Active Tactile Sensibility of Single-Tooth Implants versus Natural Dentition: A Split-Mouth Double-Blind Randomized Clinical Trial

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ABSTRACT

Background: Unlike *passive* sensitivity of implants/teeth that is assessed more, only three controversial studies have compared *active* tactile sensibility (ATS) of implants and teeth.

Purpose: We aimed to explore the difference between the ATS of teeth and single-tooth implants.

Methods: The ATS of single-tooth implants and contralateral teeth was measured in 25 patients after they bit on gold and placebo foils 0- to 70-µm thick, each for five times, in a random order blinded to patients and assessor, carried out at two sessions. Based on the experimental range of 0 µm (mock trials) to 70 µm, the sigmoid shape of psychometric curve was estimated to locate the 50% values as the ATS thresholds for each tooth or implant. ATS Data were analyzed using paired and unpaired *t*-tests and multiple linear regression ($\alpha = 0.05$, $\beta \leq 0.1$). Also, equivalence testing approach was used to assess semi-objectively the *clinical* significance.

Results: Average ATS values for teeth and implants were 21.4 ± 6.55 µm and 30.0 ± 7.55 µm, respectively ($p = .0001$ [paired *t*-test]). None of the geometric characteristics of implants nor duration of implant in function were correlated with the ATS ($p > .4$ [regression]). Age was positively associated with the ATS of both implants and teeth ($p \leq .019$ [regression]). Tooth ATS (but not implant ATS) was significantly higher in males compared with females ($p = .050$ [unpaired *t*-test]), which contributed to a generalizable tooth-implant difference higher than 8-µm clinical equivalence margin in females. The ATS was not significantly different between arches or between anterior/posterior regions ($p > .6$).

Conclusion: There was a slight but statistically significant difference between implant and tooth tactile sensitivities.

KEY WORDS: active tactile sensibility, dental implants, interdental perception, osseoperception, psychometric function, surface properties

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Source of Funding: The study was self-funded by the authors and their institution.
Conflict of interest: The authors declare no conflict of interest.

DOI 10.1111/cid.12053

INTRODUCTION

Proprioceptive feedback plays an important role in tuning fine motor control and modulating complex mandibular movements, sensory discriminative capabilities, and masticatory protective reflex.[1,2] In dentate individuals, this sensory input might be provided by the following two groups of mechanoreceptors. Remote fibers (which originate in the temporomandibular joint, oral mucosa, masticatory muscles, periosteum, and even dental pulp) correspond only to discriminating larger particles; whereas, proprioceptors in periodontal ligament (PDL) can respond to finer stimuli, contributing to specification of the direction, magnitude, and the point of attack of the occlusal forces.[1–5]

Removal of proprioceptor fibers in the PDL after tooth extraction[1,6] might undermine this precise control.[1,2] Therefore, it is the main reason for lack of proper tactile sensitivity in denture wearers.[5,6] Nevertheless, despite lacking the PDL, ankylosed implants have shown much better tactile sensitivity compared with soft tissue-based dentures, implying partial substitution of sensory feedback in the presence of implants.[2,7,8] This phenomenon, namely osseoperception, denotes a major step toward functional and physiologic integration of implants into the body and is of great interest to the scientific community.[1,2,8–10] Although the underlying mechanism is not clearly known, it is suggested that osseoperception might stem from mechanoreceptors in the remote nerve endings, periradicular tissues of the antagonist teeth,[9–11] cortical synaptic remodeling in the brain,[1,2,12] or probable innervation of peri-implant tissues, called neurointegration.[1,7–10,13]

Such implant-mediated rehabilitation of the sensory-motor interaction may help to achieve a more natural oral function and could yield important clinical implications.[1] A highly tactile-sensible implant can recover the appropriate sensory-motor control and hence can improve mastication efficiency, inhibitory reflex response in the masticatory muscles preventing traumatic occlusion, as well as sensory discriminative potentials and thus decreasing the risk of overloading the remaining teeth and implants.[2,7,9] Therefore, assessment of the efficacy of implant in discerning fine tactile stimuli is of significant value.

