Stomatologija, Baltic Dental and Maxillofacial Journal, 12: 80-6, 2010

Passive tactile sensibility of teeth and osseointegrated dental implants in the maxilla

Linards Grieznis, Peteris Apse, Leons Blumfelds

SUMMARY

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

Material and methods. Twenty-nine patients (17 males and 12 females) were included in the study. Natural teeth were subdivided into two groups: non endodontically treated teeth (NETT) and endodontically treated teeth (ETT). A computer-controlled custom-made pressure sensitive device was 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 tactile threshold – measured in Newtons. The mean values of passive tactile sensibility for natural teeth and dental implants were calculated. Comparison of the mean values was performed by the means of t-test.

Results. Passive tactile threshold for osseointegrated dental implants was 2.50 N (SD=1.39), and for teeth – 0.72 N (SD=0.49), for non endodontically treated teeth it was 0.66 N (SD=0.43) and for endodontically treated teeth – 0.96 N (SD=0.87) . The differences in mean values were statistically significant ($p<0.001$) 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. Natural 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 [1,2]. 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 [3]. 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 [4].

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 [1]. 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 re-

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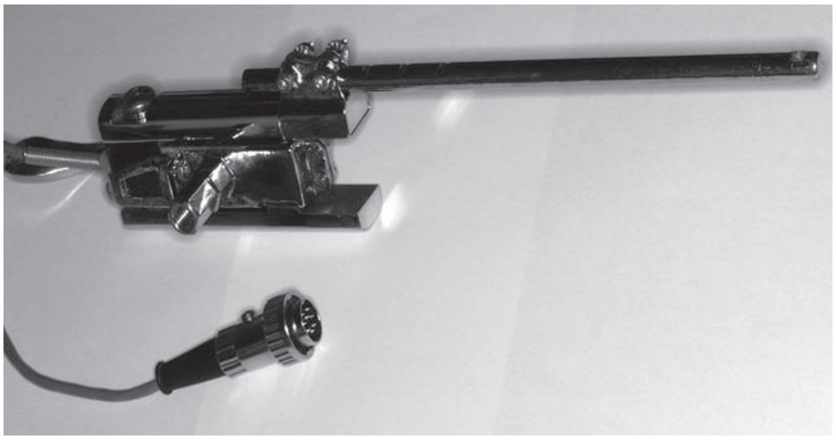

Fig. 1. Computer-controlled custom-made pressure sensitive device modified for intraoral use

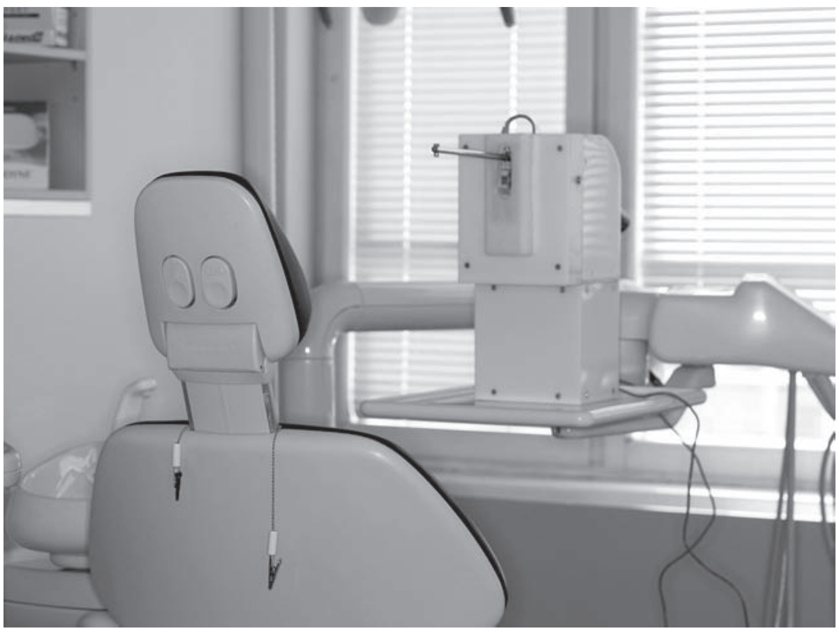

Fig. 2. Pressure sensitive instrument modified to test passive tactile threshold in the dental chair

