Analysis of Active Oral Tactile Sensitivity in Individuals with Complete Natural Dentition

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Abstract

Aim: To evaluate the active tactile sensitivity in individuals with complete natural dentition, determining the smallest thickness detected by the participants, and clarifying if there is a difference between the thicknesses analyzed.

Materials and methods: Active tactile sensitivity was evaluated in 40 research participants. Inclusion criteria included participants with complete natural dentition, without active or history of periodontal disease, absence of temporomandibular disorders, bruxism, and restorations in the evaluated area. Exclusion criteria included age below 18 years. The active tactile perception threshold was evaluated by using carbon sheets of different thicknesses (0, 12, 24, 40, 80, 100, and 200 μm), which were inserted in the participants' premolars, bilaterally. The carbon sheet was inserted so as not to come into contact with the oral soft tissues. Subsequently, the participant occluded and was asked about the perception of the intraocclusal object 20 times in each occlusal contact. The collected data were tabulated considering the amount of positive and negative responses for each carbon thickness. Values of $p < 0.05$ were considered significant.

Results: The results showed that there was linearity in perception, on both sides, besides, the natural dentition was able to perceive difference in thickness from 12 μm.

Conclusion: We conclude that the 12 μm thickness is noticeable in occlusion and can be differentiated from other thicknesses in natural dentition and that there is no difference between the tactile sensitivity of the right and left sides.

Clinical significance: A better understanding of active oral tactile sensitivity will contribute to numerous clinical applications in dentistry, including occlusal adjustment in dental rehabilitation, dental implants prosthesis design, and survival of prosthetic rehabilitation.

Keywords: Active tactile sensitivity, Dental occlusion, Mechanoreceptors, Oral proprioception, Periodontal ligaments, Permanent dentition.

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Introduction

The body's sensitivity is realized by the sensory system formed by sensory receptors or mechanoreceptors (special cells of the peripheral nervous system). These cells collect external and internal information from the body and transmit it to the central nervous system (CNS).[1,2]

Mechanoreceptors are classified into: (a) exteroceptive receptors affected by stimuli from outside the body (mild pressure and touch), (b) internal or enteroceptive receptors, affected by stimuli inside the individual, but at visceral levels, with feelings of pain or pleasure being manifested by the body, (c) proprioceptives are affected by body stimuli within the body, originating from skeletal muscles, tendons, joints and ears, transmitting tension, deep pressure, position awareness, and movement. Therefore, proprioception or kinesthesia is described as a generally unconscious sense that provides the individual with knowledge of the position, orientation, and physiological state of his muscles, joints, and limbs.[1] In turn, the CNS processes the information captured by these sensory mechanoreceptors, translating them into sensory sensations generating responses (sensory or proprioceptive feedback).[3,4]

The buccal mechanoreceptors are located in the periodontal ligament, alveolar mucosa, gingiva, bone, periosteum, and tongue.[3,5,6] Periodontal mechanoreceptors play an important role in detecting and discriminating dental loads and controlling mandibular position when occlusal contact occurs, that is, oral function.[3,5,7,8] In addition, to mechanoreceptors, periodontal ligaments and musculature are responsible for oral tactile sensitivity.[5]

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There are three types of oral tactile sensitivities commonly evaluated: (1) passive tactile sensitivity, where a stimulus is passively applied to a tooth or implant, (2) active tactile sensitivity, where the patient perceives objects interposed between the antagonist arches, and (3) vibro-tactile sensitivity (dynamic sensitivity threshold) which is little researched.[9,10]

Active tactile sensitivity enables the presence or absence of periodontal ligament receptors to be evaluated when teeth are still present, noninvasively and with clinical applicability, since purely passive stimuli are practically absent during mandibular chewing, swallowing, and speech movements.[11]

Knowledge of the active tactile sensitivity in natural dentition may contribute as a basis for future studies in dentistry, in order to improve the detection of proprioception for oral rehabilitation, either through conventional prosthesis: fixed prosthesis, removable prosthesis, or mucosupported prostheses and implant supported. However, there is a lack of information regarding the tactile sensitivity threshold in natural dentition, which can be used as a reference in clinical practice in dentistry. Thus, the objective of the present study is to evaluate the active tactile sensitivity in participants with complete natural dentition, determining the smallest thickness detected by the participants and clarifying if there is a difference between the thicknesses analyzed.