Tactile perception can be measured through two types of experiments, either as the minimum detectable force applied to the tooth/implant (passive tactile sensibility [PTS] measured in Newton units), or expressed in micrometer when the participant actively bites on interocclusal foreign bodies and determines whether it was perceived (active tactile sensibility [ATS]).[9–11] The PTS only evaluates individual neural receptors, whereas the ATS is more relevant to practical dentistry because it resembles normal function more effectively.[9–11] While the PTS of implants has been widely assessed, only few studies exist with regard to implant ATS, with quite controversial results,[9–11] ranging from 10 to 100 μm depending on the test segment and measurement methods (i.e., minimum, 50%, and 80% values in the psychometric curve of patient response).[7–11,14] There is also debate over tooth ATS, ranging from less than 10 to 110 μm.[4,7–11] Some authors have asserted that an implant does not significantly differ in tactile sensitivity from a natural tooth,[10,11] while some have opposed this, finding significant differences.[8]

The controversy might root in drawbacks or variations in sampling, experimental methods, or statistical approaches. Most of the previous studies have small samples.[9] In none of them, the foils were burnished/adjusted over the occlusal surface. Therefore, the foils did not follow the natural morphology of occlusal contact areas needed for biting in maximum intercuspation, possibly increasing the rate of false positive error. Many of them have not adopted a split-mouth design to control for the interindividual differences.[9] In addition, to the best of our knowledge, none of the previous studies on implant ATS have reported the exclusion of patients without proper interocclusal contacts, which is essential for normalizing the sample and reducing the confounders. Further, power calculations crucial for reducing false negative/positive error rates were performed for only two investigations[10,11] out of the only three implant-tooth ATS studies available in the literature.[8,10,11]

In view of the few and controversial implant-tooth ATS studies and some methodological flaws of the earlier reports, this study was carried out to assess whether implant ATS is different from tooth ATS. Also the risk factors associated with the ATS thresholds were explored.

MATERIALS AND METHODS

This split-mouth, double-blind, randomized clinical trial was performed on 50 specimens from 25 single-tooth implant patients enrolled during the years 2007 to 2009. The subjects were approved in accordance with the inclusion criteria comprising patients' willingness to participate, the presence of a proper occlusion of a single-tooth implant with a porcelain fused to metal crown and its antagonist tooth on one side and occlusion of the corresponding pair of antagonist natural teeth on the contralateral side, at least 6 months of successful implant function in a competent occlusion according to clinical and radiographic examinations, and the absence of any root canal treatments, coronal restorations, or any pathologic mobility of the natural teeth, any bone resorptions around the teeth, and any evidences of malocclusion, any premature or open interocclusal contacts, as well as any signs/symptoms of temporomandibular disorders. Of the implants used, 13 were ITI (Straumann GmbH, Freiburg, Germany) with titanium plasma sprayed surfaces, 8 were Replace Select (Nobel Biocare AB, Göteborg, Sweden) with

TiUnite™ titanium oxide (TiO_2) and phosphate- and crystalline-enriched surfaces, and 4 were Xive (Dentsply Friadent, Mannheim, Germany) with grit-blasted and high-temperature, acid-etched surfaces. The protocol ethics were approved by the internal review board of the university in accordance with the Declaration of Helsinki, and signed written consents were taken from the patients prior to the study.

Data Collection

Although the protocol was explained in detail to the patients, the study goal was not described to them in order to prevent biasing their responses. They were instructed to avoid eating or chewing 1 hour prior to the study.[15] The patients were seated in a semi-supine position on a dental unit in a quiet room with stable illumination.[1] They were asked to close their eyes during the experiments. The presence of proper and stable occlusal contacts on the involved teeth and prostheses were confirmed by examining with 15-μm thin articulation bands (Arti-Fol, Bausch KG, Cologne, Germany) in maximum intercuspation (for posterior teeth) and in edge-to-edge relation (for anterior teeth). Occlusal contact areas were initially marked with the articulating paper (Arti-Fol). For the experiments, industrially manufactured 24 karat gold foils were used (Mitotoyo, Japan), measuring 20 to 70 μm in thickness, 3 mm in width, and 3 mm in length, and were held by a needle holder. Before asking the patient to bite on the foil, the foil was molded on the marked occlusal surface of the mandibular tooth/prosthesis. Therefore, after each experiment, it was distorted and was disposed. Each foil thickness was tested five times, following a computer-generated random order unknown to the observer and the patient. The subjects were instructed to report the presence or absence of the foil after occluding. Both implant and control sides were examined (a pair of teeth or tooth/implant in each side).

