

Evaluation of Active Tactile Perception of Single Tooth Implant Prosthesis

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ABSTRACT

Purpose: The phenomenon of developing a certain tactile sensibility through osseointegrated dental implants is called osseoperception. Active tactile sensibility can be tested by having the subject bite on test bodies. The aim of the study was to assess the active tactile sensibility of osseointegrated single tooth dental implants according to psychophysical method of constant stimuli.

Materials and methods: Twenty subjects (10 male and 10 female) with single tooth implants located in the posterior region with natural, healthy antagonistic teeth were included in the study. Ten implants were located in the maxilla and 10 in the mandible. The subjects were also divided into two age groups 30 to 40 years and 40 to 50 years, and the active tactile perception was studied according to the psychophysical method of constant stimuli.

Results: The active tactile perception of osseointegrated single tooth dental implants with natural healthy antagonist revealed a threshold ranging between $24 \pm 8 \mu$. The active tactile perception of healthy natural tooth with natural healthy antagonist revealed a threshold ranging between $12 \pm 4 \mu$. No statistically significant results were found between different age groups (30-40 years age group and 40-50 years age group). The threshold for tactile perception was found to be similar in both male and female subjects. No statistical significance was found in the threshold between different implant locations (maxilla and mandible).

Conclusion: Active tactile sensibility of implants with natural antagonistic teeth is similar to that of teeth. Implant-supported prosthesis restores jaw function more appropriately, with improved psychophysiological discriminatory ability.

Keywords: Active tactile perception, Osseoperception, Dental implants, Proprioception.

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INTRODUCTION

Between 1950 and 1960, Brånemark established that bone is a dynamic living tissue. The importance of nerve fibers accompanying the bone vessels was recognized only 10 years later.

The capability of osseointegrated titanium implants to transmit a certain sensibility was termed osseoperception by Brånemark. Tactile sensibility can be passive or active. Passive tactile discrimination is measured in Newtons on application of passively applied pressure. Active tactile sensibility can be expressed in microns by having the subject actively bite on test bodies. The study of passive tactile sensibility only allows the testing of individual neural receptors whereas active tactile sensibility more effectively represents normal function and is therefore more relevant for practical dentistry.

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 The reason sensibility can be restored by using dental implants is assumed to be the activation of receptors in the bone, the periosteum, the joint capsule, or other tissues.² 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.^{2,3} The sensory mechanism in osseoperception is qualitatively different from that of natural teeth.⁴ It is not clear how the neurophysiological mechanisms that modulate jaw movement are associated with the sensory structures around the osseointegrated dental implants. Based on the nerve stimulation or neural inputs, which change the jaw movement patterns, there are various theories suggested by different authors. These theories are beneficial to understand the implant-related osseoperception (Table 1).²

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.^{2,5} 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.

Table 1: Theories of osseoperception	
Steenberg's	Suggests that periosteum may be the source of proprioceptive response
Yamashiro's	Postulates that occlusal load results in strain of bone that is interpreted by proprioceptive response
Klineberg's	Suggests that joint receptors substitute for periodontal ligament of natural teeth
Weiner's	Suggests that bone in the regions adjacent to implant contains nerve fibers
Linden and Scott's	PD receptors remain within the bone after extraction
Bonte's	Suggests reinnervation in association with controlled forces directed to implants

Aim

To assess the active tactile sensibility of osseointegrated single tooth dental implants according to psychophysical method of constant stimuli.

