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Osseoperception: active tactile sensibility of single tooth implants and natural teeth

Integrative systematic review

Océane Sarah Eloïse Hervineau

Dissertação conducente ao **Grau de Mestre** em **Medicina Dentária (Ciclo Integrado)**

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Trabalho realizado sob a Orientação de
Mestre Juliana de Sá

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RESUMO

Introdução: É essencial para a saúde e função da cavidade oral e dos ouvidos ter uma sensibilidade tátil ativa (movimento deliberado dos dentes e da mandíbula para ajudar na mastigação deglutição, fonação). Um implante é um dispositivo médico, desenhado para ser uma raíz dentária artificial capaz de suportar uma coroa dentária unitária ou conjunto das mesmas, quer seja(m) aparafusada(s) ou cimentada(s), ao contrário de um dente. O dente é um órgão formado por conjuntos de diferentes tecidos que por sua vez são agrupamentos de células que se associam e organizam para desempenhar determinada função. O ligamento periodontal funciona como um órgão sensorial no contexto da osseopercepção, transferindo entradas mecânicas e dados táteis para os tecidos circundantes.

Objetivo: O objetivo é precisar a diferença que existe entre um implante unitário e um dente natural relativamente á sua sensibilidade táctil ativa.

Materiais e métodos: Para a realização desta revisão sistemática integrativa, foi realizada uma busca bibliográfica em diferentes motores de busca até 2023. Após a aplicação dos critérios de inclusão e exclusão, obtiveram-se 7 artigos científicos.

Resultados: Os 7 estudos tiveram como objectivo a comparação da sensibilidade tatil ativa entre implante unitário e os dentes.

Discussão: Em contraste com os dentes naturais, os implantes dentários têm uma relação menos pronunciada ou pronunciada entre a intensidade da estimulação tátil e a sensação percebida.

Conclusão: De acordo com esta revisão sistemática integrativa, os implantes dentários unitários que ocluem com os dentes naturais do que os implantes unitários com dentes naturais opostos têm uma sensibilidade tátil ativa muito semelhante aos dentes naturais.

Palavras-chave : Implantes dentários unitários, sensibilidade tátil ativa, osseopercepção

ABSTRACT

Background: It is essential for the health and function of the oral cavity and ears to have active tactile sensitivity, which is the deliberate movement of the teeth and jaw to aid in chewing, swallowing, phonation. An implant is a medical device, designed to be an artificial dental root capable of supporting a single dental crown or a set of them, whether screwed or cemented, unlike a tooth. The tooth is an organ formed by sets of different tissues that in turn are groupings of cells that associate and organize to perform a certain function. The periodontal ligament functions as a sensory organ in the context of osseoperception, transferring mechanical inputs and tactile data to surrounding tissues.

Aim: The objective is to specify the difference that exists between a dental implant and a natural tooth in terms of their active tactile sensitivity.

Materials and methods: To carry out this integrative systematic review, a bibliographic search was performed in the databases up to 2023. After applying the inclusion and exclusion criteria, a text body of 7 scientific articles was obtained.

Results: The 7 studies aimed to compare the active tactile sensitivity between single implant and teeth.

Discussion: In contrast to natural teeth, dental implants have a less pronounced or pronounced relationship between the intensity of tactile stimulation and perceived sensation.

Conclusion: According to this integrative systematic review, single dental implants that occlude with natural teeth than single implants with opposing natural teeth have an active tactile sensitivity very similar to natural teeth.

KEYWORDS: Dental single-tooth implants, active tactile sensibility, osseoperception

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ATS: active tactile sensibility

CI: confidence interval

SMD: standardized mean difference

VAS: visual analog scale

I. INTRODUCTION

One of the most useful advancements in modern dentistry is oral implantology. With reported success rates surpassing 90%, it is now possible to predictably restore cosmetic and masticatory function using implants in patients who are completely or partially dentate. [1] [2]

Despite all the advancements, it is important to keep in mind that stiff implants cannot replicate the functional qualities of a natural tooth but may serve as an adequate stopgap when teeth have already been lost. Dental implants are prosthetic tooth roots that are surgically inserted into the jawbone to support a bridge or replacement tooth. Since titanium is biocompatible and gradually fuses with the surrounding bone to form a strong foundation for the replacement tooth, implants are frequently constructed of this material. [3-5]