In order to include the 0 μm foil thickness in the model, and exclude response bias/guessing strategy of the patient, there was a mock trial in each row, during the examination of each side (five trials per side at each session). The patients had been informed of this beforehand.[1] Subjects claiming to sense a placebo (null) foil on both sides would be excluded (no subjects met this exclusion criterion). Patient response to the placebo trials (0 μm thickness) were as well used in estimating the psychometric curve.

The experiments were repeated for each patient after at least 1 week.

Estimation of ATS by Drawing the Psychometric Curve

Based on the responses of each patient on each side to the range of 0 to 70 μm thicknesses, a sigmoid psychometric curve (fitted on the cumulative Weibull distribution) was computed for each side of every patient. Derived from the estimated function of the psychometric curve, the foil thickness at which the 50% value stood was located as the ATS threshold. The 50% values were recorded for each tooth and implant in each subject at each interval.

Statistical Analysis

Power calculation and reliability of the method. Based on a pilot study on 15 subjects, the sample size was predetermined as 25 implants and 25 teeth to obtain a test power > 0.90 ($d = 8$ μm, $SD = 8$ μm) at a 0.05 level of significance. The results pertaining to the pilot study were integrated into this research. Descriptive statistics were calculated for the ATS thresholds (the 50% values) across the sample at each session and for both sessions combined. There was an excellent intraobserver agreement between the values obtained at the two intervals (Cohen's Kappa > 0.9, $p = .0001$).

Hypothesis testing (conventional statistical significance). Tactile sensitivities (the 50% values) of the teeth were compared with the ATS of the implants using a paired-samples t-test. Associations between the ATS with the variables age, gender, geometric properties of the implants, arches, posterior/anterior regions, and duration of implant in function were also assessed using an unpaired t-test and a multiple linear regression analysis. The level of significance was set at 0.05.

Equivalence testing. In order to explore semi-objectively the clinical significance, 95% confidence intervals (CIs) were calculated for the tooth-implant ATS differences. The CIs were compared with an 8-μm thickness assumed as the margin of clinical equivalence, borrowed from the studies of Enkling and colleagues.[10,11] Only in case both CI bounds were simultaneously below or beyond this zone of –8 to 8 μm, it could be certainly inferred (at 95% CI level) that the tooth-implant difference varied from this margin and therefore might be clinically significant in the true population. Otherwise the result would be inconclusive in terms of practical significance.

RESULTS

More than 60 patients were evaluated to approve the included ones. None of the patients was excluded due to falsely reporting perception of mock trials in both sides. The mean age of the subjects was 30.1 ± 11.7 years (range 21–66 years). Of them, 15 (60%) were female with mean age of 28.7 ± 8.1 years. The mean age of males was 32.2 ± 12.7 years. No statistically significant difference was found between the mean ages of the two genders ($p = .4$ [t-test]).

The occlusion of 20 patients (82%) was Angle's Class I and that of 5 was Class II. The occlusion pattern was canine rise in 12 participants (48%), while it was group function in the remainder. Of the fixtures, 12 (48%), 13 (52%), 16 (65%), and 9 (35%) were respectively placed in the anterior segment, posterior segment, maxilla, and mandible. Of them, nine (36%) had been placed between 6 and 12 months prior to the study and the rest (16) were in function for more than a year. The mean diameter and length of the implants were 4.05 ± 0.35 mm and 12.72 ± 1.7 mm, respectively.

