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Active tactile sensibility with implant-supported prostheses versus natural teeth: A comparative study

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Abstract:
Loss of periodontal mechanoreceptors after tooth loss reduces tactile discrimination, although implant-supported prostheses may regain sensory function through osseoperception. Therefore, it is of interest to evaluate the active tactile sensibility using 8-200 µm articulating foils and papers in tooth-implant and implant-implant contacts compared with contralateral tooth-tooth controls at baseline, 3 months and 6 months. At baseline, test contacts showed lower detection at the thinnest foils, with significant differences at several thresholds, whereas detection progressively improved after functional loading. By 6 months, tooth-implant contacts were comparable with natural dentition across the tested thicknesses, while the available implant-implant data showed improvement through 3 months; a separate 6-month Group 2 source table was unavailable. Thus, active tactile sensibility improved over time in the available observations, while age and sex showed no significant effect in this sample.

Keywords: Active tactile sensibility, osseoperception, dental implants, implant-supported prosthesis

Background:
Implant-supported prostheses aim to restore function, comfort, speech and aesthetics in patients with partial or complete tooth loss **[1-3]**. Osseointegration provides direct structural contact between bone and the implant surface, but dental implants lack the periodontal ligament mechanoreceptors that contribute to the fine tactile discrimination of natural teeth **[4-6]**. Sensory feedback after implant rehabilitation may arise through osseoperception, involving mechanoreceptors in periosteum, temporomandibular tissues, masticatory muscles, oral mucosa and the remaining dentition **[7-10]**. Therefore, it is of interest to compare the active tactile sensibility in tooth-implant and implant-implant contacts with natural tooth-to-tooth contacts over time.

Materials and Methods:
This prospective split-mouth clinical study was conducted in the Department of Prosthodontics, Faculty of Dental Sciences, Banaras Hindu University, Varanasi, India. Twenty participants meeting the inclusion and exclusion criteria were enrolled. Fifteen participants contributed tooth-implant experimental contacts with contralateral tooth-to-tooth controls (Group 1) and five participants contributed implant-implant experimental contacts with tooth-to-tooth controls (Group 2). Participants were 20-40 years of age, were informed about the study procedures, provided written informed consent and were enrolled after institutional ethical clearance.

Patient selection criteria:
Inclusion criteria:
[1] Patients aged 20-40 years.
[2] Patients with a missing molar, with or without opposing natural dentition.
[3] Good oral hygiene and healthy periodontal status of the remaining dentition.
[4] Intact hearing without the use or requirement of a hearing aid.

Exclusion criteria:
[1] History of chronic systemic illness.
[2] History of a bone disorder or current medication affecting bone metabolism.
[3] History of temporomandibular disorders.
[4] History of parafunctional habits such as bruxism, tongue thrusting, or clenching.

The armamentarium for active tactile sensibility testing included Arti-Fol metallic articulating films and Arti-Chek articulating papers (Bausch; Katara Dental Private Limited, Pune, Maharashtra) with nominal thicknesses of 8, 12, 16, 40, 100 and 200 µm (**Figure 1**).

Methodology:
Individual sessions were conducted in a quiet room with the participant seated comfortably in a slightly reclined dental chair. The procedure was explained in simple language and participants were asked to keep their eyes closed throughout testing.

Procedure:
Articulating foils/papers of 8, 12, 16, 40, 100 and 200 µm were held with an articulating-paper holder between the selected occlusal contacts. Each thickness was tested 20 times in a randomized sequence of true and sham insertions. After maximum intercuspation, the participant indicated whether the material was perceived. Testing proceeded from thinner to thicker material. In Group 1, the test contact was tooth-implant and the contralateral control was tooth-tooth (**Figure 2**); in Group 2, the test contact was implant-implant and the control was tooth-tooth (**Figure 3**). Active tactile sensibility was recorded at the scheduled assessments.