MATERIALS AND METHODS

Experimental Design

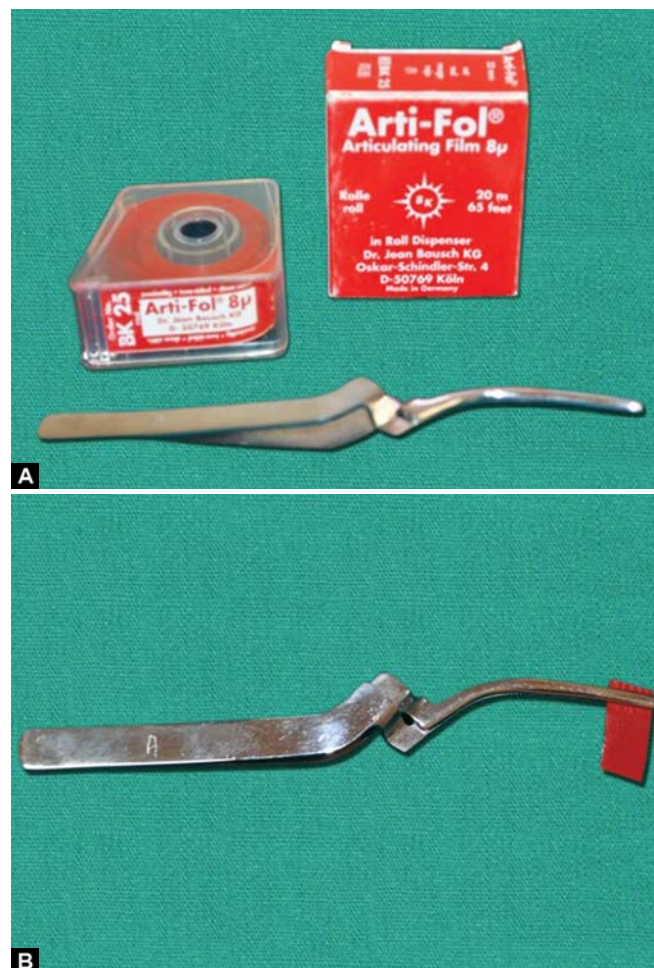
The active tactile perception of single tooth implants was to be investigated by the psychophysical method of constant stimuli in a single-blinded study and statistically evaluated by Chi-square test.

Subject Population

Twenty subjects (10 males and 10 females) aged between 30 and 50 years with single-tooth implants located in the posterior region (10 located in maxilla and 10 in mandible) with natural, healthy antagonistic teeth were included in the study. The subjects were also divided into two age groups 30 to 40 years and 40 to 50 years. The implants had been restored with metal ceramic restorations, i.e. fully ceramic veneered single crowns with a cast metal framework. The implant prosthesis in all subjects were prosthetically restored with implant-protected occlusion. The patients were informed in detail about the study procedure and signed an informed consent.

Clinical Procedure and Randomization

Shim stock articulating foil (Bausch Arti-Fol®) of 8 to 56 μ thickness (Fig. 1A) was placed interocclusally using Miller articulating paper holder. Figure 1B between the single-tooth implant and the natural opposing tooth. Figure 2 is of the test subject who were asked to bite briefly on them and indicate whether or not they felt the foreign bodies. Subjects were instructed to lift their right hand for positive response.



Figs 1A and B: (A) Bausch Arti-Fol® 8 μ and (B) Miller articulating paper holder



Fig. 2: Implant vs tooth

The foils were placed in random order of thickness. The procedure was repeated on contralateral natural healthy teeth with the opposing antagonist (Fig. 3). The mean tactile sensibility was based on relative frequency of positive answers. The tactile sensibility of both the groups were statistically analyzed and results were obtained.



Fig. 3: Tooth vs tooth

STATISTICAL ANALYSIS

Female Group

Table 2 Illustrates tactile perception in the female group.

Implant vs Tooth Group

- None of the subjects gave a positive response for sensitivity at 8 μ
- At 16 μ group 40% of the subjects gave positive response
- At 24 μ group 80% of the subjects gave a positive response
- Whereas at 32 μ , 48 μ and 56 μ , positive response was given by all the subjects.

Tooth vs Tooth Group

- 30% of the subjects gave positive response at 8 μ
- At 16 μ , 24 μ , 32 μ , 48 μ and 56 μ all the subjects gave a positive response.

Male Group

Table 3 illustrates tactile perception in the male group.

Implant vs Tooth Group

- 10% of the subjects gave a positive response for sensitivity at 8 μ
- At 16 μ group 30% of the subjects gave positive response and was statistically insignificant
- At 24 μ group 80% of the subjects gave a positive response
- At 32 μ , 48 μ and 56 μ group, positive response was given by all the subjects.

Tooth vs Tooth Group

- 30% of the subjects gave positive response at 8 μ .
- At 16 μ , 24 μ , 32 μ , 48 μ and 56 μ all the subjects gave a positive response.

Female vs Male

When the results for active tactile sensitivity between the male and female groups were compared, the data revealed no statistically significant difference between the two groups.

Maxilla Group

Table 4 illustrates tactile perception in the maxilla group.