A natural tooth is a living structure made up of the enamel, dentin, pulp, and root, among other layers. The dentin is a softer layer that lies beneath the enamel and acts as a cushion and support for the tooth. Enamel is the tooth's hard, external coating that shields it from harm. The root of the tooth holds the pulp, which is the tooth's interior layer and includes nerves and blood arteries, in the jawbone. [3, 5-7]

The sensory feedback process known as osseoperception enables a person to perceive the location and movement of their teeth within their jaws. The interaction of numerous sensory receptors, nerve fibers, and bone tissue is a complex process. [8, 9]

The stimulation of the periodontal ligament, a small layer of connective tissue that encircles each tooth's root and holds it to the bone, is a necessary component of osseoperception in the case of teeth. Mechanoreceptors, which are specialized cells that react to changes in pressure, tension, and movement, are present in the periodontal ligament. People use their posterior teeth to eat, and while they do so, parodontal receptors with various force-codage characteristics record and highlight various mechanical events that occur during their release. The information provided by the receptors is essential for describing the forces used when the food is handled, positioned between the teeth, and ready to be

chewed. The brain processes this sensory information, enabling the person to understand the position, motion, and force of their teeth within their jaws. The modulation of biting and chewing forces, as well as the preservation of appropriate dental alignment and occlusion, are all crucial functions of the sensory feedback process known as osseoperception. By indicating when excessive force or pressure is being applied, it also contributes to the protection of the teeth and the surrounding tissues from harm. [10-15]

Individuals may sense and interact with their surroundings by using their teeth thanks to two different types of sensory feedback mechanisms: passive and active tactile sensibility. [16]

Only three contentious investigations have studied the ATS of implants and teeth, in contrast to the more frequently evaluated passive sensitivity of implants and teeth. Passive tactile sensitivity related to long-term implants was not correlated with any of the factors investigated (age, gender, time since implant placement, implant length, and implant separation). Active tactile sensibility entails purposeful jaw and tooth movement to actively examine the environment. When someone purposefully moves their teeth or jaw to contact or engage with an object or substance, they experience this kind of sensory feedback. The movement of the teeth and jaw, for instance, can provide sensory feedback about the texture, form, and resistance of an object when someone uses their teeth to grasp and break open a box. [17, 18]

II. OBJECTIVES

The objective is to specify the difference that exists between a dental implant and a natural tooth in terms of their active tactile sensitivity.

III. MATERIALS AND METHODS

For the realization of this integrative systematic review, we did a bibliographic search in the database up to 2023: PubMed (via National Library of Medicine), ScienceDirect, Cochrane Library and Wiley Online Library using the following combinations of keywords: (dental implants) AND (natural teeth) AND (proprioception) OR (active tactile perception) OR (tactile sensibility) OR (osseoperception) OR (proprioceptive feedback).

To carry out this integrative systematic review, the checklist with 27 items from PRISMA ("The Preferred Reporting Items for Systematic Review and Meta-analysis") was used as a guideline.

1. Eligibility criteria

As a starting point of this systematic review, a question was formulated: "What is the difference in active tactile sensibility between single-tooth implants and natural teeth, specifically with regards to osseoperception according to the PICOS strategy "Population, Intervention, Comparation, Outcomes and Study design" (Table 1).

Table 1 - PICOS Strategy

Population	Clinical studies of human patients who underwent implant surgery
Intervention	Understanding osseoperception in natural teeth and dental implants
Comparation	Comparing the osseoperception between the natural tooth and an implant
Outcomes	Results of clinical studies on the difference in active sensitivity between a natural tooth and an implant
Study design	Randomized controlled trials, meta-analyses, comparative studies, prospective studies

Articles were selected according to the following inclusion criteria:

- Articles published from 1992 until 2023

- Studies written in English

- Studies performed in humans

- Randomized clinical trial, prospective and retrospective clinical studies

- Articles that talk only about single implants

- Articles that talk about single implants placed both anteriorly and posteriorly in the maxilla and/or the mandible

Other studies were excluded, such as:

- Systematic reviews, thesis, and dissertations

- Articles whose title and/or abstract do not fit the theme or that compare overdentures with implants or natural root

- Implants with splinted rehabilitation

- Studies in vitro

2. Information sources

A bibliographic search was performed in the database from 1992 until 2023: PubMed (via National Library of Medicine), ScienceDirect, Cochrane Library and Wiley Online Library. Articles published until 2023 in English were analyzed. The research used keywords related to the topic in question. The references of the included articles were analyzed, and a manual search was also carried out in books to identify and retrieve articles that were not found in electronic searches. Search strategies are detailed in Table 2.