Implant versus Tooth

The ATS of the teeth and implants differed significantly in all groups and subgroups (Table 1).

According to the equivalence testing approach, the 95% CIs indicated that the difference was inconclusive

TABLE 1 Active Tactile Sensibility Thresholds for the Implants and Teeth

Group	Subgroup		Mean (μm)	SD	CV (%)	p*	95% CI (μm)	
Interval	1st	Implant	30.6	9.15	29.9		26.82	34.38
		Tooth	21.0	7.05	33.6		18.09	23.91
		Difference	9.60	8.40	87.5	.0001	6.13	13.07
	2nd	Implant	30.6	7.70	25.2		27.42	33.78
		Tooth	21.8	8.00	36.7		18.50	25.10
		Difference	8.80	8.80	100	.0001	5.17	12.43
	Both	Implant	30.6	7.55	24.7		27.48	33.71
		Tooth	21.4	6.55	30.6		18.70	24.10
		Difference	9.20	7.00	76.1	.0001	6.31	12.09
Arch†	Maxilla ($n = 16$)	Implant	30.14	6.44	21.4		27.48	32.79
		Tooth	20.78	6.8	32.7		17.97	23.58
		Difference	9.36	7.36	78.6	.0002	6.32	12.40
	Mandible ($n = 9$)	Implant	31.07	9.15	29.5		27.29	34.84
		Tooth	22.03	6.3	28.6		19.42	24.63
		Difference	9.04	7.35	81.3	.0194	6.01	12.07
Region†	Anterior ($n = 12$)	Implant	30.42	3.95	13.0		28.79	32.05
		Tooth	22.08	7.21	32.6		19.11	25.05
		Difference	8.33	6.13	73.6	.0010	5.80	10.86
	Posterior ($n = 13$)	Implant	30.77	9.95	32.3		26.66	34.88
		Tooth	20.77	6.06	29.2		18.27	23.27
		Difference	10	7.90	79.0	.0046	6.74	13.26
Gender†	Male ($n = 10$)	Implant	29.69	5.50	18.5		27.41	31.96
		Tooth	23.99	6.42	26.8		21.34	26.63
		Difference	5.70	8.16	143.1	.0425	2.33	9.07
	Female ($n = 15$)	Implant	31.52	8.75	27.8		27.90	35.13
		Tooth	18.82	5.93	31.5		16.37	21.26
		Difference	12.70	10.11	79.6	.0001	8.53	16.87

*Paired t-test.
†Only the total values (both sessions combined) are shown.
SD, standard deviation; CV, coefficient of variation; CI, confidence interval.

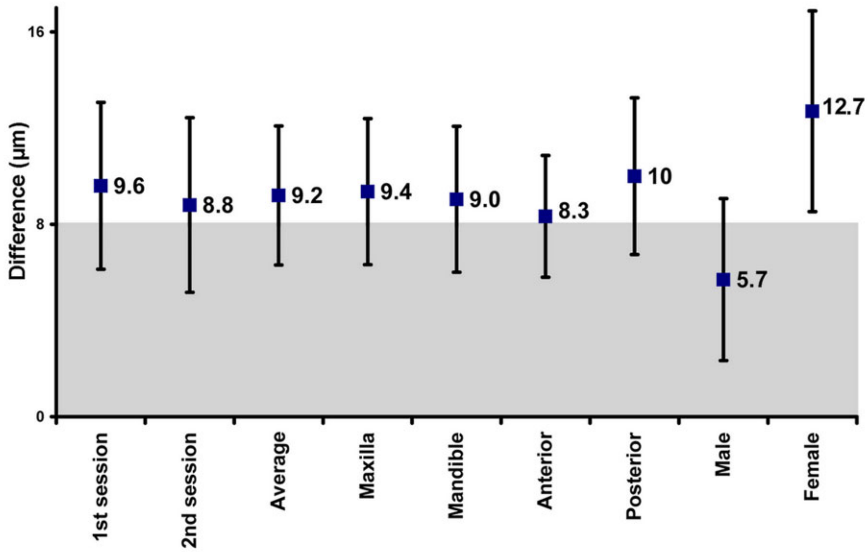

Figure 1 The differences (and 95% CI) between the ATS values of the implants and teeth in different groups. The gray band is indicative of the positive side of the margin of *clinical* equivalence. Both CI bounds should be either above +8 µm or below −8 µm for definitive conclusions. Note that no CI bounds crossed zero, indicating the *statistical* significance of all the differences (as confirmed by the hypothesis testing approach [*t*-tests]).

with regard to clinical significance in all groups and subgroups except for females (Table 1, Figure 1).

