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ORIGINAL ARTICLE

Tactile Sensibility of Natural Teeth and Osseointegrated Dental Implants to Loading

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SUMMARY

Introduction. Dental implant therapy has become a popular method of replacing one or more missing teeth. Osseointegrated dental implants have been studied from histological, microbiologic and biomechanical point of view, but the neurophysiologic integration of the implants and the supported prostheses has received less attention. The sensory mechanism of dental implants is qualitatively different from that of natural teeth. Psychophysiological tests are used to determine the tactile sensibility perceived with the implants and teeth.

Aim of the study. The purpose of this study was to compare tactile sensibility of natural teeth and osseointegrated dental implants.

Material and methods. Forty-three patients were included in the study. Natural teeth were divided into two groups: non endodontically treated teeth (NETT) and endodontically treated teeth (ETT). Load tests were done by a computer-controlled pressure sensitive device („Power Lab" Data Acquisition System – model 4/25T, sensor – model MLT003/D; *ADInstruments*), specially modified for intraoral use. Pushing forces were applied parallel to the vertical axis of teeth and implants. The patient held a signal button which he/she activated as soon as touch was sensed. At this moment the computer registered *passive absolute tactile threshold* - measured in Newtons. The mean values of *passive absolute tactile threshold* for natural teeth and dental implants were calculated. Comparison of the mean values was performed by the means of *t-test.*

Results. *Passive absolute tactile threshold* for osseointegrated dental implants was 2.39 N (SD=1.92), and for teeth - 0.67 N (SD=0.72), for non endodontically treated teeth it was 0.63 N (SD=0.72) and for endodontically treated teeth - 0.73 N (SD=0.69). The differences in mean values were statistically significant ($p<0,0001$) except for mean values of NETT vs. ETT.

Conclusion. This study shows that patients with osseointegrated implants subjectively feel "touch" sensation when greater force is applied compared with natural teeth.

Key words: tactile sensibility, osseoperception, proprioception, teeth, implants

INTRODUCTION

To control oral motor functions – chewing, biting, speech etc., the central nervous system (CNS) relies on information from the sensory organs in the orofacial structures. Teeth are equipped with tactile sensors – periodontal mechanoreceptors that provide feedback of magnitude, direction, and rate of occlusal load application for sensory perception and motor function (4,11). As periodontal neural receptors play an important role in oral tactile function, the impact of tooth extractions on the sensory feedback pathway may be considerable (13). After extraction of teeth the periodontal neural feedback pathways are destroyed since the periodontal ligament receptors are eliminated. The loss of periodontal mechanoreception influences the control of jaw function and the precision of magnitude, direction, and rate of occlusal load application (1).

Dental implant therapy has become a popular method of replacing one or more missing teeth. To ensure a long term function, it is important that implant prostheses harmonize functionally and biologically with the stomatognathic system (4). Osseointegrated implants have been studied from histological, microbiologic and biomechanical point of view, but the neurophysiologic integration of the implants and the supported prostheses has received less attention. Osseoperception is defined as mechanoreception in the absence of a functional periodontal mechanoreceptive input and it is derived from TMJ, muscle, cutaneous, mucosal, periosteal mechanoreceptors which provide mechanosensory information for oral kinesthetic sensibility in relation to the jaw function and the contacts of artificial teeth (10,11). The sensory mechanism in osseoperception is qualitatively different from that of natural teeth (18). It is not clear how the neurophysiological mechanisms that modulate jaw movement are associated with the sensory structures around the osseointegrated dental implants.

Psychophysiological tests are used to determine the tactile sensibility perceived with the implants and teeth. The scientific sources refer to both active and passive threshold of sensibility (6,11). Passive threshold is determined by application of an external stimulus on teeth or implants, and is independent of patient's participation. Active threshold is determined by patient's interocclusal detection of thickness and shape of various objects.

This clinical study was focused on the determination of the passive sensibility threshold of the teeth and implants.

AIM OF THE STUDY

The purpose of this study was to compare passive tactile sensibility of natural teeth and osseointegrated dental implants.

