

Tactile Sensibility Thresholds in Implant Prosthesis/Complete Dentures/Natural Dentition

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The periodontium has important proprioceptive receptors that prevent teeth from using excessive occlusal forces during chewing. There are other receptors from adjacent tissues that replace periodontal ones when teeth are extracted and rehabilitated with prosthesis, although they seem to be less effective. Psychophysical studies investigate tactile sensibility thresholds, which are useful to measure this masticatory efficiency in different prosthetic rehabilitations. There are two types of sensibility depending on the receptors that are activated during these studies: active and passive tactile sensibility. The mean values of active tactile sensibility thresholds in complete dentures, implant prosthesis and natural dentition are 64 μ , 23.3 μ and 16.1 μ , respectively. The mean values of passive tactile sensibility thresholds in implant prosthesis and natural dentition are 6.7 N and 0.8 N, respectively. Implant prosthesis have lower thresholds, that are very close to those present in natural dentition, than complete dentures due to an increased tactile sensibility. Active tactile sensibility thresholds present fewer differences between values than passive tactile ones; as these are only influenced by receptors from periodontal or periimplant tissues.

Keywords: osseoperception ; tactile sensibility ; interocclusal thickness ; interocclusal perception

1. Introduction

The periodontal ligament (PDL) is a great source of sensitive information inside the oral cavity as it contains several kinds of mechanoreceptor. These receptors are very important in the functioning of the masticatory system. One of their main functions is avoiding excessive forces during occlusal chewing so as not to harm teeth. They notice small pressure or position changes that may happen in the interocclusal space, or even the toughness of food inside mouth; then, this information is quickly transmitted to the brain ^{[1][2][3]}.

Edentulous patients have lost periodontal receptors and the important proprioceptive information associated with them. When these patients are rehabilitated with complete dentures, other receptors from adjacent tissues, such as muscles or temporomandibular joints, are stimulated during chewing. This provides useful proprioceptive information which is known as tactile sensibility ^{[3][4][5][6][7][8]}. This tactile sensibility appears to be increased in patients wearing implant prosthesis due to a sensitive phenomenon called osseoperception ^{[9][10][11][12][13]}. Osseoperception is the sensation coming from the mechanical stimulation of implant-supported prosthesis when receptors from peri-implant bone are activated, as well as other receptors from surrounding tissues ^{[14][15][16][17]}. A Corpas investigation ^[18] demonstrated the presence of nerve fibers surrounding osseointegrated implants that might be responsible for this increased tactile sensibility. Neurophysiological studies have tried to demonstrate how the brain changes when people rehabilitate a tooth with an implant, in order to understand the complex phenomenon of osseoperception ^{[19][20][21][22]}. For example, Habre-Hallage ^[23] performed a relevant investigation with functional magnetic resonance imaging (fMRI) that showed how there is a response in the cortical brain after the mechanical stimulation of implant prosthesis. This study also suggests that after tooth extraction and its rehabilitation with implants, brain plasticity seems to occur. Although these investigations are helpful to understand osseoperception, this phenomenon is not well known yet.

Tactile sensibility allows people to evaluate the efficiency of the masticatory system in different occlusal settings ^{[24][25][26]}. This sensibility may be passive or active. While passive tactile sensibility only measures receptors from periodontium or peri-implant tissues, active tactile sensibility also evaluates remote receptors, such as those that come from temporomandibular joint or masticatory muscles. Besides this, passive tactile sensibility is measured by Newtons, representing the minimal strength that an implant or a tooth can perceive. Active tactile sensibility is measured by micrometers (μ) as it evaluates the perception of interocclusal thickness that can be noticed by a patient during chewing ^{[14][27]}.

Psychophysical investigations study both active and passive tactile sensibility in order to obtain their thresholds and to know how different receptors are stimulated. Active tactile sensibility psychophysical studies are more common, as their functioning is easy to perform on a dental chair. Thin foils with different thicknesses are placed interocclusally, so patients can state if they are able to notice them during chewing or not. Passive–active tactile sensibility studies are more complex, as they are based on the mechanical stimulation of implants or teeth by special devices designed to apply forces directly to them. These devices punctuate implants and teeth at different intensities, then patients have to affirm whether they can perceive this mechanical stimulation [27][28].

2. Tactile Sensibility Thresholds in Implant Prosthesis/Complete Dentures/Natural Dentition

Psychophysical studies concerning passive tactile sensibility are very scarce as they are more difficult to perform. There are only two studies [28][29] that measure this figure as it is necessary to design a complex device that applies pressure to dental implants and teeth. This pressure is measured by Newtons and is controlled by a computer. After the activation of these devices, receptors from periodontal or peri-implant tissues are stimulated, and, depending on the pressure level applied, the patient will either be able to notice a stimulus or not.