3. Selection of articles

First, an advanced search was performed using the keywords in the database. Thanks to the Zotero citation tool, duplicate articles were removed. Then, the titles and abstracts of the various articles found were analyzed to determine whether they corresponded to the purpose of the study. Second, articles that met the inclusion criteria were read in full and evaluated for eligibility. Finally, the selected articles were evaluated, and their data organized in a table. (Table 2).

Table 2 - Search strategy and databases used.

Data base	Search strategy	Identified articles	Selected articles
PubMed	(dental implants) AND (natural teeth) AND ((proprioception) OR (active tactile perception) OR (tactile sensibility) OR (osseoperception) OR (proprioceptive feedback)	30	7
ScienceDirect	(dental implants) AND (natural teeth) AND ((proprioception) OR (active tactile perception) OR (tactile sensibility) OR (osseoperception) OR (proprioceptive feedback)	70	0
Cochrane Library	(dental implants) AND (natural teeth) AND ((proprioception) OR (active tactile perception) OR (tactile sensibility) OR (osseoperception) OR (proprioceptive feedback)	4	0
Wiley Online Library	(dental implants) AND (natural teeth) AND ((proprioception) OR (active tactile perception) OR (tactile sensibility) OR (osseoperception) OR (proprioceptive feedback)	1	0

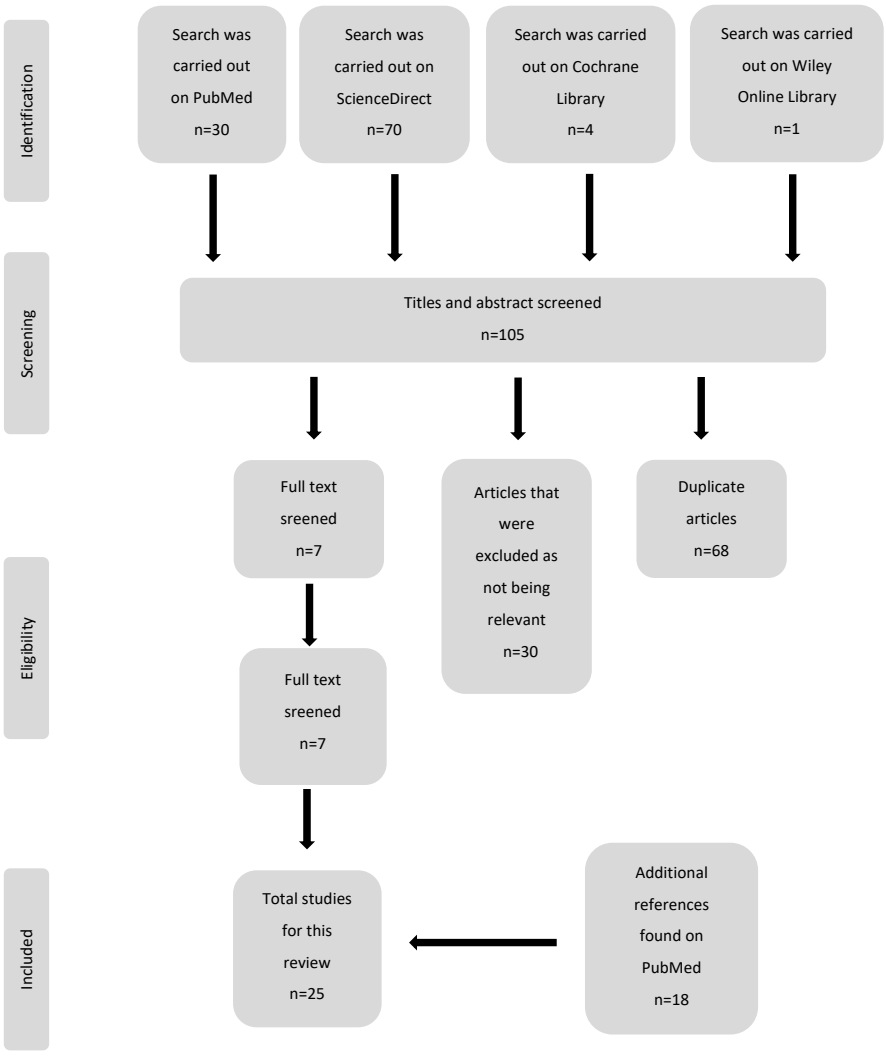
IV. RESULTS

1. Selection of articles

The search carried out with the keywords mentioned above 105 articles. After applying the inclusion criteria, 35 articles remained. After applying the exclusion criteria, upon reading title, abstract and the article, was decided to select 7 articles. (The flow chart of study selection for our review is indicated figure 1.)