MATERIAL AND METHODS

Forty-three patients who had received dental implants and prosthetic treatment at the Rīga Stradiņš University, Institute of Stomatology participated in the study. The teeth and implants were assessed both clinically and radiologically by intraoral examination and by long cone periapical radiographs respectively. After the radiological examination, natural teeth were divided into 2 groups – endodontically treated teeth (ETT) and non-endodontically treated teeth (NETT). According to FDI (World Dental Federation) nomenclature, a tooth was considered to be endodontically treated if it had a radiopaque material in the pulp chamber and/or in the root canal(s) (9). Periapical staus was assessed radiologically using periapical index (PAI), where 1 - normal periapical appearance, 2 - minor changes in the periapical bone appearance, 3 – changes in the bone structure with some mineral loss, 4 – periapical periodontitis with well-defined radiolucent area, 5 – severe periodontitis with exacerbating features (17).

Inclusion criteria for participants were : aged 18 years or over; have both natural teeth and implants; dental periapical index of 1 or 2; dental implants inserted at least 5 months prior to the study; individual (not splinted) teeth and implants; tooth mobility within normal physiological limits; asymptomatic both teeth and dental implants. Exclusion criteria were : teeth or implants in connected constructions, e.g. bridges, splinted crowns; dental periapical index of 3 or more; symptomatic teeth or implants; sensitivity of examined teeth or implants, and/or the adjacent teeth and implants during examination; difficulties of adequate mouth opening, and/or temporomandibular pain; poor compliance.

The study was conducted in the Department of Human Physiology and Biochemistry of Rīga Stradiņš University. Prior to the study all participants had the purpose of the study and the process of the examination explained in detail, and signed an informed consent form approved by the RSU Ethics Committee. Examinations took place in a quiet room, minimizing the influence of external factors as much as possible. Aside from the examined person, there were two other people present in the room. Load tests were done by a computer-controlled pressure sensitive device („Power Lab" Data Acquisition System – model 4/25T, sensor – model MLT003/D; ADInstruments), specially modified for intraoral use (Figure 1 and 2). The instrument was calibrated using the standard weights.

During the examination patient was seated in the dental chair and was asked to close their eyes. A cheek retractor was used to aid the procedure. Pushing forces were applied by the device parallel to the vertical axis of the tooth and dental implant separately (Figure 3).

The participant was holding a signal button which he/she was asked to activate when the pressure was felt as increasing loading was applied. For natural teeth and osseointegrated implants the passive absolute tactile threshold (PATT) were registered, tested by steadily increasing axial pressure. Passive absolute tactile threshold is minimum pressure value (N), perceived by the patient as a sensory touch (Figure 4).

Prior to commencing the test several trials were run to familiarize the participant with the procedure. Before each load test, the subject was informed verbally of the starting of the experiment. The staff communicated with previously agreed non-verbal signs to avoid distracting the participant. The examined tooth or dental implant was identified according to localisation and status and labeled according to the FDI classification. Endodontic status and dental implants were identified as follows: A – non-endodontically treated tooth, B – endodontically treated tooth, C – implant. For example, 24A – 4^{th} tooth of the second quadrant, non endodontically treated; 16B – 6^{th} tooth of the first quadrant, endodontically treated; 35C – dental implant in the site of the 5^{th} tooth of the third quadrant.

Load tests were conducted for 80 implants, 173 non-endodontically treated teeth and 63 endodontically treated teeth. For each particular tooth or implant the measurements were repeated 3 times. In total, 948 load tests were undertaken.

The mean values of passive absolute tactile threshold for natural teeth and dental implants were calculated. Comparison of the mean values was performed by the means of t-test. P value < 0.05 was used as a level of statistical significance for the difference of mean values. According to the aim of the study, analysis was mainly focused on differences in mean values of passive tactile sensibility for natural teeth and dental implants. In this case only two groups were compared; therefore use of t-test is justified. However, in case where more than two groups were compared (NETT, ETT, and implants) ANOVA analysis and Bonferroni correction was used to control over-all type I error rate.

RESULTS

After the selection forty-three patients were deemed eligible and took part in the study; of which 65.1% were females (n=28) and 34.9% (n=15) males. Mean age of participants was 40.1 years ranging from 21 to 71 years. For females and males the mean age was 38.3 and 43.4 years respectively.

The values of passive absolute tactile threshold (PATT) for teeth both endodontically treated (ETT) and non endodontically treated (NETT) – and implants are shown in Figure 5, 6 and 7.

The mean values of implants PATT in both maxilla and mandible separately, and in both jaws together were considerably higher than PATT values of both endodontically treated and non endodontically treated teeth.

