this method the person is subjected to a pair of stimuli, one standard stimulus and one experimental, variable stimulus. The person has to decide which one is heaviest without knowing which stimu-

Table 1. Distribution on right and left sides of vital and non-vital mandibular canines of the nine test persons

| No. of persons | Right | Left |
|---|---|---|
| 3 | Vital | Vital |
| 3 | Vital | Non-vital |
| 2 | Non-vital | Non-vital |
| 1 | Non-vital | Vital |

lus will be presented first. The stimuli were presented in a randomized manner.

As a standard stimulus a weight of 50 g was used. Variable stimuli were 20 g, 30 g, 40 g, 60 g, 70 g, and 80 g. Every variable stimulus was offered 10 times; that is, the person had to make 60 comparisons in each situation, and, as mentioned previously, there were 3 different situations. The load was allowed to affect the occlusal surface of the first molar on the left-hand side for about 3 sec; then it was removed, and a new offer was made with an altered weight. After having made 12 comparisons, the person was allowed to have a rest and close his mouth, rinse, and talk for around 20 sec. All three test situations were carried out on the same occasion.

The endodontic condition of the abutments is presented in Table 1. On the test occasion four of the patients had a vital left lower canine, and five had a non-vital, endodontically treated root-filled one.

The assessment of the contact area between the abutments and the surrounding bone was made by measuring the intraoral radiographs by means of the technique described by Jepsen (16). The method gives the periodontal area as a percentage of the total root area.

### *Statistical methods*

Data are presented as group values for the different levels and situations. The chi-square test was used to test for differences between discrimination ability and type of cantilever situation. Analysis of variance, supplemented with a Newman–Keuls multiple comparison test, was used to reveal possible differences between the three cantilever situations. Ninety-five per cent confidence intervals for the differences were calculated.

Probabilities of less than 5% ($p < 0.05$) were considered statistically significant.

Table 2. The number of wrong decisions in three different test situations. The total number of tests with each construction was 540, and for all three test situations, 1620

| Level (g) | Pontics | Saddles | No contact | Total |
|---|---|---|---|---|
| 20 | 12 | 17 | 3 | 32 |
| 30 | 11 | 25 | 21 | 57 |
| 40 | 27 | 25 | 29 | 81 |
| 60 | 36 | 40 | 31 | 107 |
| 70 | 28 | 22 | 25 | 75 |
| 80 | 13 | 19 | 11 | 43 |
| Total | 127 | 148 | 120 | 395 |

## Results

More incorrect decisions were made when the test stimulus was heavier than the standard stimulus. There were 225 wrong decisions out of 810 choices, compared with 170 out of 810 choices when the test stimulus was lighter than the standard stimulus. No statistically significant differences were found between the three test situations—that is, with different cantilever types. Nevertheless, there was a tendency ($p = 0.08$) to make more faulty decisions when there was saddle contact compared with other situations (Table 2).

When subjects were compared with regard to the periodontal bone area of the lower left canine, patients with a limited bone reduction (<20%) had a significantly better test result than those with a greater reduction (>40%) of the bone support around the tooth in question (Table 3). The patient who had lost most bone (about two-thirds) also made most mistakes in the tests. There was no difference in the frequency of discrimination mistakes in relation to the endodontic status of the lower left canine (four vital, five non-vital) (Table 4), nor between three

Table 3. Number (N), mean (M), and range (R) of wrong decisions in three persons (group I) with reduced marginal bone level (<60%) of lower left canines and in three persons (group II) with good marginal bone level (>80%)

| Group | | Pontics | Saddles | No contacts | Total |
|---|---|---|---|---|---|
| I | N | 54 | 62 | 50 | 166 |
| | M | 18.0 | 20.7 | 16.7 | 18.4 |
| | R | 12–23 | 16–24 | 12–20 | 12–24 |
| II | N | 28 | 30 | 25 | 83 |
| | M | 9.3 | 10.0 | 8.3 | 9.2 |
| | R | 6–12 | 9–11 | 7–9 | 6–12 |

Table 4. Number (N), mean (M), and range (R) of wrong decisions in three different test situations: group I (4 persons) with a vital 33, group II (5 persons) with a non-vital and endodontically treated 33

| Group | Pontics | Saddles | No contacts | Total |
|---|---|---|---|---|
| I: vital 33 | | | | |
| N | 58 | 72 | 53 | 183 |
| M | 14.5 | 18 | 13.3 | 15.3 |
| R | 6–23 | 9–24 | 9–20 | 6–24 |
| II: non-vital 33 | | | | |
| N | 69 | 75 | 67 | 211 |
| M | 13.8 | 15 | 13.4 | 14.1 |
| R | 12–20 | 10–22 | 7–19 | 7–22 |

patients with only vital and two with non-vital abutments.