On the other hand, psychophysical studies measuring active tactile sensibility are easier to reproduce on the dental chair and are more common in the literature. These studies are based on the minimum interocclusal thickness that can be noticed by a patient with natural dentition or rehabilitated with some kind of prosthesis [30]. The methodology of these investigations is based on placing metal foils with different thicknesses interocclusally. These foils are very thin and are measured in μ . Next, the patient bit these foils so scholars could find out if they were able to perceive them between their teeth.

In this case, not only receptors from periodontal or peri-implant tissues are activated but also other receptors from adjacent tissues, and temporomandibular joints or masticatory muscles are stimulated too [27][28][29][30][31][32][33][34][35][36].

The clinical implications of this investigation are very relevant as implant rehabilitation is a very common treatment nowadays. These results reflect how prosthesis can influence masticatory function. Beside this, it can be demonstrated how complete dentures are less effective than implant prosthesis at perceiving small occlusal forces during chewing.

Both active and passive tactile sensibility thresholds in implants are slightly reduced with respect to those present in natural dentition. Beside this, the difference between values in passive tactile sensibility is increased. This is because proprioceptive sensibility is only activated by mechanoreceptors from peri-implant tissues, without taking into account the other receptors from joints or muscles [37][38][39][40]. However, tactile sensibility thresholds in implants have values that are very close to those present in natural dentition. Thus, implant prosthesis can achieve a great adaptation and operation.

It has been a great challenge to find tactile sensibility thresholds in complete dentures as there are very few psychophysical studies on this subject, and few investigations comparing these values with tactile sensibility thresholds in implants or natural dentition. Besides this, there are no values of passive tactile sensibility in complete dentures, as these prosthesis do not have periodontal or peri-implant receptors associated with them that can be stimulated during psychophysical studies. Therefore, psychophysical studies in complete dentures must focus on receptors from surrounding tissues such as muscles, mucous membranes and temporomandibular joints. The stimulation of these receptors is measured by active tactile sensibility [31][14].

Grieznis' investigation [28] set the active tactile sensibility thresholds in implants and natural dentition at 2.5 N and 0.8 N, respectively. The difference between these values is 1.7 N. There is a previous study [29] that also measures the active tactile sensibility threshold in implants (10.9 N) without studying this same value in natural dentition. The difference between these values is so big because the methodology of both studies is not homogeneous. Concretely, the scientific sample is very different. Every investigator uses different devices and the prosthesis measured are not the same. Therefore, after calculating the mean values of thresholds in implant prosthesis the resulting figure is 6.7 N.

There are only found two investigations comparing active tactile sensibility thresholds between complete dentures, implant prosthesis and natural dentition [30][35]. Batista said that active tactile sensibility threshold in complete dentures was 92 μ , while Shala set this figure at 36 μ .

The difference between thresholds in complete dentures and implant prosthesis is 40.6 μ . This value is almost six times higher than the difference between thresholds in implant prosthesis and natural dentition (7.2 μ), which highlights the fact that there is an increased tactile sensibility in implant prosthesis with respect to complete dentures.

Tactile sensibility is an important parameter during the evaluation of prosthetic rehabilitation's efficiency. This proprioceptive information protects us from applying an excessive chewing force when we are eating. Without this sensibility we could harm our teeth or break our prosthesis while biting hard food. Although the differences in values of active tactile sensibility between implants and natural dentition is small, it is enough to induce fractures in prosthesis because of this deteriorated masticatory function. As the tactile sensibility in implants is increased and its thresholds are similar to those present in natural dentition, implant-supported prostheses are a great alternative to complete dentures, which have a higher threshold and for which the proprioceptive information is limited.

3. Conclusions

Passive tactile sensibility thresholds are 6.7 N in implant prosthesis, and 0.8 N in natural dentition. After calculating the mean values of active tactile sensibility thresholds, these figures are: 64 μ in complete dentures, 23.3 μ in implant prosthesis, and 16.1 μ in natural dentition.

Implant prosthesis have lower thresholds, which are very close to those present in natural dentition compared to complete dentures due to an increased tactile sensibility related to osseoperception. As active tactile sensibility stimulates a higher number of receptors compared with passive tactile sensibility, its values present fewer differences between thresholds than passive tactile ones, as these are only influenced by receptors from periodontal or peri-implant tissues.