For the introduction and the discussion, we used 18 additional references, found on Pubmed, we judged interesting to complement our study.

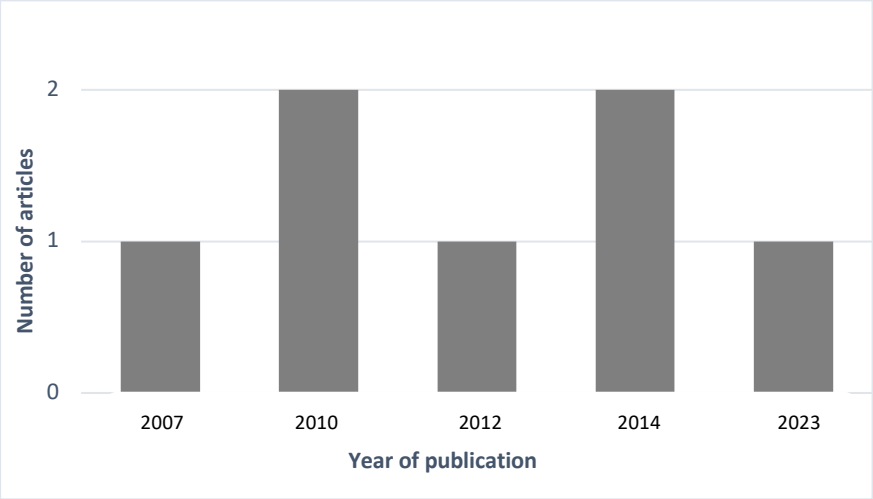
Figure 1 - Flow chart of study selection for the review



2. Characteristics of the included studies

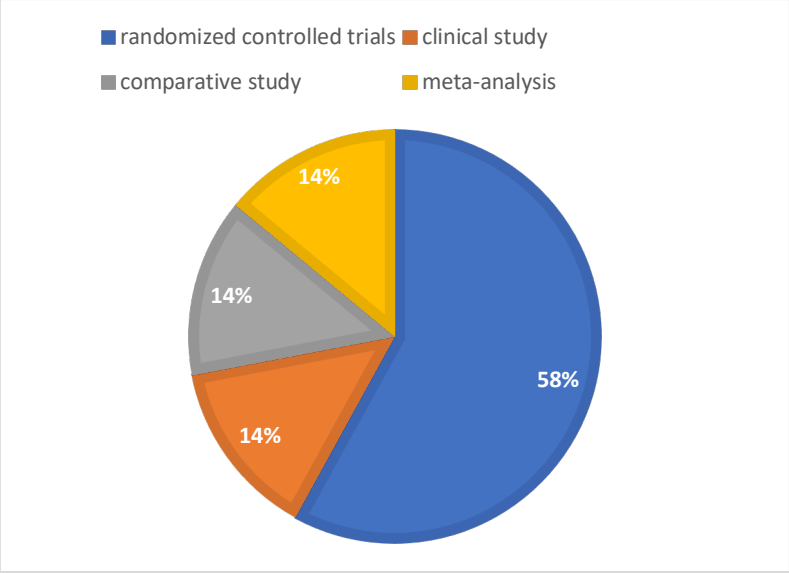
Regarding the period of publication, the years 2014 and 2010 registered the highest number of articles on the subject in question, presenting 2 articles, the years 2012, 2007 and 2023 with 1 article on the subject in question. (Figure 2)

Figure 2 - Distribution by year of publication of the articles included.



As for the type of studies of the evaluated articles, 4 are randomized controlled trials (58%), 1 is a clinical study (14%), 1 is a comparative study (14%) and 1 is a meta-analysis (14%). (Figure 3)

Figure 3 - Distribution according to the type of study



3. Data collection process

Table 3 collects the different information extracted from the selected studies: The study (title, name of the first author, year of publication and the type of study), the purpose, the method (population, sample size), the results (natural teeth vs dental implants) and conclusion.

Table 3 - Relevant data gathered from included studies.