## Discussion

The main finding of this study is that, with the method used and the limited number of subjects, only small (non-significant) differences in force discrimination were observed in situations with various mucosal contacts on the cantilever sections. It might have been anticipated that the larger mucosal contact provided by the saddles should have given a better discrimination ability than the pontic situation or the no-contact situation. On the contrary, there was a tendency for poorer discrimination with saddles. One explanation for this might be that the saddle construction gave increased support, diminishing the load on the abutments and thus diminishing the influence of the periodontal receptors. It can be assumed that the periodontal receptors are more responsible for this sensory input than mucosal ones (17).

It was expected that the vital teeth should have a superior discriminative ability compared with the non-vital ones (18, 19). However, when sides with vital teeth were compared with non-vital ones, no significant difference was found. As five of the nine subjects had both types of abutment teeth, it is possible that such a difference was disguised by the fact that the vital tooth took over more of the sensory responsibility in these jaws. It was therefore of interest to compare the few patients with only vital (3) or non-vital (2) abutments. This comparison, however, showed no significant difference between the two groups. Loewenstein & Rathkamp (4) showed that the individual thresholds of force producing a sensation of pressure in pulpless teeth were significantly higher than in normal teeth. The observed average threshold increase was 57%. This figure should be compared with an increase of 127% when a normal tooth is covered with a metallic cap. The results from the present study did not show any significant difference between the two groups—the capped normal-teeth group and the capped pulpless-teeth group. This result must be interpreted with caution, however, since a small number of subjects were compared.

Teeth with periodontal bone loss have been found to have impaired ability to discriminate bite force compared with teeth in subjects free of periodontal disease (8). Although the latter can achieve maximum bite force just slightly lower than those with natural teeth (10), van Steenberghe et al. (12) concluded in their study that the degree of inflammation influences the sensory qualities of the periodontium more than a reduction in the amount of tissue does. Williams et al. (11), however, contradict this in their study, stating that individuals with loss of attachment but free of inflammation have impaired sensory function. In our study,

patients with more than 80% of the roots in contact with bone had significantly better discrimination ability than those who had less than 60%. The worst result was found in the patient who had less than 40% bone contact left.

Mechanoreceptors within the periodontal ligaments have been categorized as consisting of both rapidly and slowly adapting types (3). Rapidly adapting receptors are known to fire only a few impulses when a stimulus is applied to a tooth, whereas slowly adapting receptors fire continuously throughout the stimulus period (20). It is hypothesized that improved bite force discrimination would result when using incisors or canines compared with molars because of the higher number of slowly adapting receptors in the anterior teeth. These receptors contribute most to the discrimination of differences in biting force (21). A reduced number of periodontal ligaments means a reduced ability to discriminate, and this does not seem to be compensated for by receptors in the mucosa. Combined with the ability to chew hard, this means that the risk of clinical failure during function increases. Nevertheless, most of the extensive FPDs examined functioned over many years, as presented previously (14).

In this study the applied forces were directed along the vertical axis of the first molar pontic. The canine was affected by means of a bending movement. The periodontal ligaments were compressed and stretched in different parts. The canines have been shown to have a slightly higher pressure threshold than the incisors but smaller than the molars for both axial and lateral stresses (4, 22–24). In contradiction to this, Bonaguro et al. (25) found that subjects' ability to discriminate differences in applied forces was greatest when using the canines.

The fact that more wrong decisions were made when the test stimulus was heavier than the standard stimulus may be explained by Weber's law—a psychophysical law stating that perceived sensation increases proportionally to the logarithm of the intensity of the stimulus (26). Practically, this means that it is easier for a subject to feel the difference between a 20-g and a 50-g weight than between a 50-g and an 80-g weight. Expressed as a percentage, the differences between the weights are 150% and 60%, respectively.

In summary, there was a tendency towards better discrimination ability for patients with fixed partial dentures on mandibular canine teeth without mucosal contact through pontics or saddles than for those with mucosal contacts through saddles.

With strongly reduced periodontal bone contact, discrimination ability was markedly reduced.

No difference was obtained in discrimination ability with regard to the endodontic status of the abutments.

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