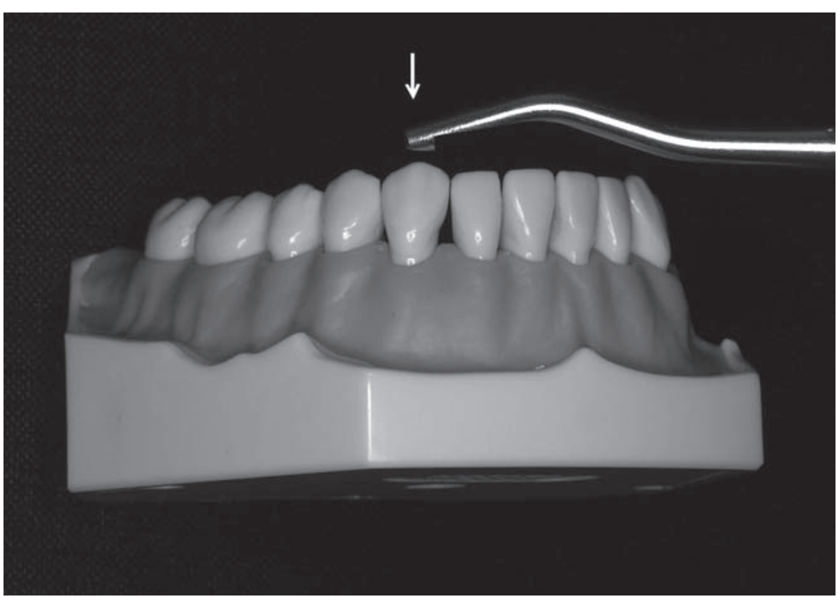

Fig. 3. Representative graph of loading and subject response

lation to the jaw function and the contacts of artificial teeth [2,5]. The sensory mechanism in osseoperception is qualitatively different from that of natural teeth [6]. 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 of the implants and teeth. The scientific sources refer to both active and passive threshold of sensibility [2,7]. 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.

Purpose

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

MATERIAL AND METHODS

Twenty-nine patients (17 males and 12 females) aged from 21-71 were included in the study. The inclusion criteria were: isolated natural teeth and implants in the maxilla; at least 5 months after implant placement; tooth mobility in normal physiological limits; immobile implants; asymptomatic teeth and implants. The teeth and implants were studied both by intraoral examination and by radiographs. Natural teeth were subdivided into two groups (as determined from radiographs): non endodontically treated teeth (NETT) and endodontically treated teeth (ETT) without evidence of pathology. According to FDI nomenclature, the teeth were

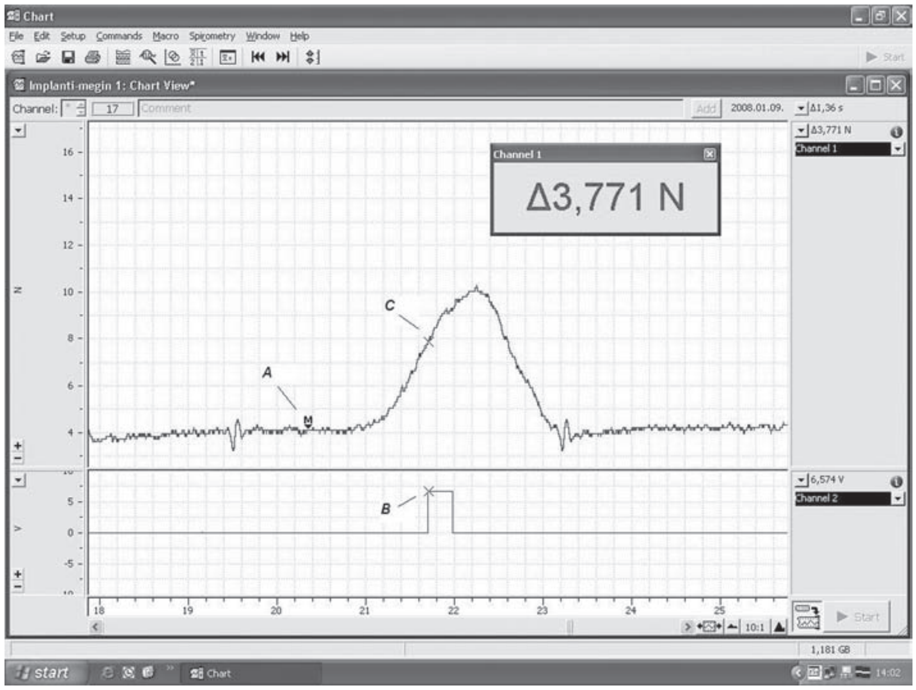

Fig. 4. Passive tactile sensibility graphic representation : A – start point, no contact with test instrument; B – patient presses the buttom indicating a sensation; C – corresponds to the loading in Newtons at time of buttom depression (this case 3.771 N).

