RĪGA STRADIŅŠ UNIVERSITY

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Tactile sensibility of natural teeth and osseointegrated implants to loading

(speciality – Prosthetic Dentistry)

Summary of promotion work

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Secretary of the Promotion Council:  
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1. Introduction

1.1. Topicality of theme

Teeth are part of the digestive system, with their main function being trituration of food. World Health Organization has stated that total loss of teeth in a human can be equalled to a loss of a body part. After tooth loss progressive resorption and remodelling of the alveolar bone occurs, lips are not supported and the facial shape changes. Removable dentures alone made for replacement of missing teeth (both total, and partial) cannot restore and ensure function to a full extent, as well as provide the best aesthetic and psychosocial comfort. Thus a complete tooth loss affects the individual’s quality of life (Laurina and Soboleva, 2006).

In 1965 Professor Per-Ingvar Brånemark and his colleagues introduced osseointegrated dental implants to provide a better support, stability and retention for dental prostheses for replacement of missing teeth. This was considered a major development in dentistry in the restoration of the masticatory system. Implants could now be used as supportive structures for prostheses much like natural teeth, restoring all masticatory functions and with it improving the quality of life for the patient.

Nowadays replacement of missing teeth by dental implants is a recognized and widely used method. Implants can be used in restoration of any tooth loss starting from a single tooth to edentulous alveolar ridge. However, there are still several aspects associated with dental implants that are not fully understood. One such issue is the sensory mechanism that governs masticatory function for, unlike natural teeth, dental implants lack the periodontal ligament that provides sensory input to the central nervous system (CNS). Without this physiological function it is not clear how the implants affect the functionality of the masticatory system.

By receiving information from the receptors in orofacial region, the brain controls the oral motor functions – biting, chewing, speech, etc. (Trulsson, 2006). The periodontal ligament, enveloping the root of natural tooth, consists of collagen fibres and microneurovascular tissue. The periodontal ligament transfers occlusal forces to the maxillary and mandibular alveolar bone and acts as a mechanical buffer (Hoshino et al., 2004). Periodontal receptors perceive the force of occlusal load and detect its direction and speed, and therefore have a significant role in sensory perception and in controlling jaw movements (Klineberg and Murray, 1999). After tooth extraction the periodontal ligament and its receptors are lost, thus altering sensory perception (Abarca et al., 2006).

Implants, replacing the natural teeth, have a direct contact with bone (within a few nanometers) and lack periodontal ligaments. Therefore the CNS cannot receive sensory messages
from the periodontal receptors and consequently the control of oral motor function might be altered (Trulsson, 2006). Due to lack of the periodontal complex, bone surrounding the implants perceive occlusal forces biomechanically differently in comparison to the natural teeth. In cases of implant-supported prostheses, one can observe various complications, such as fractures of implants, abutment fracture, screw loosening and fracture, porcelain fracture etc. A better understanding of biomechanics and physiology of bone supporting osseointegrated implants might help to avoid such complications.

Osseointegration of implants has been widely studied histologically, biomechanically and microbiologically. However, physiological integration of implants has received less attention (Abarca et al., 2006). There have not been adequate studies conducted on how neurophysiological mechanisms, which produce jaw movements, are connected with sensory structures around the dental implants.

1.2. Originality of research

While esthetical and biological aspects of dental implants have been discussed and analysed extensively, the issues of implant physiology have not been widely studied. In the current clinical study the passive tactile sensibility of natural teeth and osseointegrated implants was measured. In order to make measurements, computer-controlled pressure sensitive device („Power Lab” Data Acquisition System; ADInstruments) was used, which was modified for application in the oral cavity. This method for determining the tactile sensibility of teeth and implants allows to understand more precisely the local sensory perception mechanisms, which are the basis for understanding the different types of mechanoreceptors, as well as various mechanisms of formation of tactile sensation in the oral cavity. In the current work the analysis of the issues of physiological integrity of dental implants will allow the dentist to understand more clearly the oral sensory perception mechanism in various clinical situations and assist in designing an appropriate dental treatment plan ensuring longevity of prosthetic restoration in the oral cavity.
2. Aim and objectives of research

Aim of research
To compare the tactile sensibility of natural teeth and osseointegrated implants.

Objectives of research

1. To determine the absolute threshold of increasing axial pressure on natural teeth and implants in maxilla and mandible.
2. To determine the differential threshold of axial pressure on teeth and dental implants in maxilla and mandible.
3. To compare the quantitative values of tactile sensibility parameters for teeth and dental implants at different sites in the mouth.
4. To assess the influence of the age and gender on the tactile sensibility of the teeth and implants.
3. Material and methods

Forty-three patients who had received both 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) (Jimenez-Pinzon et al., 2004). Periapical status 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 (Orstavik et al., 1986).

Inclusion criteria for participants:
- 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:
- 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.