Results:
In Group 1, 15 participants (7 men and 8 women) contributed tooth-implant test contacts and contralateral tooth-to-tooth control contacts; mean age was 29.40±6.21 years. At baseline, detection differed most at the thinnest test materials. At 8 µm, 13.3% of tooth-implant contacts detected the foil compared with 66.7% of tooth-to-tooth controls (χ^2=8.8, p=0.003). At 12 µm, detection was 33.3% and 100%, respectively (χ^2=11.625, p=0.001). Differences became smaller as material thickness increased

(**Table 1**). At 3 months, detection by tooth-implant contacts improved and between-group differences were reduced (**Table 2**). By 6 months, tactile performance of tooth-implant contacts approached the tooth-to-tooth controls across the tested thicknesses, with no statistically significant difference at the reported thresholds (**Table 3**). Active tactile sensibility increased progressively from baseline to the 3- and 6-month follow-up assessments. In Group 2, five participants (3 men and 2 women; mean age 34.40±5.50 years) contributed implant-implant test contacts and tooth-to-tooth controls. Baseline detection was lower for implant-implant contacts at the thinner foils, with statistically significant differences reported at 8 and 12 µm (**Table 4**). Detection improved at 3 months (**Table 5**). Because a separate 6-month Group 2 source table was unavailable, no 6-month implant-implant comparison was inferred beyond the available baseline and 3-month data. Detection was lower for tooth–implant contacts than for natural tooth–tooth contacts at 8 µm (2/15, 13.3% versus 10/15, 66.7%), 12 µm (5/15, 33.3% versus 15/15, 100%) and 16 µm (9/15, 60.0% versus 15/15, 100%). Differences decreased at 40 µm (86.7% versus 100%) and 100 µm (93.3% versus 100%), and both contacts detected 200 µm. The reported p values are reproduced in the table; their appropriateness for paired split-mouth observations should be checked against original paired responses. **Table 2** (3 months, tooth–implant): Detection improved to 46.7%, 73.3% and 93.3% for test contacts at 8, 12 and 16 µm, respectively. The corresponding natural-tooth responses were 66.7%, 100% and 100%. Both contacts reached 100% from 40 µm upward; reported between-contact differences were not statistically significant. **Table 3** (6 months, tooth–implant): At 8 µm, both tooth–implant and natural-tooth contacts detected the foil in 10 of 15 observations (66.7%). At 12 µm, detection was 14/15 (93.3%) for tooth–implant and 15/15 (100%) for controls. All contacts detected 16–200 µm, indicating convergence of discrimination within the range assessed. **Table 4** (baseline, implant–implant): None of the five implant–implant test contacts detected an 8 µm foil, compared with three of five controls (60%). At 12 µm, detection was 40% versus 80%; at 16 µm, 80% versus 100%; and both reached 100% for foils of at least 40 µm. These estimates are particularly imprecise owing to the very small sample. **Table 5** (3 months, implant–implant): Detection increased to 60% versus 80% at 8 µm and 80% versus 100% at 12 µm. Both sides detected the 16–200 µm test materials, and the reported comparisons were nonsignificant. Group 2 detection percentages for implant–implant test contacts and contralateral natural tooth–tooth controls are displayed graphically at baseline in **Figure 4** and at 3 months in **Figure 5**. Both figures show detection across the six articulating-foil thicknesses (8–200 µm), corresponding to **Tables 4 and 5**, respectively.

Table 1: Comparison of active tactile sensibility between tooth-implant test contacts and tooth-to-tooth controls at baseline (0 months)

Thickness	Test group Tooth/implant	Control group Tooth/tooth	Chi-Square Tests π 2	P value
8 µ	2 (13.3%)	10 (66.7%)	8.8	.003
12µ	5 (33.3%)	15 (100%)	11.625	.001
16µ	9 (60%)	15 (100%)	7.5	.006
40µ	13(86.7%)	15(100%)	2.143	.143
100µ	14 (93.3%)	15 (100%)	1.034	.309
200µ	15 (100%)	15(100%)	A	-

Table 2: Comparison of active tactile sensibility between tooth-implant test contacts and tooth-to-tooth controls at 3 months

Thickness	Test group Tooth/implant	Control group Tooth/tooth	Chi-Square Testsπ 2	P value
8 µ	7 (46.7%)	10 (66.7%)	1.22	.269
12µ	11 (73.3%)	15 (100%)	2.160	.142
16µ	14 (93.3%)	15 (100%)	1.034	.309
40µ	15 (100%)	15 (100%)	a	-
100µ	15 (100%)	15 (100%)	a	-
200µ	15 (100%)	15 (100%)	a	-
Total	15	15		