Study	Purpose	Methods	Results	Conclusion
"Osseoperception: active tactile sensibility of osseointegrated dental implants." Enkling N. et al. 2010 Random controlled trial	Analyze the 50% value and slope of the sensibility curve to understand tactile sensitivity in single-tooth implants.	Population: 62 participants who had single-tooth implants with natural opposing teeth. Copper foils of different thicknesses ranging from 0 to 200 µm were placed between the implant and opposing tooth in a randomized and computer-assisted manner. The participants' ability to detect pressure was then measured using the psychophysical method of constant stimuli and analyzed using logistic regression.	The tactile perception of the implants at the 50% value was 20.2 ± 10.9 µm, and the slope was 29 ± 15.	The active tactile sensibility of implants with natural antagonistic teeth was like that of teeth, but the slope of the tactile sensibility curve was flatter. Significant differences in tactile sensibility were observed based on the different implant surfaces, suggesting that receptors near the implant may be responsible for osseoperception.
"Sensory discrimination of teeth and implant-	Evaluate patient reactions to the application of load on both	Population: 10 patients who underwent a single implant-	Patients were 100% accurate in differentiating between loads to	Patients seem to have some proprioceptive awareness of implant loading, despite the

supported restorations" Hsieh et al. 2010 Comparative study	natural teeth and implants with VAS.	supported crown repair next to a natural tooth The tooth and the implant-supported crown were subjected to vibrational stresses of 0.2 N, 0.4 N, and 0.6 N. The VAS was used to gauge the intensity of the feeling.	implants and natural teeth (P = about .01). 100% of the time, the responses to loading the implant were weaker than those to loading the native tooth (P = about .01).	absence of periodontal ligament receptors in the peri-implant region. With increasing vibrational stress, this awareness resembles that of genuine teeth more and more.
« Tactile sensibility of single-tooth implants and natural teeth. » Enkling N. et al. 2007 Random controlled trial	Analyze the tactile sensitivity of the pairs of natural teeth on the opposite sides of the mouth and compare it to the active tactile sensitivity between the implants of one tooth and the opposing natural teeth.	Population: 62 subjects (n=36 from Bonn, n=26 from Bern) with single-tooth implants (22 anterior and 40 posterior dental implants). Patients were instructed to bite on thin strips of copper foil with different thicknesses (5-200 mm), to determine if with single tooth implants, they could detect a foreign body between their teeth.	[implant/natural tooth: 16.7+/-11.3 µm (0.6-53.1 µm); natural tooth/natural tooth: 14.3+/-10.6 µm (0.5-68.2 µm)]. The intraindividual variations were only significant by their mean value of 2.4+/-9.4 µm (-15.1 to 27.5 µm).	The tactile sensitivity is nevertheless extremely fine and interindividually equal between the implant and tooth even when the natural antagonists of the implant and the contralateral tooth are both under anesthesia.

« Tactile Sensibility of Single-Tooth Implants and Natural Teeth Under Local Anesthesia of the Natural Antagonistic Teeth. » Enkling N. et al. 2012 Random controlled trial	Learn more about the osseoperception 's neurophysiological underpinnings and the significance of periodontal mechanoreceptors for mouth tactile sensitivity.	Population: 32 subjects with single-tooth implants with natural opposing teeth. Copper sheets of varied thickness (0-100 mm) were positioned randomly and computer-assisted between the implant of one tooth and the natural opposing tooth, as well as between the contralateral pair of natural opposing teeth.	With a support area of 77 +/- 89 mm, the average tactile sensitivity of implants with 50% anesthetized antagonists was 20 +/- 11 mm. The tactile sensitivity at 50% for the pair of natural teeth was 16 +/- 9 mm, and the support area was 48.4 +/- 93 mm. The mean intra-individual difference was 3.5 +/- 7 mm, or 50%, and the support area was 29 +/- 93 mm.	The study's findings imply that the implant itself may have an impact on the active tactile sensibility of single-tooth implants with natural opposing teeth in addition to the periodontium of the latter tooth. This result lends credence to the idea that the implant might possess unique tactile sensitivity. This suggests that the implant's design and selection may have a big impact on the device's overall tactile sensitivity.

« Active Tactile Sensibility of Single- Tooth Implants versus Natural Dentition: A Split-Mouth Double- Blind Randomized Clinical Trail» Kazemi M. et al. 2014 Random controlled trial	See the variations between dental implants for a single tooth and teeth ATS.	Population: 25 patients They bit into gold and placebo sheets ranging in thickness from 0 to 70 mm five times each, blind to the patients and the evaluator, in two sessions.	An implant's ATS threshold may be three to six times higher than that of a tooth. ATS values: 21.4 ± 6.55 µm for teeth and 30.0 ± 7.55 µm, for implants (p = .0001 [paired t-test]).	Implant and tooth tactile sensitivity differed marginally but statistically significantly.