considered to be treated endodontically if they had been filled with a radiopaque material in the pulp chamber and/or in the root canal(s). The exclusion criteria: multiple connected constructions – bridges, splinted crowns. All patients received dental implants and prosthetic treatment at the Riga Stradins University, Institute of Stomatology.

A computer-controlled custom-made pressure sensitive device ("Power Lab" data acquisition system – model 4/25T, sensor – model MLT003/D; company ADInstruments) was modified for intraoral use (Fig. 1, 2). The instrument was modified so that it could be attached to the dental unit and the handpiece was reduced in size so that a single tooth or implant could be tested. Weights were used for calibration. The tested instrument showed both sensitivity and linearity required to test passive tactile threshold of teeth and implants.

During the study patient was seated in the dental chair and asked to close his/her eyes. An oral retractor was used in order to facilitate test procedure. The dental chair headrest was ensuring a stable position of head. Pushing forces were applied parallel to the vertical axis of teeth and implant crowns (Fig. 3). The load was applied with a speed increment of 1 N/s. The patient held a signal button which he/she activated as soon as touch was sensed. At this moment the computer registered passive tactile threshold (PTT) – measured in Newtons (Fig. 4). Prior the start of testing the nature of the study was explained to the patient and several pilot measurements were performed for patient to get acquainted with the study procedure. Measurements were performed for 43 dental implants, 59 non endodontically treated teeth and 22 endodontically treated teeth. The load test was repeated three times for each separate tooth or implant. In total there were 372 measurements. The sequence of load tests was varied.

The mean values of passive tactile sensibility for natural teeth and dental implants were calculated. Comparison of the mean values was performed

Table. Distribution of tactile sensibility among study population

Level of tactile sensibility (Newtons)	All teeth		NETT		ETT		Dental implants	
	N (patients)	%	N (patients)	%	N (patients)	%	N (patients)	%
<0.5	13	44.8	13	46.4	8	42.1	1	3.5
0.5-1	10	34.5	9	32.2	5	26.3	2	6.9
>1	6	20.7	6	21.4	6	31.6	26	89.6
Total	29	100	28	100	19	100	29	100

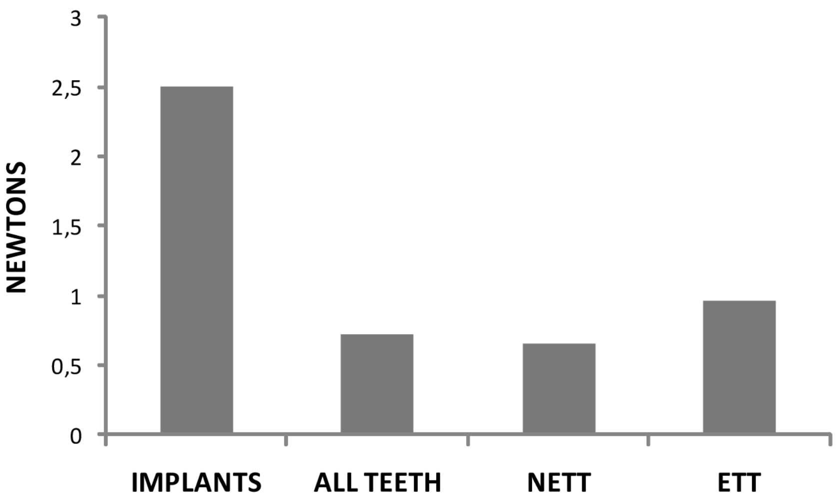

Fig. 5. Mean passive tactile threshold for osseointegrated dental implants 2.5 N (SD=1.39) , and for teeth 0.72 N (SD=0.49), for non endodontically treated teeth 0.66 N (SD=0.43) and for endodontically treated teeth 0.96 N (SD=0.87)