In the maxilla there was a statistically significant difference in mean PATT in non endodontically treated teeth and in dental implants ($p<0,0001$), as well as in endodontically treated teeth and implants (p<0,0001). This significant difference remained also when comparing the PATT values of all teeth (NETT or ETT) and implants.

The mean PATT in the mandible was also statistically significant when comparing NETT with implants (p<0,0001), ETT with implants (p=0,0001) and when examining all teeth together and implants (p<0,0001).

The same statistically significant difference in the above-mentioned values was observed also when comparing NETT, ETT and all teeth with implants (in all three cases p<0,0001) in both jaws together.

A statistically significant difference of mean PATT in NETT, in comparison to ETT was not found either in the maxilla, or mandible, nor in both jaws together.

When comparing the results for maxilla and mandible, statistically significant difference in mean PATT was detected only in dental implants (p=0,042).

DISCUSSION

Several methods of load testing were tried until finding the optimal one. During the modification phase of the pressure sensitive measuring tool, load tests were done manually. Later at the in vivo phase of research, tests were performed by using a specially adapted electroengine, that allowed great control over the speed of applied loading. However, this method significantly prolonged the testing and the participants became tired. It was also difficult to appreciate the effect of vibration of the measuring instument and the noise caused by the electroengine during the test.

As the most optimal method of load testing we found manual increase of pressure force. This method enabled relatively quick and precise measurements. The main disadvantage was the operator's influence on the process. To minimise this human factor all tests were performed by the same operator.

The main problem during the trials and testing was found to be avoiding the tip of the pressure sensitive measuring device touching the tooth or dental implant prematurely. This premature contact could confuse the participant, and it also affected the results. Although some authors believe that the measuring device should be attached to the tooth during the passive tactile threshold measuring (8), we performed our loading tests by slowly and steadily moving the measuring device towards the tooth or dental implant. In our study we did not attach the device to the tooth or dental implant before starting the test for the patients noticed feeling of light touch or pressure even before we commenced loading. Both osseointegrated implant and natural tooth can detect even loading of few grams (3), which makes the measuring process more challanging.

This study showed that the passive absolute tactile threshold (PATT) of natural teeth and dental implants is different. The lowest threshold was recorded testing non-endodontically treated teeth; slightly higher it was for endodontically treated teeth, but the highest PATT was found in testing dental implants. The PATT for implants in maxilla, mandible and in both jaws together was statistically significantly higher than the PATT for teeth - both non-endodontically and endodontically treated. In our study the mean PATT for dental implants was 3.6 times higher than the one for natural teeth, i.e., higher forces on implants than on natural teeth are required for patients to have a sensory response.

Our data suggest that tactile sensitivity for natural teeth and osseointegrated implants differ – natural teeth have significantly higher tactile sensitivity than dental implants. Also in the literature most of the authors have found that the tactile sensitivity of natural teeth is many times higher than of the dental implants (15,16,17). The tactile sensitivity of the natural teeth is determined mainly by the periodontal receptors (17). Although a dental implant lacks this receptive mechanism, it still has some tactile sensitivity. In some studies implants were anaesthetised and it proved that load applied on the dental implants is detected by receptors in adjacent tissues such as periosteum, muscle and temporomandibular joint. It is questionable whether the bone itself contains structures able to produce tactile sesnastion. There are researchers who feel that bone contains mechanoreceptors (19,20). However, Klineberg, Calford, Dreher, Henry, Macefield, Miles, Rowe, Sessle and Trulsson (2005) published consensus report that there is not sufficient data proving bone, bone marrow or periostal involvement in sensory perception.

Mean PATT was different for maxilla and mandible. Although ALL TEETH, NETT (non-endodontically treated teeth), ETT (endodontically treated teeth) groups had lower PATT in the lower jaw, there was no statistically significant difference between the tactile sensitivity in maxilla and mandible. However, in the IMPLANTS group the difference of the tactile sensitivity in the upper and lower jaws was statistically significant (p=0.042) – mean PATT in the maxilla was 55.5% higher than in mandible. Lower forces on dental implants in mandible were required to produce a detectable sensation of pressure. The higher sensitivity of mandible could be explained with additional receptors in the temporomandibular joint and muscles [20], which are not involved when the load is applied on the upper jaw.