« Do sensation differences exist between dental implants and natural teeth?: a meta- analysis » Higaki N. et al. 2014 Meta-analysis	Analyze the data pertaining to the sensory differences between osseointegrated dental implants and natural teeth.	Population: Patients of 6 studies on oral sensation Using the keywords "perception or feeling and dental implant," a systematic search of English-language literature published from January 1980 to May 2012 was conducted.	The tactile threshold values of implants were roughly 4–20 times greater than those of natural teeth in terms of sensitivity. The tactile sensibility of an implant has a SMD of 8.3619 (95% CI, 6.3920-10.3317) and a P < 0.0001. The thickness discrimination was significantly higher than that of natural teeth with an SMD of 1.2368 (95% CI, 0.8699-1.6038) and a P < 0.0001, it's 1.2-2.3 times higher than that of natural teeth.	Tactile sensibility and thickness discrimination thresholds of implants were both significantly higher than those of natural teeth. This meta-analysis reconfirms that sensation differences between dental implants and natural teeth exist.

"Evaluation of active tactile perception of single tooth implant prothesis" Deepika et al. 2023 Clinical study	Evaluate the osseointegrated single tooth dental implants' active tactile sensitivity using a psychophysical method of continual stimulation.	Population: 20 participants, 10 men and 10 women, who had single tooth implants in the posterior region with their naturally occurring, healthy opposing teeth. There were ten implants in the maxilla and ten in the mandible. The subjects were split into two age groups, 30 to 40 and 40 to 50, and the psychophysical method of constant stimuli was used to study active tactile perception.	The active tactile perception of single dental implants that have osseointegrated with healthy natural antagonists showed a threshold between 24 and 8. The threshold for active tactile perception of healthy, natural teeth with healthy, natural antagonist was found to be between 12 and 4.	When natural opposing teeth are present, implants' active tactile sensibility is comparable to that of teeth. An implant-supported prosthesis improves psychophysiological discriminatory ability while restoring jaw function more correctly.

V. DISCUSSION

Dental implants 'oral sensory perception sensitivity can be tested by either applying passive pressure to the implant's occlusal surface to measure passive tactile sensitivity or by having test subjects bite down on small test subjects to measure tactile sensitivity. The slight pressure that was felt through the implant serves as a representation of the results for passive tactile sensitivity (represented in newtons). Active tactile sensitivity is expressed by the thickness of the perceived foreign body that is the thinnest (represented in millimeters). The study of passive tactile sensitivity only allows for the testing of individual neuronal receptors, whereas active tactile sensitivity more accurately mimics normal function and is therefore more interesting for dental practice.[19]

Hsieh et al. (2010) used this vibration approach on patients who were rating their sensations on a VAS regarding patients' ability to differentiate between loads applied to dental implants and natural teeth, as well as their responses to such loads. As compared to loading a natural tooth, patient reactions to loading an implant were consistently weaker. Patients had a lesser feeling or response when a load was given to an implant than when it was placed to a normal tooth. The dependability of this difference is once again highlighted by the statistical significance (P = approximately 0,01). It's interesting to note that the article claims that when vibrational stress increases, this knowledge of implant loading grows closer to that of natural teeth. According to this, patients may interpret implant loading more similarly to how they would perceive loading on natural teeth when the severity or amplitude of the vibrational stress rises. The sensory perception of vibrations between natural teeth and dental implants may converge at greater vibrational pressures. It suggests that the strength or size of the applied vibration may have an impact on one's capacity to distinguish between the two. [20]

Enkling N. et al. studied osseoperception as dependent on peripheral mechanoreceptors in the orofacial and temporomandibular tissues as well as central impacts from corollary discharge from cortico-motor orders to jaw muscles. Enking's findings were on how dental implants feel to the touch. A tactile stimulus must be detected at a certain degree

of sensitivity, as evidenced by the tactile perception measurement at the 50% value. With a range of individual variations, the tactile perception of the implants had an average value of 20.2 10.9 m. The study discovered notable variations in tactile sensitivity based on the various implant surfaces. This shows that osseoperception may be influenced by receptors close to the implant, such as those in the surrounding tissues. Indeed, natural teeth have periodontal mechanoreceptors that transmit information about tooth loads, in contrast to osseointegrated dental implants. Mechanoreceptors and other sensory organs found in the periodontal ligament give information regarding the position, motion, and force applied to the teeth during biting and chewing. [21]
The regulation and synchronization of jaw motions are greatly influenced by these sensory inputs, which aid in the fine control needed for manipulating food inside the mouth.[20]