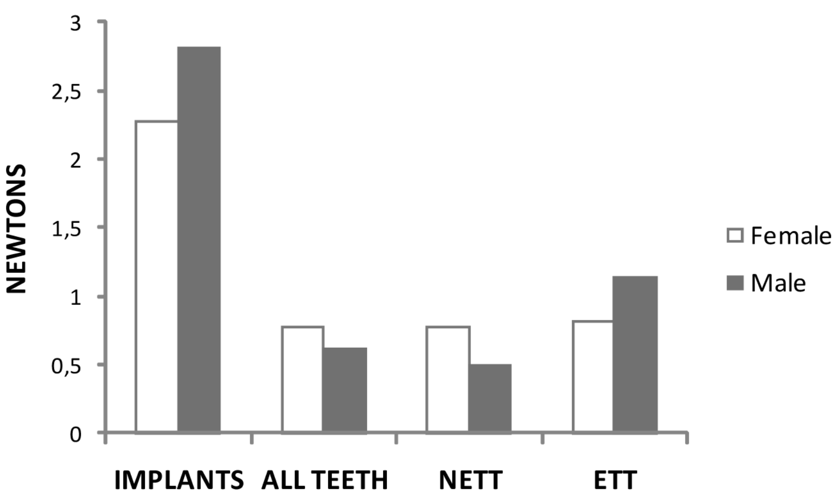

Fig. 6. Mean passive tactile threshold for implants 2.28 N (SD=1.41) – female and 2.81 (SD=1.37) – male; for teeth 0.78 N (SD=0.39) – female and 0.62 (SD=0.62) – male; for non endodontically treated teeth 0.77 N (SD=0.40) – female and 0.5 (SD=0.43) – male; for endodontically treated teeth 0.82 N (SD=0.47) – female and 1.14 (SD=1.25) – male

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

The mean values of passive tactile thresholds for natural teeth and dental implants are presented in Figure 5.

The differences in mean values were statistically significant ($p<0.001$) except for mean values of NETT vs. ETT.

Majority of the patients with ETT and NETT had a passive tactile sensibility less than 0.5 Newtons, whereas for patients with dental implants passive tactile sensibility was more than 1 Newtons (Table).

No differences were detected between males and females (Fig. 6).

DISCUSSION

In this study PTT was measured for maxillary teeth and implants since head position could be stabilized and to reduce the effect of TMJ and masticatory muscle mechanoreceptors during the test procedure. Both screw and cement fixation implants were used as the rigidity of both attachment methods are equal. Implant length and diameter were within a narrow range and differences in the tactile sensibility have not been reported. A 5 month minimum time limit for testing of dental implants to allow for bone healing and adaptation (osseointegration). No age limit was set for patients included in this study as a number of authors have reported that this factor is not significant [8]. Number of participants in this study (29) was chosen like in similar studies of tactile sensibility where 20-30 people were taking part [8,9,10]. Both anterior and posterior teeth were included in the analysis although further studies may show a diference between the tooth/implant locations in PTT testing. In this study we found that passive tactile sensibility differs between teeth and dental implants. Mean passive tactile threshold for osseointegrated teeth was 3.47 times higher than for natural teeth. This study shows that patients with osseointegrated implants subjectively feel ”touch” sensation when greater force is applied compared with natural teeth.

Passive tactile threshold (PTT) for osseointegrated dental implants has been reported to be up to 100 times higher than for natural teeth [11-13]. Yamauchi and Amano [14] measured PTT of sapphire endosseous implants and compared with those of natural teeth. The PTT were determined with calibrated von Frey filaments. This study showed that passive tactile threshold of natural teeth measured in the axial direction ranged from a minimum of 1.0 g to a maximum of 21.4 g, but threshold of implants ranged from a minimum 54.0 g to a maximum of greater than 119.9 g. Karayiannis et al. [15] found passive discrimination of dental implants to be 10 times higher than that of natural teeth (implants 3.42 N and teeth 0.34 N). Jacobs and van Steenberghe [16] detected the implant threshold to be 50 times higher than that of teeth.

Active detection threshold for implants is up to 6 times higher than for teeth [17]. Jacobs and van Steenberghe [7] published that tactile sensibility of implants is reduced with regard to natural teeth. In this study the active threshold for dentures was 7-8 times higher that of natural teeth, but 3-5 times higher for implants in comparison with the tactile function of natural teeth. Mericske-Stern [18] found that the active tactile sensibility was significantly improved when natural roots were tested. When comparing the minimal thickness of foils, which was recorded without incorrect assessment, a significantly lower threshold was observed on natural roots than on implants. In contrast Fenton and Lundqvist [19] found the same perceptive ability in patients with implants and with natural teeth.