Differences between Subgroups

Neither tooth tactile sensitivities, nor implant sensitivities were significantly different between the maxilla and mandible ($p_{\text{tooth}} = .655$, $p_{\text{implant}} = .768$), and between the anterior and posterior regions ($p_{\text{tooth}} = .626$, $p_{\text{implant}} = .911$), according to the unpaired *t*-test (Table 1). The unpaired *t*-test showed no significant differences between the implant ATS thresholds in males and females ($p = .563$). However tactile sensitivity of the natural teeth differed significantly between males and females ($p = .050$, Table 1).

Associations with Covariables

The multiple linear regression analysis indicated the presence of significant positive correlations between age and the ATS of teeth (beta = 0.47, $p = .013$) and implants (beta = 0.33, $p = .019$). None of the factors: duration of implant in function, implant diameter, length, surface type, and surface area were associated with the tactile sensitivity (beta < 0.1, $p > .4$).

DISCUSSION

The findings of the current study indicated that compared to teeth, implants have significantly higher ATS thresholds in all subgroups. In females, the difference might be greater than 8 µm and hence perhaps clinically noteworthy as well. Sensitivity of both teeth and implants was similarly affected by age. Except for age, no risk factor was associated with tactile sensitivity. Female gender negatively influenced the ATS of natural teeth only.

Tooth-Implant ATS Discrepancy

The ATS threshold for an implant might be about 3 to 6 times greater than that of a tooth.[1,2,13] Some authors have found greater levels for implant ATS (50–100 µm),[13,14,16] being markedly higher than the tooth tactile perception capacity, although even such a comparatively lower sensitivity still satisfied the patients.[1,14] Certain investigators found a small but statistically significant difference between implant and teeth in terms of discriminative ability (similar to the findings of this study),[8,13] and in certain studies the difference was as small as 2 or 3 µm.[10] Comparable small differences however were interpreted as non-significant by Enkling and colleagues,[10,11] considering an 8-µm margin of clinical equivalence.

In the present study, the difference was close to those reported earlier, that is, less than 10 µm. The CIs revealed that it was not definitely conclusive whether the difference fell within the margin of clinical equivalence, although CI bounds were inclined partly to values greater than 8 µm. The dispute in the literature might arise from the high interindividual variations in the ATS of teeth, as well as sampling and experimental methods,[11] such as small samples and comparing implants with teeth in different people.[9] Of the three studies that compared implant and tooth ATS, one reported statistical significance only,[8] while two relied only on clinical significance using the equivalence testing approach, not the hypothesis testing.[10,11] We used both methods to improve the comparability of the results.

Maxilla versus Mandible

Some authors have reported that mandibular teeth might be more sensitive while being subjected to passive tactile tests, sugessting the involvement of remote fibers originated in the joint, muscles, and tendons.[17] However, this finding was not confirmed by the present research and some other studies on the ATS,[9] which might be caused by the presence of lurking variables in the dynamic setup of active tactile testing. To our knowledge, no other studies were available in order to compare and discuss the results further.