Table 3: Comparison of active tactile sensibility between tooth-implant test contacts and tooth-to-tooth controls at 6 months

	Test groupTooth/implant	Control groupTooth/tooth	Chi-SquareTests π	P value
8 µ	10 (66.7%)	10 (66.7%)	.00	1.00
12µ	14(93.3%)	15 (100%)	1.034	.309
16µ	15 (100%)	15 (100%)	a	-
40µ	15 (100%)	15 (100%)	a	-
100µ	15 (100%)	15 (100%)	a	-
200µ	15(100%)	15(100%)	a	
Total	15	15		

Table 4: Comparison between implant-implant test contacts and tooth-to-tooth controls at baseline (0 months)

Thickness	Test groupimplant/implant	Control groupTooth/tooth	Chi-SquareTests π	P value
8 µ	0 (0%)	3 (60%)	4.286	.038
12µ	2 (40%)	4 (80%)	6.13	.024
16µ	4 (80%)	5 (100%)	1.11	.292
40µ	5 (100%)	5 (100%)	a	-
100µ	5 (100%)	5 (100%)	a	-
200µ	5 (100%)	5 (100%)	a	-
Total	5	5		

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The source dataset did not contain a separate 6-month Group 2 comparison table; therefore, the implant-implant analysis in this manuscript is restricted to the available baseline and 3-*month data.*

Table 5: Comparison of active tactile sensibility between implant-implant test contacts and tooth-to-tooth controls at 3 months

Thickness	Test group implant/implant	Control groupTooth/tooth	Chi-SquareTests π	P value
8 µ	3 (60%)	4 (80%)	.476	.490
12µ	4 (80%)	5 (100%)	1.11	.292
16µ	5 (100%)	5 (100%)	a	-
40µ	5 (100%)	5 (100%)	a	-
100µ	5 (100%)	5 (100%)	a	-
200µ	5 (100%)	5 (100%)	a	-
Total	5	5		

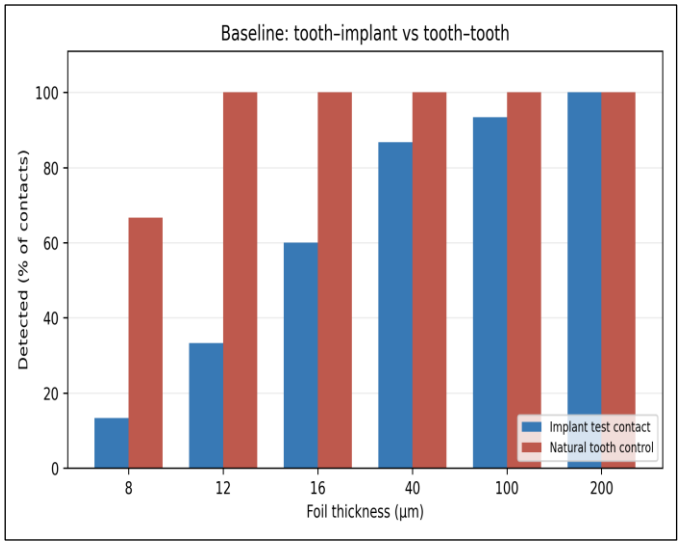


Figure 1: Percentage of detected articulating foils by thickness for baseline: tooth–implant vs tooth–tooth (test and contralateral control contacts)

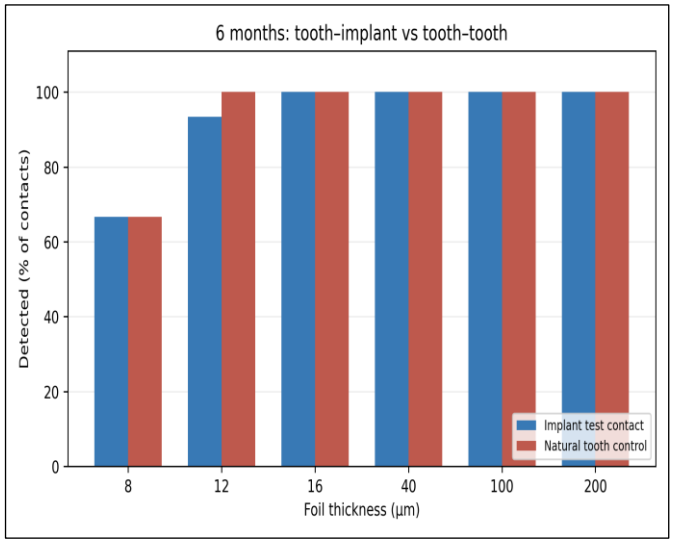


Figure 3: Percentage of detected articulating foils by thickness for 6 months: tooth–implant vs tooth–tooth (test and contralateral control contacts)