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

**Figure 2.** Load test device modified for measuring the passive tactile sensibility threshold in a dental chair
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 parallelly to the vertical axis of the tooth and dental implant separately (Figure 3).

![Figure 3. Schematic of load test](image)

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 absolute and differential sensitivity parameters of load were registered, tested by steadily increasing axial pressure:

1. $P_1$ – minimum pressure value (N), perceived by the patient as a sensory touch (passive absolute tactile threshold) (Figure 4).
2. $P_2$ -minimum pressure value (N), pressure steadily rising which was distinguished from $P_1$ (Figure 5).
Figure 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 P1 (passive absolute tactile threshold) was 0,353 N.

Figure 5. Continuation of the load test: D- a moment when the patient felt the pressure rise in relation to passive absolute tactile threshold, E – corresponding measurement was registered and measured in Newtons (N) - in this case P2 was 4,181 N.
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 – 4th tooth of the second quadrant, non endodontically treated; 16B – 6th tooth of the first quadrant, endodontically treated; 35C – dental implant in the site of the 5th 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.

**Statistic analysis**

Descriptive and analytical statistic methods were used for data analysis. Mean values of registered pressures P1 and P2 of natural teeth and osseointegrated dental implants were calculated. Statistic significance of the difference of mean values was determined using t-test. P-value of 0.05 was used as a level of statistic significance for the difference of mean values. Association of tactile sensibility to the age and gender was assessed using ANOVA variance analysis.

In order to analyse the association between the intensity of the irritant and the sensory intensity, the *Weber law* was used. For the quantitative evaluation of differentiation abilities, differential sensibility (Weber) coefficient was used:

\[ C = \frac{(P2 - P1)}{P1}. \]
4. 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.

4.1. Passive absolute tactile threshold for natural teeth and osseointegrated implants

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 6, 7 and 8.

Figure 6. Mean values of the passive absolute tactile threshold (standard deviation) in the maxilla.
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).

4.2. Effect of age of subject on tactile sensibility of teeth and implants

A statistically significant correlation between mean PATT and the age was not found either in maxilla or mandible, nor both jaws together. The mean PATT was not associated with the age, i.e., the values neither increased nor decreased with the age.
4.3. Effect of gender on tactile sensibility of teeth and implants

A comparison of mean PATT in the maxilla and mandible in both genders, is shown in Figure 9 and 10.

![Figure 9](image_url)  
**Figure 9.** Comparison of mean values of passive absolute tactile threshold (standard deviation) in the maxilla depending on the gender

![Figure 10](image_url)  
**Figure 10.** Comparison of mean values of passive absolute tactile threshold (standard deviation) depending on the gender (\(^ p=0.04 \))

Newtons

<table>
<thead>
<tr>
<th></th>
<th>NETT</th>
<th>ETT</th>
<th>ALL TEETH</th>
<th>IMPLANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>0.61 (0.19)</td>
<td>0.72 (0.11)</td>
<td>0.68 (0.07)</td>
<td>2.84 (0.64)</td>
</tr>
<tr>
<td>Male</td>
<td>0.67 (0.08)</td>
<td>0.96 (0.37)</td>
<td>0.72 (0.21)</td>
<td>2.81 (0.39)</td>
</tr>
</tbody>
</table>
When comparing the mean PATT in the maxilla and mandible of both genders, no statistically significant difference between males and females was found, except for endodontically treated teeth in the mandible, where the mean values of passive tactile threshold in females was lower than in males (0,46 N, comparing to 0,96 N, differences p=0,04).

4.4. Effect of localisation on tactile sensibility of teeth and implants

In order to analyse the effect of implant position in the dental arch on its tactile sensibility, all teeth and dental implants were divided in two groups according to their localisation. The frontal group included the 1<sup>st</sup> and 2<sup>nd</sup> teeth (the central and lateral incisors) and implants in the corresponding area in all 4 quadrants. The distal group comprised of the 5<sup>th</sup> and 6<sup>th</sup> teeth and corresponding dental implants (2<sup>nd</sup> premolar and 1<sup>st</sup> molar area) in all 4 quadrants. Comparison of mean PATT of teeth and implant groups in the maxilla, mandible and both jaws together, depending on the localisation, is shown in Figure 11, 12 and 13.

![Figure 11](image-url)  
*Figure 11. Comparison of mean values of passive absolute tactile threshold (standard deviation) in the maxilla depending on localisation*
Depending on the localisation, mean PATT for dental implants in maxilla, as well as in mandible and in both jaws together were statistically significantly higher than mean PATT for teeth.

In the maxilla there was a statistically significant difference of mean PATT for the teeth
depending on their localisation (p=0.028) – in the frontal teeth mean PATT was lower than the mean PATT in the distal teeth. On the other hand, the difference of the mean PATT for the implants in maxilla depending on their localisation was not statistically significant.