References

1. Trulsson, M. Sensory-motor function of human periodontal mechanoreceptors. *J. Oral Rehabil.* 2006, 33, 262–273.
2. Haggard, P.; de Boer, L. Oral Somatosensory awareness. *Neurosci. Biobehav. Rev.* 2014, 47, 469–484.
3. Bhatnagar, V.M.; Karani, J.T.; Khanna, A.; Badwaik, P.; Pai, A. Osseoperception: An Implant Mediated Sensory Motor Control—A Review. *J. Clin. Diagn. Res.* 2015, 9, 18–20.
4. Jacobs, R.; Van Steenberghe, D. From osseoperception to implant-mediated sensory-motor interactions and related clinical implications. *J. Oral. Rehabil.* 2006, 33, 282–292.
5. Abarca, M.; Van Steenberghe, D.; Malevez, C.; Jacobs, R. The neurophysiology of osseointegrated oral implants. A clinically underestimated aspect. *J. Oral Rehabil.* 2006, 33, 161–169.
6. Van Steenberghe, D.; Jacobs, R. Jaw motor inputs originating from osseointegrated oral implants. *J. Oral Rehabil.* 2006, 33, 274–281.
7. Feine, J.S.; Lund, J.P. Measuring chewing ability in randomized controlled trials with edentulous populations wearing implant prostheses. *J. Oral Rehabil.* 2006, 33, 301–308.
8. Bhandari, A.; Hedge, C.; Prasad, K. Relation between oral stereognosis and masticatory efficiency in complete denture wearers: An in vivo study. *Braz. J. Oral Sci.* 2010, 9, 358–361.
9. Kumar, A.; Castrillon, E.; Trulsson, M.; Svensson, K.G.; Svensson, P. Fine motor control of the jaw following alteration of orofacial afferent inputs. *Clin. Oral Investig.* 2017, 21, 613–626.
10. Klineberg, I.; Calford, M.B.; Dreher, B.; Henry, P.; Macefield, V.; Miles, T.; Trulsson, M. A consensus statement on osseoperception. *Clin. Exp. Pharmacol. Physiol.* 2005, 32, 145–146.
11. Kumar, L. Osseoperception in Implants Supported Prosthesis—A Review. *Online J. Med. Med. Sci. Res.* 2012, 1, 1–4.
12. Higaki, N.; Goto, T.; Ishida, Y.; Watanabe, M.; Tomotake, Y.; Ichikawa, T. Do sensation differences exist between dental implants and natural teeth?: A meta-analysis. *Clin. Oral. Impl. Res.* 2014, 25, 1307–1310.
13. Tanaka, M.; Bruno, C.; Jacobs, R.; Torisu, T.; Murata, H. Short-term follow-up of masticatory adaptation after rehabilitation with an immediately loaded implant-supported prosthesis: A pilot assessment. *Int. J. Implant. Dent.* 2017, 3, 1–7.
14. Mishra, S.K.; Chowdhary, R.; Chrcanovic, B.R.; Brånemark, P.I. Osseoperception in Dental Implants: A Systematic Review. *J. Prosthodont.* 2016, 25, 185–195.
15. Hoshino, K.; Miura, H.; Morikawa, O.; Kato, H.; Okada, D.; Shinki, T. Influence of occlusal height for an implant prosthesis on the periodontal tissues of the antagonist. *J. Med. Dent. Sci.* 2004, 51, 187–196.
16. Kayumi, S.; Takayama, Y.; Yokoyama, A.; Ueda, N. Effect of bite force in occlusal adjustment of dental implants on the distribution of occlusal pressure: Comparison among three bite forces in occlusal adjustment. *Int. J. Implant. Dent.* 2015, 1, 14.