The study of Reverdo et al. implies that single dental implants that have successfully merged with healthy natural opposing teeth fall within a threshold range of 24 to 8 for active tactile perception, or the capacity to feel and experience tactile stimuli. On the other hand, healthy natural teeth with healthy natural opposing teeth have an active tactile sensory threshold that ranges from 12 to 4. The passage also implies that an implant-supported prosthesis enhances psychophysiological discriminatory capacity in addition to restoring appropriate jaw function. This suggests that people who use implant-supported prostheses not only regain their functional skills, but also have improved sensory perception and discrimination. [22]

In intraindividual comparisons, it was demonstrated that the tactile sensibility is the same between single-tooth implants and naturally occurring contralateral teeth in the condition of active tactile sensibility, which most closely resembles natural function. Despite the absence of periodontal ligament receptors in the peri-implant region, patients retain some level of proprioceptive awareness of implant loading. Individual differences exist in the active tactile sensitivity of implants, which ranges from 2 µm to 54 µm with a mean value of 21 µm. Even when the opposing teeth, which function as the implant's natural antagonists, were sedated, the tactile sensitivity between the

implant and tooth did not change. This shows that the anesthetic of the opposing teeth does not greatly impair the capacity to feel touch inputs. The tactile sensitivity between the implant and tooth is nonetheless extremely fine and interindividual equal even when the natural antagonists of the implant and the contralateral tooth are under anesthesia. Enkling and al. (2009), researchers investigated the ATS of dental implants. In the study, a median value of 20,2 ± 10,9 µm was noted. Mahmoud Kazemi and al. (2013) compared the active tactile sensitivity of implants to that of teeth. It was determined that the average ATS values for teeth and implants were 21,4 µm and 30 µm, respectively. It shows that dental implants had marginally higher ATS values than healthy teeth, indicating that implants can offer a marginally greater capacity to sense tactile stimuli. [20-24](Table 4)

Table 4 - Findings in the literature regarding active tactile sensibility of implants

Study	Year	Mean active tactile sensibility (µm)
Enkling and al. [23]	2007	21
Enkling and al. [21]	2009	21,2
Reveredo Am et al. [22]	2013	24
Mahmoud Kazemi et al. [24]	2014	30

Dental implants' sensitivity could not be as exact or precisely calibrated as natural teeth. There are notable variations in tactile sensitivity based on the various implant surfaces. The tactile sensitivity of dental implants and natural teeth differs significantly. When comparing implants to natural teeth, the tactile threshold values, which show the minimal stimulus needed to evoke a sensory response, were roughly 4–20 times higher for implants. With a 95% CI ranging from 6.3920 to 10.3317, the study's meta-analysis revealed that the SMD for tactile sensitivity between implants and natural teeth was 8.3619. The fact that implants have a substantially greater tactile sensitivity threshold than natural teeth is further supported by the fact that the difference is statistically significant (p-value = 0.0001) and statistically significant. The study also discovered that implants considerably outperformed natural teeth in terms of thickness discrimination—the capacity to recognize changes in the thickness or size of items. With a 95% CI range from 0.8699 to 1.6038, the SMD for thickness discrimination between

implants and normal teeth was 1.2368. A statistically significant difference with a p-value of less than 0.0001 suggests that implants are better at differentiating between thicknesses than natural teeth. This suggests that compared to natural teeth, implants need a far stronger stimulation to elicit a sensory response. The meta-analysis confirms that there are notable variations between dental implants and natural teeth in tactile sensibility and thickness discrimination. Compared to natural teeth, implants have a higher threshold for sensory responses and a greater capacity to distinguish between thicknesses. These results demonstrate the sensory differences between dental implants and natural teeth, emphasizing the significance of taking these distinctions into account while assessing and creating dental restorations. According to the passage, an implant may have an AST that is three to six times greater than that of a natural tooth. The AST is the minimal degree of stimulation needed to elicit a sensory response. [20, 22, 25]