Mean PATT for the teeth in the mandible differed statistically significantly depending on their localisation (p=0.036) – the frontal teeth mean PATT was lower than the mean PATT for the distal teeth. Similarly, there was no statistically significant difference of mean PATT for the dental implants in mandible irrespective of their localisation.

In both jaws together mean PATT for the distal teeth was statistically significantly higher than those in the frontal region (p=0.011), while the difference of mean PATT for the dental implants depending on localisation – frontally or distally – was not statistically significant.

When comparing the maxilla with mandible, the teeth had a statistically significant difference in mean PATT both in the frontal and distal areas (p=0.05), while implants had a statistically significant difference in mean PATT in the maxilla and mandible only in the distal region (p=0.022).

4.5. Differential tactile sensibility of natural teeth and osseointegrated implants

Minimum pressure values with steadily increasing pressure recognised by the examined person as different from PATT, are shown in Figure 14, 15, 16.
Figure 14. Mean minimum pressure value of the maxilla \textit{(standard deviation)}, with pressure steadily increasing, which was differed from passive absolute tactile threshold.

Figure 15. Mean minimum pressure value of the mandible \textit{(standard deviation)}, with pressure steadily increasing, which was differed from passive absolute tactile threshold.
Figure 16. Mean minimum pressure value of the maxilla and mandible (standard deviation), with pressure steadily increasing, which was differed from passive absolute tactile threshold

Differential sensibility coefficient for the teeth and implants is shown in Figure 17, 18 and 19.

Figure 17. Weber’s coefficient (standard deviation) for teeth and implants in the maxilla
Weber’s coefficient for the teeth in the maxilla and in mandible, as well as in both jaws together was considerably higher than that for the dental implants. There was a statistically significant Weber’s coefficient difference for the teeth and implants in the maxilla \( (p=0.0002) \), in the mandible \( (p<0.0001) \) and in both jaws together \( (p<0.0001) \).

When comparing maxilla with mandible, only teeth had a statistically significant difference in Weber’s coefficient \( (p=0.048) \).
5. Conclusions

1. Teeth and implants differ in their sensory response to loading stress.
2. The passive absolute tactile threshold for osseointegrated implants is higher than that for natural teeth, i.e., higher forces on implants than on natural teeth are required for patients to have a sensory response.
3. Passive absolute tactile thresholds in endodontically treated and non endodontically treated teeth do not differ.
4. The passive absolute tactile threshold for implants is higher in the maxilla than in the mandible, i.e., lower forces on dental implants in mandible are required to produce a detectable sensation of pressure. In opposite, for the teeth, passive absolute tactile threshold in the maxilla and mandible does not differ.
5. Tactile sensibility is not affected by the age of the subject.
6. Gender does not affect the tactile sensibility either of teeth or dental implants.
7. In frontal teeth the passive absolute tactile threshold is lower than in the distal teeth. However, implants’ tactile sensibility is not affected by their position in the dental arch.
8. The differential sensibility (Weber) coefficient for the teeth is higher than that for the dental implants, i.e., a greater force has to be applied on tooth in order to feel the increase of pressure in comparison to passive absolute tactile threshold.
9. When designing a dental treatment plan, it is important to preserve the natural teeth with a healthy periodontium.
6. Summary

This study has shown that natural teeth and osseointegrated dental implants express different sensory response to loading forces. The lowest passive absolute tactile threshold was recorded in non endodontically treated teeth, slightly higher in endodontically treated teeth, with the highest in dental implants. The results show that tactile sensibility for natural teeth and osseointegrated implants differ – natural teeth have significantly higher tactile sensibility than dental implants. Although the use of osseointegrated dental implants allows prosthodontic treatment a wider scope and carries excellent long term prognosis along with good physiological and psychological acceptance by the patient, prosthesis supported by natural teeth have been shown to be subjectively superior judged by patients' satisfaction. Sensory and motor abilities for patients with implant-supported prostheses are lower than for patients with natural teeth. Thus, when planning the treatment, it is important to preserve the teeth with a healthy periodontium. An appropriate treatment plan based on biological, biomechanical and physiological principles, as well as evidence based surgical and prosthetic treatment, are preconditions for the quality and longevity of the dental implants and the implant supported dental prosthesis.
7. Publications


Accepted for publication:


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8. Reports about results of presented thesis

The 1st Baltic Scientific Conference in Dentistry (Pärnu, Estonia, 2006)

RSU 6th Scientific Conference (Riga, Latvia, 2007)

The 2nd Baltic Scientific Conference in Dentistry (Riga, Latvia, 2007)

RSU 7th Scientific Conference (Riga, Latvia, 2008)

RSU 9th Scientific Conference (Riga, Latvia, 2010)

7th Congress of Baltic Association for Maxillofacial and Plastic Surgery (Riga, Latvia, 2010)