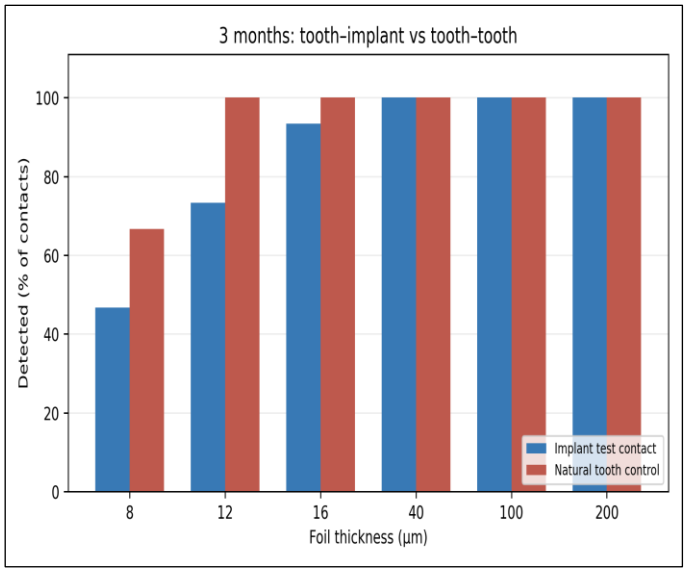


Figure 2: Percentage of detected articulating foils by thickness for 3 months: tooth–implant vs tooth–tooth (test and contralateral control contacts)

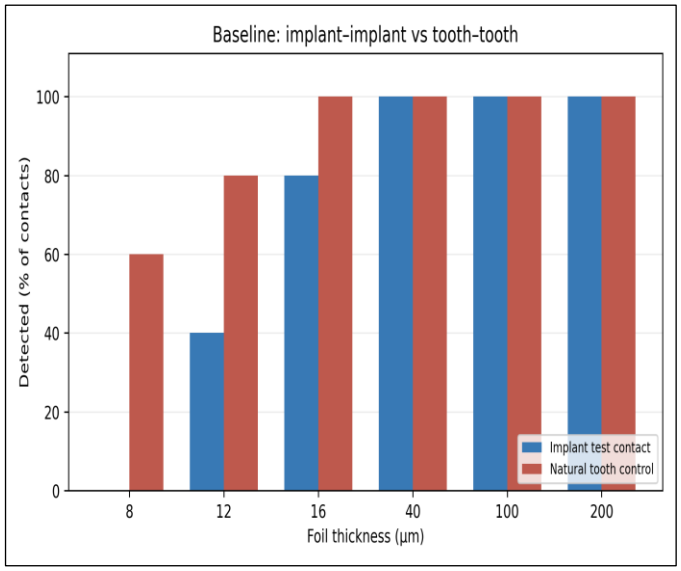


Figure 4: Baseline active tactile detection (%) across six articulating-foil thicknesses (8, 12, 16, 40, 100 and 200 µm) in Group 2 (n=5): implant–implant test contacts versus contralateral natural tooth–tooth control contacts

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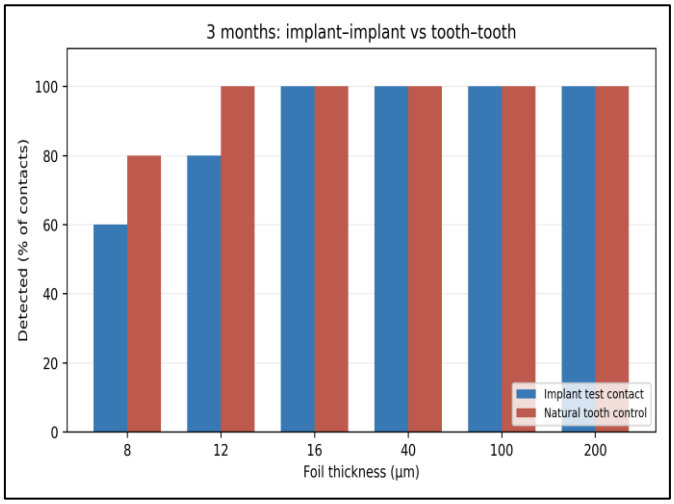