Implant vs Tooth Group

- 10% of the subjects gave a positive response for sensitivity at 8 μ

Table 2: Tactile perception in the female group

	Sensitivity at 8 μ	Sensitivity at 16 μ	Sensitivity at 24 μ	Sensitivity at 32 μ	Sensitivity at 48 μ	Sensitivity at 56 μ
Implant vs tooth	0 (0%)	4 (40%)	8 (80%)	10 (100%)	10 (100%)	10 (100%)
Tooth vs tooth	3 (30%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)
Significance levels	0.06	0.025	0.136	NA	NA	NA

Table 3: Tactile perception in the male group

	Sensitivity at 8 μ	Sensitivity at 16 μ	Sensitivity at 24 μ	Sensitivity at 32 μ	Sensitivity at 48 μ	Sensitivity at 56 μ
Implant vs tooth	1 (10%)	3 (30%)	8 (80%)	10 (100%)	10 (100%)	10 (100%)
Tooth vs tooth	3 (30%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)
Significance levels	0.264	0.001	0.136	NA	NA	NA

Table 4: Tactile perception in the maxilla group

	Sensitivity at 8 μ	Sensitivity at 16 μ	Sensitivity at 24 μ	Sensitivity at 32 μ	Sensitivity at 48 μ	Sensitivity at 56 μ
Implant vs tooth	1 (10%)	4 (40%)	8 (80%)	10 (100%)	10 (100%)	10 (100%)
Tooth vs tooth	3 (30%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)
Significance levels	0.264	0.003	0.136	NA	NA	NA

- At 16 μ group 40% of the subjects gave positive response
- At 24 μ group 80% of the subjects gave a positive response
- Whereas at 32 μ, 48 μ and 56 μ, positive response was given by all the subjects.

Tooth vs Tooth Group

- 30% of the subjects gave positive response at 8 μ
- At 16 μ, 24 μ, 32 μ, 48 μ and 56 μ all the subjects gave a positive response.

Mandible Group

Table 5 illustrates tactile perception in the mandible group.

Implant vs Tooth group

- None of the subjects gave a positive response for sensitivity at 8 μ
- At 16 μ group 50% of the subjects gave positive response
- At 24 μ group 80% of the subjects gave a positive response
- Whereas at 32 μ, 48 μ and 56 μ, positive response was given by all the subjects.

Tooth vs Tooth Group

- 30% of the subjects gave positive response at 8 μ
- At 16 μ, 24 μ, 32 μ, 48 μ and 56 μ all the subjects gave a positive response.

Maxilla vs Mandible

When the results for active tactile sensitivity between the maxilla and mandible groups were compared, the data revealed no statistically significant difference between the two groups.

30 to 40 Years Group

Table 6 illustrates tactile perception in the 30 to 40 years group.

Implant vs Tooth Group

- None of the subjects gave a positive response for sensitivity at 8 μ
- At 16 μ group 40% of the subjects gave positive response
- At 24 μ group 90% of the subjects gave a positive response
- Whereas at 32 μ, 48 μ and 56 μ, positive response was given by all the subjects.

Tooth vs Tooth Group

- 30% of the subjects gave positive response at 8 μ
- At 16 μ, 24 μ, 32 μ, 48 μ and 56 μ all the subjects gave a positive response.

40 to 50 Years Group

Table 7 illustrates tactile perception in the 40 to 50 years group.

Table 5: Tactile perception in the mandible group

	Sensitivity at 8 μ	Sensitivity at 16 μ	Sensitivity at 24 μ	Sensitivity at 32 μ	Sensitivity at 48 μ	Sensitivity at 56 μ
Implant vs tooth	0 (0%)	5 (50%)	8 (80%)	10 (100%)	10 (100%)	10 (100%)
Tooth vs tooth	3 (30%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)
Significance levels	0.06	0.01	0.136	NA	NA	NA

Table 6: Tactile perception in the 30 to 40 years group

	Sensitivity at 8 μ	Sensitivity at 16 μ	Sensitivity at 24 μ	Sensitivity at 32 μ	Sensitivity at 48 μ	Sensitivity at 56 μ
Implant vs tooth	0 (0%)	4 (40%)	9 (90%)	10 (100%)	10 (100%)	10 (100%)
Tooth vs tooth	3 (30%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)
Significance levels	0.062	0.003	0.138	NA	NA	NA