When comparing the tactile sensitivity of endodontically and non-endodontically treated teeth, the mean PATT in maxilla, in mandible and in both jaws together were higher for endodontically treated teeth, but this difference was not statistically significant. The small difference of ETT and NETT could be explained with the fact vital teeth unlike nonvital teeth have both periodontal and intrapulpal mechanoreceptors (11). Our data suggest that mechanoreceptors of dental pulp have little contribution to tooth's tactile sensitivity. Also in the literature there are different opinions regarding the influence of the pulp on the tactile sensitivity. Loewenstein and Rathkamp (14) in their study found that the absolute tactile threshold of vital teeth was lower than the one of nonvital teeth. However, Linden (12) did not confirm this difference. Also Jacobs and van Steenberghe (7) agree that the tactile sensitivity of vital and nonvital teeth is similar.

CONCLUSION

This study has shown that natural teeth and osseointegrated dental implants express different sensory response to loading forces. Tactile sensibility for natural teeth and osseointegrated implants differ – natural teeth have significantly higher tactile sensibility than dental implants. This points to the fact that periodontal mechanoreceptors play a valuable part in tactile sensibility and are likely to protect the dentition. When planning the treatment, it is important to preserve the teeth with a healthy periodontium.

Fig. 1. ***ADInstruments*** **computer-controlled pressure sensitive device**

Fig. 2. Load test device modified for measuring the passive tactile sensibility threshold in a dental chair

Fig. 3. Schematic of load test

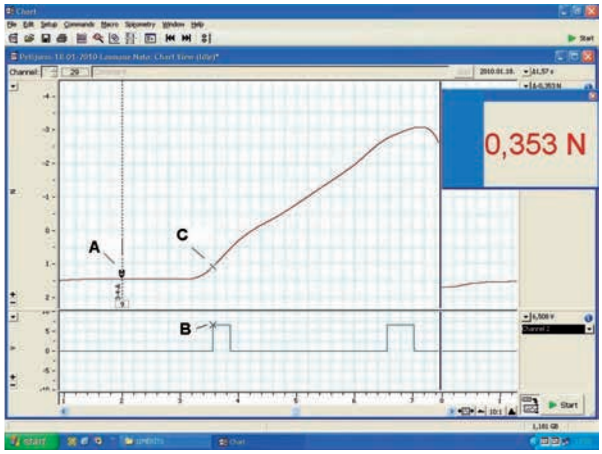

Fig. 4. Curve of the load test: A- starting point of measurements, sensor has not contacted the tooth or implant, B- moment when the patient felt the touch and pressed the signal button, C- corresponding measurement was registered and measured in Newtons (N) - in this case passive absolute tactile threshold was 0,353 N

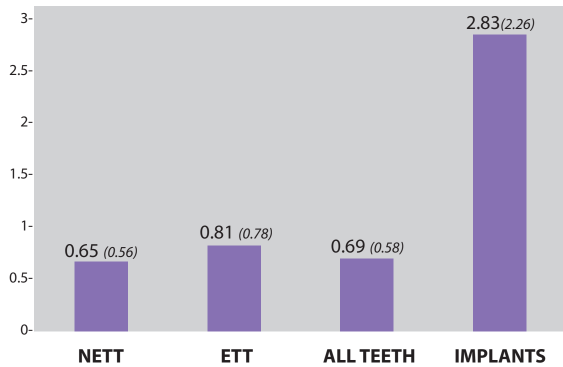

Fig. 5. Mean values of the passive absolute tactile threshold (standard deviation) in the maxilla

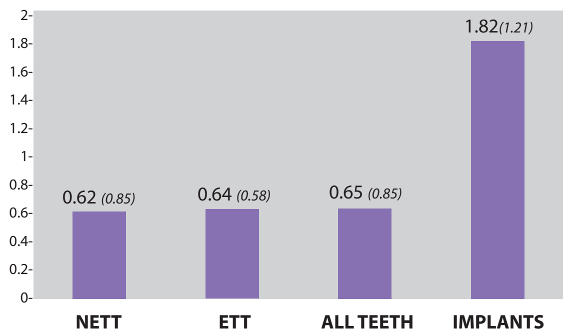

Fig. 6. Mean values of the passive absolute tactile threshold (standard deviation) in the mandible

Conflict of interest: None

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