Figure 5: Active tactile detection (%) at 3 months across six articulating-foil thicknesses (8, 12, 16, 40, 100 and 200 µm) in Group 2 (n=5): implant–implant test contacts versus contralateral natural tooth–tooth control contacts

Discussion:

An implant-supported fixed prosthesis represents a favorable treatment option to reestablish the ability of tactile perception, known as osseoperception and thus improve the quality of life for the prosthesis wearer. Osseoperception is defined as a mechano-reception in absence of functional periodontal mechanoreceptors and it can be obtained from surrounding receptors of TMJ, periosteum and alveolar bone, periodontium of the remaining dentition and functional integration of implants in the body and also sprouting of new fibers and free nerve endings close to the bone-to–implants interface, with partial regeneration of periodontal ligament on the implant surface **[11].** It is also assumed that fast elastic deformation of a bone during loading over implants may activate the periosteal mechanoreceptors in the fascia, periosteum and periodontal ligaments. However, more studies are required to be conducted to locate the specific group of tactile receptors that transmit information to the central nervous system in subjects with the implant-supported prosthesis **[12].** Neurophysiological mechanisms that modulate jaw movement associated with implants are still not clear **[13].** Psychophysical methods allow connecting the psychological response of the patient to the physiological functions of the receptors involved. When they are performed meticulously and under standardized conditions, these studies may reveal nearly as precise information as neurophysiological setups. Psychophysical studies are further divided into active or passive tactile sensibility. The difference between the two can be explained by the fact that active perception, various groups of fibers are activated which can be present in bone TMJ or periosteum whereas in passive active sensibility is due to the presence of pdl fibers of that of the previous tooth **[14].** The results of this study showed that after a certain period time the sensibility of implant supported prosthesis was comparable to the of natural dentition. It was similar to study of Jacobs and van Steenberghe **[15]** who stated that proper peripheral feedback pathway can be restored when using dental implants. Another possibility is it can be sensed by proximal teeth receiving vibrations from implants during occlusion and bone deformation. Forces from the implant can cause the movement of the interstitial fluid if the cancellous bone of mandible and can activate the receptors in the adjacent bone **[16].** However, it must be taken into consideration that the implants have 8-10 folds higher threshold value than the natural tooth **[17].** In an experimental model, osseointegrated implants led to a reflex mechanism of the trigeminal nerve which depended upon the remaining natural dentition. From this, they drew a conclusion that inhibition reflexes of the masticatory muscles might originate in an activation of the periodontal receptor of adjacent teeth **[18-20].** An explanation for good integration of implants in respect to tactile perception is yet to be found. A 2026 systematic review similarly reported that implant-supported prostheses develop measurable active tactile sensibility over time, although sensory thresholds generally remain higher than those of natural teeth **[21].** Related psychophysical studies by Negahdari *et al.*, González-Gil *et al.* and González-Gil *et al.* describe better tactile discrimination with implant-supported rehabilitation than complete dentures, while generally finding natural dentition more sensitive; different material thicknesses and contact configurations limit direct numerical comparison **[22-24]**.

Conclusion:

Active tactile sensibility in tooth-implant contacts increased with time after functional loading and approached natural-tooth performance by 6 months, while the available implant-implant data showed improvement through 3 months. Age and sex were not significantly associated with the measured tactile response. Larger longitudinal studies should evaluate implant position, bone-implant contact, foil temperature, loading protocol and complete longer-term implant-implant follow-up.

Limitation of the study:

This study could not distinguish active tactile perception between anterior and posterior teeth. The hypothesis that differences in the bone and implant contact surface resulting from an altered implant geometry or surface structure could have an influence on the tactile sensibility which could not be confirmed. Furthermore, foil temperature that might affect tactile sensitivity by influencing pulp receptors was not controlled in this study. Moreover, a smaller sample size was also a limiting factor.

Conflict of interest: None

Financial support: None

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