Anterior versus Posterior

In agreement with most of other ATS studies,[11,16,18–20] but in contrast to one report,[10] no significant differences were observed between the anterior and posterior sides in the current research. It is demonstrated that the PTS might differ considerably between anterior and posterior segments, and also that anterior teeth and implants might be more sensitive in terms of ATS.[10] The remarkable anterior-posterior PTS variation is probably attributable to greater root surface areas of posterior teeth, which minimizes the pressure needed for firing of the PDL mechanoreceptors. Such an influence might be compromised in ATS studies by some confounders such as extra mechanoreceptors in jaws and muscles.[19] The posterior regions need more mouth opening; so higher muscle traction occurs. It might predispose the distant fibers to firing (by lowering their threshold) and thus might compensate for the effect of the greater force needed to rise the pressure beyond the level of triggering PDL mechanoreceptors.[19] Besides, edge-to-edge contact of the anterior teeth needs mandibular advancement which would result in traction of some masticatory muscles, playing as other confounders.[10]

Gender

While implant sensitivity did not differ between the genders in the present setup, females had a little more precise sensitivity on the part of natural dentition. Apart from few studies that reported the presence of gender effect,[3] almost all other studies have reported that gender has no or minimal effect on tactile sensitivity of either teeth or implants.[9–11,18,19,21] In this research as well, gender only affected tactile perception of teeth, but not implants. Such a slight but still generalizable superiority existed in sensitivity of females' teeth which accounted for a higher ATS discrepancy between teeth and implants in them. Therefore, the difference between the ATS of implants and teeth reached above the available threshold of clinical significance (8 μm) in females. Whereas, the difference was less likely to reach outside the equivalence zone in males (due to their lower tooth ATS, not changes in the implant ATS). The literature lacked studies in this matter in order to compare the results. However, it is known that although tactile sensory systems of women and men might operate alike, women might have greater ability to discern subtle changes in chin, cheek, and lip position,[1] which might partly justify their better tooth ATS. Because the age of females and males did not differ significantly, and also since the pattern of age effect quite varied from the pattern of gender effect, it was unlikely that the significant differences seen between the genders were confounded by age.

Age

Aging might influence both production and process of sensory stimuli, resulting in impaired perception in older individuals.[1,18] The effect of age has been a source of ongoing debate. Some authors have asserted that age does not affect tactile sensitivity of teeth[8,10,20] or implants,[8–11,22] while some have considered a negative role for aging on tactile sensitivity of teeth or implants.[11,18,19,21,22] Even some investigators have found that older people might detect smaller particles.[23] Consistent with the results of some studies,[8,10] the findings of the current research exhibited a decline in sensitivity of both teeth and implants by aging. The controversies might be attributable to methodological and sampling differences. For instance sampling from younger participants might hide the role of age, as its role might appear in older ages.

This study along with the other ones[9,11,24] did not find any significant correlations between tactile sensitivity of implants with geometric properties and period of prosthesis load, nor between the ATS and implant surface,[10,11] although few studies related tactile perception to surface topography of implant.[9] The inadequate evidence to associate these items with the ATS implies that rather than being caused by implant innervation, the ATS might be associated with bone deformation during loading over implants (which can activate the mechanoreceptors in the fascia, periosteum, and PDL).[8] In addition, it might be sensed by proximal teeth through receiving the vibrations from the implant[2,11] or during their spontaneous occlusion or bone deformation. The incredibly great difference between the PTS of an implant and a tooth, which is about 50 times greater in implants, might indicate the principal role of remote fibers present in ATS experiments but absent in PTS trials.[1,2,13]

Limitations and Strengths

The present study was limited by some factors. A constraint was standardizing the dynamic forces in the mouth, which was not possible. Nevertheless, the intraindividual comparison of this study could reduce this factor. Some factors could increase the reliability of the findings. Unlike all other studies, easily adjustable gold foils with low hardness were used in this research. Therefore, they were burnishable and might be less likely to click in ears through bones.

Enkling and colleagues[9–11,18] masked this click sound by transmitting noises at the highest volume possible to a patient's ear. Although this method was successful in eliminating the sound of biting on the foils, it might be a strong distractor and confounder itself,[1] as it could render the patients lethargic or might reduce their focus on tactile perception and the commands.