The study discovered that the average AST score for teeth was 21.4 6.55 m and for implants it was 30.0 7.55 m. (Table 4) The difference between the tactile sensitivity of implants and natural teeth is statistically significant, as shown by the p-value of 0.0001. This indicates that there is a clear difference between the two in their capacity to perceive touch inputs. Even though there was just a little difference in the tactile sensitivity of implants and natural teeth, the difference was statistically significant. Despite the possibility of some tactile sensitivity overlap between implants and natural teeth, this implies that there is a discernible difference in how each group of teeth responds to touch stimuli. the results show that, in comparison to natural teeth, implants often have a greater AST threshold and a marginally lower tactile sensitivity. This knowledge is crucial for comprehending dental implants' sensory perception capabilities and may be used to evaluate and design implant restorations so that patients receive the best tactile input possible. [24]

In addition to discussing the tactile sensitivity and support area of natural teeth, the section also discusses the average tactile sensitivity and support area of implants with 50% anesthetized antagonists. The interpretation is as follows: The support area for

these implants was 77 +/- 89 mm, and the average tactile sensitivity of the implants with 50% anesthetized antagonists was 20 +/- 11 mm. This shows that, on average, people with these implants had a sensitivity of 20 mm and a support area of 77 mm for tactile inputs. Comparatively, a set of natural teeth had a tactile sensitivity of 16 +/- 9 mm at 50% and a support area of 48.4 +/- 93 mm. This implies that people with natural teeth had a smaller support area of 48.4 mm and somewhat lower tactile sensitivity of 16 mm. The average intra-individual variation, or difference within one individual, was 3.5 +/- 7 mm, or 50%, of the total. This demonstrates that people's own levels of tactile sensitivity varied, with an average variance of 3.5 mm or 50%. The intra-individual difference's support area was 29 +/- 93 mm, indicating that the support area's dimensions might vary. Along with the periodontium of the natural tooth, the implant itself may influence the active tactile sensitivity of single-tooth implants with natural opposing teeth. This implies that the implant's tactile sensitivity can be affected by the design and material choices used. In other words, depending on their design features, various implants may offer varying degrees of tactile sensation. Compared to natural teeth, implants' tactile sensitivity and support area might vary. Design and selection of the implant play a critical role in defining its tactile sensitivity, and careful consideration should be made to these parameters to guarantee that patients with single-tooth implants have the best possible tactile sense. [25]

VI. CONSTRAINTS

A constraint for osseoperception in a study environment refers to a restriction or aspect that might influence the study or inquiry of osseoperception. There are several restrictions on this integrative systematic review. According to the research that were examined, limitations on sample size, participant characteristics, measurement methods, ethics, study duration, funding, and resources. These restrictions may cover a range of elements that have an influence on the technique, research design, or result interpretation.

A study's inclusion of a small number of people may restrict the findings' capacity to be generalized and their statistical power. A limited sample size might make results less reliable or make it more difficult to spot significant differences or connections.

Confounding factors that may affect osseoperception might be introduced by participant characteristics like age, gender, oral health status, or specific medical diseases. It can be difficult to separate the effects of osseoperception alone since a few variables may interact with or influence how dental implants are perceived sensory-wise. The assessed psychophysical touch thresholds were undoubtedly influenced by factors such as participants' motivation, distraction, exhaustion, and attentiveness.

The accuracy and dependability of the results may be impacted by methodologies' intrinsic flaws or sources of inaccuracy, which might add bias into the measuring process. Researchers must consider the accuracy and validity of the measuring methods employed like the implant's size, surface finish, timing of placement, and position may all have an impact on tactile perception. It should be emphasized that forces applied in a vibratory mode may be resonantly conveyed to nearby tissues, such as the periosteum and gums, which are fitted with capsule receptors, potentially distorting the results that have been reported. [20]

A study's time frame may be constrained, which may make it difficult to evaluate osseoperception over a prolonged length of time. To comprehend osseoperception's stability, flexibility, and possible changes over time, long-term assessment of the phenomenon may be required.

For performing thorough osseoperception investigations, enough funding and resources are crucial. The breadth and quality of the research may be constrained by a lack of funds, access to specialist equipment, knowledge, or participant recruitment.

VII. CONCLUSION

According to this integrative systematic review, single dental implants that occlude with natural teeth than single implants with opposing natural teeth have an active tactile sensitivity very similar to natural teeth. In contrast to natural teeth, dental implants have a less pronounced or pronounced relationship between the intensity of tactile stimulation and perceived sensation. The complex sensory functions of a normal tooth and its periodontal ligament cannot be fully replicated by osseoperception, although it does provide some tactile feedback. Dental implants may not provide the same sensory experience as natural teeth and may require some personal adjustment on the part of the person.

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