Table 7: Tactile perception in the 40 to 50 years group

	Sensitivity at 8 μ	Sensitivity at 16 μ	Sensitivity at 24 μ	Sensitivity at 32 μ	Sensitivity at 48 μ	Sensitivity at 56 μ
Implant vs tooth	1 (10%)	5 (50%)	7 (80%)	10 (100%)	10 (100%)	10 (100%)
Tooth vs tooth	3 (30%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)
Significance levels	0.264	0.01	0.132	NA	NA	NA

Implant vs Tooth Group

- None of the subjects gave a positive response for sensitivity at 8 μ
- At 16 μ group 40% of the subjects gave positive response
- At 24 μ group 80% of the subjects gave a positive response
- Whereas at 32 μ , 48 μ and 56 μ , positive response was given by all the subjects.

Tooth vs Tooth Group

- 30% of the subjects gave positive response at 8 μ
- At 16 μ , 24 μ , 32 μ , 48 μ and 56 μ all the subjects gave a positive response.

30 to 40 Years vs 40 to 50 Years Group

When the results for active tactile sensitivity between the 30 to 40 and 40 to 50 age groups were compared, the data revealed no statistically significant difference between the two groups.

RESULTS

The active tactile perception of osseointegrated single tooth dental implants with natural healthy antagonists revealed a threshold ranging between $24 \pm 8 \mu$.

The active tactile perception of healthy natural tooth with natural healthy antagonists revealed a threshold ranging between $12 \pm 4 \mu$.

The mean threshold values for implants were two times higher than for teeth.

No statistically significant results were found between different age groups (30-40 age group and 40-50 age group).

The threshold for tactile perception was found to be similar in both male and female subjects.

No statistical significance was found in the threshold between different implant locations (maxilla and mandible).

DISCUSSION

It is important to ascertain the tactile perception of osseointegrated implants as it restores sensitivity to mechanical stimulation, thereby enhancing patient function and preventing implant overloading. It is known that in older individuals the tactile perception of natural teeth does depend on age.⁶ Therefore patient-related factors, such as age and gender were considered in this study to evaluate their effect on tactile sensibility of implants. However, the results for these variables was similar to previously published studies.⁷ The test strips used were precision shim stock foil that adapt to the occlusal surface, ensuring the intended interocclusal clearance during testing.

In animal studies, it was shown that implant materials are surrounded by nerve fibers in the area of the bone-implant interface⁸ and that there is a negative correlation between bone contact rate and nerve density.⁹ This led to the hypothesis that nerves originate from the residues of the periodontal tissue of extracted teeth¹⁰⁻¹² and that therefore the tactile perception of the implant would be lower the longer the natural tooth has been absent and that different implant surfaces, because of differing bone apposition rates, might cause different degrees of tactile perception.⁹ Hence, only those with duration of edentulism of implant site of 3 months were included in the present study.

Conventional loading protocol was followed for all the implants for standardization of the prosthetic loading. Implant surface, implant geometry (i.e. length and diameter) may be of importance to osseoperception. In the present study, implant length and diameter were within a narrow range and all the implants were nonsurface coated machined implants (Neo-Biotech). The influence of antagonistic natural teeth of the tested implants via their periodontal receptors can affect tactile perception. But the influence was similar to all subjects.

A study setup with decreasing/increasing foil thickness described in the literature, led to learning effect and gave better results for thinner foils.¹³ In the present study these effects were compensated by randomizing the foil thickness. Because the material used for prosthesis is of importance therefore only metal ceramic crowns were included in this study. The mean value of threshold of 24 μ m for active tactile perception was found for implants versus natural tooth when compared to 12 μ m found with natural tooth vs natural tooth. This indicated that the uncertainty of feeling foreign bodies is more pronounced for implants than it is for natural teeth. Age and gender did not have any effect on tactile perception. In the present study, implants in the maxilla and were found to have similar tactile perception.

CONCLUSIONS AND CLINICAL IMPLICATIONS

Osseoperception is often disregarded, but its importance is crucial. Within the limitations of this study it can be concluded that accurately designed osseointegrated implant-retained prosthesis, closely resembles a dentate situation. Osseoperception should be considered among the main advantages of implant prostheses, in comparison with mucosa-supported prostheses.

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