The large discrepancies between active and passive thresholds can be explained by the fact that several receptor groups are involved in active testing [17]. Passive discrimination depends on periodontal and/or intrabony mechanoreception and is activated by the application of controlled forces to a tooth or an implant, while active discrimination is based on objects placed between teeth or implants, and involves a number of mechanoreceptor inputs located in teeth, periodontium, gingiva, jaw muscles and temporomandibular joint [2,7,17]. Vital and non-vital teeth show a comparable tactile sensibility [17]. Slightly higher value of tactile threshold for ETT than for NETT may be explained in that both intradental pulp and periodontal mechanoreceptors are concerned in tactile sensation [20]. To compare active and passive tactile thresholds a clearer understanding of their relationship would be gained from testing teeth and implants using both methods in one study. The fairly large differences in results between studies could be explained by the use of different methodology as well as the subjectivity (patient) of the test.

The human cortical adaptive processes in relation to the loss of teeth or their substitution with implants have not been extensively studied [2,21,22]. It is important to understand how the extraction of a tooth, the process of healing and the subsequent replacement of the missing tooth with an osseointegrated implant influence the sensory reaction. Following the extraction of a tooth, the periodontal ligament and receptors are lost and that in turn has an impact on sensory reaction and the motor function. By putting an implant into a bone a direct contact between the surface of the implant and the bone is established, i.e., the ankylosis of the implant [23]. By replacing natural teeth with implants the sensory motor function is altered [4]. The authors are cautious, however, in their opinions as to what do these alterations represent and how great they are. Abarca et al. [21] stated that as the prosthetic construction attaches indirectly to the bone via the implant following the osseointegration principle, there is a partial sensory response. It is likely that the sensory reaction is due to the activation of the receptors adjacent to the implants. Several studies point out that the oral tactile function is influenced by the dental status and the position of the teeth [20,24,25]. The tactile function of the teeth is primarily determined by the periodontal receptors. In the event of their absence or partial absence (in the case of extraction, periodontitis or anaesthesia), the oral tactile function deteriorates [24].

The objective of such studies is not only the impact of tooth extraction and subsequent implantation on the sensory reaction but also the cerebral responsive reaction which translates itself as activity of masticatory muscles. In the event of a total or partial loss of the teeth, there are changes which influence both sensory perception and responsive reaction that translates itself as activity of masticatory muscles. Abarca et al. [21] postulated that upon the extraction of the teeth the protective reflexes of masticatory muscles that prevent a traumatic occlusion, are partially lost. Periodontal ligament receptors play a part in controlling the masticatory muscle activity, but this is not the only pathway. The receptors in the pulp, oral mucous membrane, muscles, tendons and joints also play a part in controlling this activity [29].

The osseointegrated dental implants physiologically differ from natural teeth as to how they perceive occlusal load. Patients with implants subjectively feel a load when greater force is applied to an implant when compared to forces applied to natural teeth. Some researchers suggest that the higher tactile thresholds may result in overload to the implant and the prosthesis [17, 26]. Fontijn–Tekamp et al. [27] claim that following the insertion of the implants the maximum biting force gradually increases. However, they emphasize that such increase could also be explained in terms of the improved self-assurance and the increased feeling of safety as compared to the initial situation. Several authors have suggested that initial loading after implant placement should be reduced to allow possible innervations of the surrounding bone to take place [17, 28].

When the removable prostheses are supported by osseointegrated implants, the motor control and perception are greater than in the event of the complete dental prostheses [22]. However, the sensory and motor capabilities of the patients with implant-supported prostheses are lower than those of the patients with natural teeth [25, 30]. Many authors emphasize that the implant-supported restorations do not reach the same level of subjective satisfaction that is felt by the individuals with natural teeth.

CONCLUSION

This study shows the reduced passive tactile sensibility of oral implants in comparison to teeth. This points to the fact that periodontal mechanoreceptors play a valuable part in tactile sensibility and are likely to protect the dentition. The oral tactile function depends on the presence of natural teeth and therefore it is important to maintain as much of the natural dentition as possible.

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Received: 05 06 2010
Accepted for publishing: 23 09 2010