17. Bakshi, P.V.; Thakur, S.; Kulkarni, S. Perception by Osseointegrated Dental Implants Supporting a Fixed Prosthesis: A Prospective Study. *Int. J. Oral. Maxillofac. Implant.* 2017, 32, 1346–1350.
 18. dos Santos Corpas, L.; Lambrechts, I.; Quirynen, M.; Collaert, B.; Politis, C.; Vrielinck, L.; Jacobs, R. Peri-implant bone innervation: Histological findings in humans. *Eur J. Oral Implant.* 2014, 7, 283–292.
 19. Yan, C.; Ye, L.; Zhen, J.; Ke, L.; Gang, L. Neuroplasticity of edentulous patients with implant-supported full dentures. *Eur. J. Oral Sci.* 2008, 116, 387–393.
 20. Miles, T.S. Reorganization of the human motor cortex by sensory signals: A selective review. *Clin Exp. Pharmacol. Physiol.* 2005, 32, 128–131.
 21. Calford, M.B. Degree of adaptability of the somatosensory cortex to change: Prospects for integration of bone-mounted dental prostheses. *Clin. Exp. Pharmacol. Physiol.* 2005, 32, 115–118.
 22. Habre-Hallage, P.; Hermoye, L.; Gradkowski, W.; Jacobs, R.; Reychler, H.; Grandin, C.B. A manually controlled new device for punctuate mechanical stimulation of teeth during functional magnetic resonance imaging studies. *J. Clin. Periodontol.* 2010, 37, 863–872.
 23. Habre-Hallage, P.; Dricot, L.; Jacobs, R.; van Steenberghe, D.; Reychler, H.; Grandin, C.B. Brain plasticity and cortical correlates of osseoperception revealed by punctate mechanical stimulation of osseointegrated oral implants during fMRI. *Eur. J. Oral Implant.* 2012, 5, 175–190.
 24. Svensson, K.G.; Trulsson, M. Impaired force control during food holdings and biting in subjects with tooth or implant-supported fixed prostheses. *J. Clin. Periodontol.* 2011, 38, 1137–1146.
 25. Flanagan, D. Bite force and dental implant treatment: A short review. *Med. Devices* 2017, 10, 141–148.
 26. Huang, Y.; Van Dessel, J.; Martens, W.; Lambrechts, I.; Zhong, W.-J.; Ma, G.-W.; Lin, D.; Liang, X.; Jacobs, R. Sensory innervation around immediately vs. delayed loaded implants: A pilot study. *Int. J. Oral Sci.* 2015, 7, 49–55.
 27. Enkling, N.; Utz, K.H.; Bayer, S.; Stern, R.M. Osseoperception: Active tactile sensibility of osseointegrated dental implants. *Int. J. Oral Maxillofac Implant.* 2010, 25, 1159–1167.
 28. Grieznis, L.; Apse, P.; Blumfelds, L. Passive tactile sensibility of teeth and osseointegrated dental implants in the maxilla. *Stomatologija* 2010, 12, 80–86.
 29. El Sheik, A.M. Passive tactile sensibility in edentulous subjects treated with dental implants: A pilot study. *J. Prosthet. Dent.* 2004, 91, 26–32.
 30. Shala, K.S.; Dula, L.J.; Pustina-Krasniqi, T.; Bicaj, T.; Ahmed, E.F.; Lila-Krasniqi, Z.; Tmava-Dragusha, A. Evaluation of Sensibility Threshold for Interocclusal Thickness of Patients Wearing Complete Dentures. *Int. J. Dent.* 2017, 2017, 1–5.
 31. Negahdari, R.; Ghavimi, M.; Ghanizadeh, M.; Bohlouli, S. Active tactile sensibility of three-unit implant-supported FPDs versus natural dentition. *J Clin Exp Dent.* 2019, 11, e636–e641.
 32. Kazemi, M.; Geramipناه, F.; Negahdari, R.; Rakhshan, V. Active tactile sensibility of single-tooth implants versus natural dentition: A split-mouth double-blind randomized clinical trial. *Clin. Implant. Dent. Relat. Res.* 2014, 16, 947–955.
 33. Reveredo, A.M.; Shetty, S.; Babu, C.S.; Kumar, G.S.; Priya, K.S.; Pandurangappa, R.; Shetty, A. Evaluation of active tactile perception of single tooth implant prosthesis. *Int. J. Oral Implant. Clin. Res.* 2013, 4, 1–6.
 34. Enkling, N.; Heussner, S.; Nicolay, C.; Bayer, S.; Mericske-Stern, R.; Utz, K.H. Tactile sensibility of single-tooth implants and natural teeth under local anesthesia of the natural antagonistic teeth. *Clin. Implant. Dent. Relat. Res.* 2012, 14, 273–280.
 35. Batista, M.; Bonachela, W.; Soares, J. Progressive recovery of osseoperception as a function of the combination of implant-supported prostheses. *Clin. Oral Implant. Res.* 2008, 19, 565–569.
 36. Enkling, N.; Nicolay, C.; Utz, K.H.; Jöhren, P.; Wahl, G.; Mericske-Stern, R. Tactile sensibility of single-tooth implants and natural teeth. *Clin. Oral Implant. Res.* 2007, 18, 231–233.
 37. Ma, L.; Xiang, L.; Yao, Y.; Yuan, Q.; Li, L.; Gong, P. CGRP-alpha application: A potential treatment to improve osseoperception of endosseous dental implants. *Med. Hypotheses.* 2013, 81, 297–299.
 38. Gulati, M.; Anand, V.; Govila, V.; Jain, N.; Rastogi, P.; Bahuguna, R.; Anand, B. Periodontio-integrated implants: A revolutionary concept. *Dent. Res. J.* 2014, 11, 154–162.
 39. Zhang, X.; Tang, T.; Zhao, Z.; Zheng, L.; Ding, Y. Visualization analysis of research frontiers and trends in nerve regeneration and osseoperception in the repair of tooth loss. *Neural Regen. Res.* 2013, 9, 2013–2018.
 40. Piancino, M.G.; Isola, G.; Cannavale, R.; Cutroneo, G.; Vermiglio, G.; Bracco, P.; Anastasi, G.P. From Periodontal mechanoreceptors to chewing motor control: A systematic review. *Arch. Oral Biol.* 2017, 78, 109–121.
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