This was the only study that adjusted the foils on the occlusal surface before biting. Using unadjustable foils does not guarantee a cusp-to-fossa contact and thus is not representative of mouth closure in maximum intercuspation. Besides, proper occlusal contacts had been assessed on both sides in the current study as an inclusion criterion which was present in only one study on teeth but not on implants.[18] Furthermore, foil temperature that might affect tactile sensitivity by influencing pulp receptors[21] was controlled in this study where ambient temperature was fixed at about 25°C and burnishing the foil on the tooth allowed it to become warmer to the mouth temperature.[9–11,18]

Additionally, Enkling and colleagues[9–11,18] instructed patients to operate the right and left mouse keys to signal the response. This task required certain levels of manual skill and intelligence.[11] Nevertheless, in the present study, the patients were to report the sense of contact by raising a hand, which might be more convenient and less confusing to them.

As the most reproducible method,[18] rather than finding the thinnest detectable foil or the 80% value, the 50% value was found in this research for each tooth or implant (based on the shape of the psychometric function derived from patient answers). Another advantage was the split-mouth nature of this study that could eliminate the existing high interindividual variations.

The notion of clinical significance is a subjective matter. We tried to frame it with the semi-objective method of equivalence testing, for which an objective threshold was borrowed from previous studies.[10,11] For this purpose, Enkling and colleagues[10,11] considered the minimum thickness detectable, less than which no participants could notice the foils. Nevertheless, this minimum limit depends only on subjects with the best perception potential, and disregards less precise sensitivities. Hence, future research should also use the average of the thinnest foils discerned by different patients.

Similar to the studies of Enkling and colleagues,[9–11,18] and in contrast to some other studies,[8] we randomized the order of foils to prevent learning curve of patients that could lead to false positive errors in detecting thinner foils. Both the patient and assessor were unaware of the treatment assignment to exclude the reporting bias. Moreover, unlike all previous investigations, in this study, each patient was examined at two intervals in order to reduce the effect of psychophysical status on patients' responses as well as increasing the generalizability of the findings. Breaking the number of tests into two sessions, and the smaller number of test foils at each trial would as well allow each session to be as brief as possible (20–30 minutes in this study versus about 2 hours in another study[11]). This could maintain patient focus during the test.

Another advantage of this design over several other studies[8–11,18] was that the participants had been asked prior to the examinations to avoid chewing on gums or foods, so that the possibility of receptor numbness could be eliminated.[15]

A sufficiently large sample collected through the broad range of inclusion criteria, various types/brands of implants used with different types of roughened surfaces as well as testing on different sites/genders could favor the generalizability of the findings. However, no implants with machined or very rough surfaces were included which might limit the generalizability to roughened surfaces.

Some investigators had adopted smaller ($n = 17 + 29$[8]) or larger samples ($n = 32 \times 2$,[10] 52×2,[11] 68 teeth only,[18] 62 implants only[9]). Merely two of these sample sizes were determined based on power calculations (to obtain powers ≥ 0.8).[10,11] Although our sample was smaller ($n = 25$ teeth + 25 implants), considering the high power of this study (> 0.9) and excluding inter-individual variations, its size seemed reasonable and adequate. It should be taken into account that excessively large samples and too high powers can inflate the rate of false positive errors and should be avoided when not necessary.

It was better to compare pairs of occluding teeth with occluding antagonist implants (instead of implant-tooth pairs) in order to reduce the role of remaining PDL in the implant-tooth side, acting as a confounding factor. However, it was much more difficult to find such patients, and this was not affordable in any of the previous studies as well. Further, the findings clearly showed that even despite the partial presence of PDL, significant decreases in the ATS were identified. The significant results, very low variations, and the high intraobserver agreement observed confirm the sufficient power and well control over the confounders in the present setup.

CONCLUSION

Compared with the natural dentition, implants might be slightly, although significantly, less sensitive to tactile stimuli.

The geometric properties of implants as well as their surface texture did not have any effects on tactile sensitivity. Apart from gender, other potential risk factors affected the ATS of the implants and teeth alike. Aging reduced sensitivity of both the teeth and implants. Gender only affected significantly tactile perception of natural teeth (females had better sensitivity) but had no discernable influence on implant ATS. The combination of these led to a tooth-implant difference in females which could be assumed higher than 8 μm.

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