Materials and Methods

This study was conducted according to principles of the Helsinki Declaration of 2013, with the norms of good scientific conduct with human beings and the National Health Council Resolution No. 466 of December 12, 2012, being approved by the Ethics Committee, for Research Involving Human Beings, Faculty of Medicine, Fluminense Federal University, Niterói, RJ, Brazil, under the number 1.616.110, on June 28, 2016. This research was developed at the Post-graduation in Implant Dentistry at the Fluminense Federal University.

Selection of Survey Participant

Forty volunteers, students, and teachers, of the Post-graduation in Implant Dentistry, participated in the research. They willingly agreed to participate in the study and signed the free and informed consent form.

Inclusion criteria included participants with complete natural dentition, without active or history of periodontal disease, absence of temporomandibular disorders, bruxism, absence of restorations, absence of fixed orthodontic appliance, and fixed prosthesis in the area to be evaluated.

There was no age limitation, any volunteer who fit the proposed groups and met the inclusion criteria could participate in this study. It is also important to emphasize that the use of drugs and systemic diseases did not exclude the research participant. Only participants who did not sign the free and informed consent form were excluded as well as those who did not meet the inclusion criteria.

Assessment of Active Tactile Sensitivity

To assess the active oral tactile sensitivity threshold, Bausch (KG, Cologne, Germany) dental carbon sheets of different thicknesses (12, 24, 40, 80, 100, and 200 μm), with 1×2.5 cm^2, were inserted into the premolars region of the evaluated group of research participants. The premolar region was chosen because it has easy access to the interposition of carbon leaves during the tests. A placebo test was carried out, in which Miller tweezers of the Golgran brand (São Caetano do Sul, SP, Brazil) were inserted, represented by 0 μm and it was applied at the same region with the same number of repetitions to the other thickness.

A total of 140 tests per research participant were performed, 70 for the right hemiarch and 70 for the left hemiarch (10 tests for each thickness: 12, 24, 40, 80, 100, and 200 μm, and 10 tests for placebo). The total duration of the evaluation was approximately 40 minutes.

Thickness selection was performed randomly, the carbon sheets were randomly selected, and the study was double-blind, that is, one evaluator interposed the carbon sheet between the participant's arches without knowing which thickness was used and another evaluator wrote down the result on the data collection form. During the experiment, participants were sitting upright in a quiet environment and blindfolded. The dental lip retractor (Morelli Ltda, Sorocaba, SP, Brazil) was used to facilitate the interposition of the carbon leaf in the region to be evaluated and to prevent the contact of the leaf with other regions, such as cheeks and lips (Fig. 1). The carbon sheets were inserted by evaluator 1 with the aid of Miller tweezers, and as soon as the carbon sheet was inserted in the premolar region, the participant was commanded to occlude. Through gestures performed with the left hand, the participant informed evaluator 2 whether or not he felt the presence of the carbon sheet. Evaluator 2 wrote down the results in their form for data collection. The tests were performed on the right hemiarch initially and later on the left side and each carbon leaf was tested ten times. The placebo test where there was no carbon sheet was also performed ten times, totaling 70 tests for each hemiarch (Figs 1A to C).

Statistical Analysis

Data processing and statistical analysis were performed using the GraphPad Prism 6.0 software (CA, USA). The Shapiro–Wilk test was used to evaluate the distribution between the variables. ANOVA/Kruskal–Wallis followed by Dunn's multiple comparisons test with Bonferroni correction to adjust multiple comparisons between groups. p-values < 0.05 were considered statistically significant with a confidence interval (CI) of 95%.

Results

A total of 40 research participants were included in the study, with a mean age of 25 ± 30 years, 30 women and 10 men, all with complete dentition (28 teeth).

In general, all participants were able to detect the placebo thickness. Significant statistical difference was observed between the 0 μm thickness and the other analyzed thicknesses (12, 24, 40, 80, 100, and 200 μm, $p < 0.0001$).

Comparison of Sensitivity Proportionality between Right and Left Sides

The proportionality analysis considered the mean interposition value of all carbon thicknesses and placebo in the interocclusal region. It was observed that there was linearity in perception, on both sides, as the carbon thickness increased (Fig. 2). There was no statistically significant difference when comparing the right side with the left side ($p > 0.05$).

Comparison of Tactile Sensitivity Proportionality between Carbon Thicknesses on Each Side

Right Side

When comparing the carbon thickness to the right side, a statistically significant difference was observed between the 0 μm thickness and all other thicknesses analyzed (12 μm ($p = 0.0027$), 24, 40, 80, 100, and 200 μm ($p < 0.0001$)), showing that the natural dentition can perceive a difference in thickness from 12 μm.

Figs 1A to C: (A) Evaluation of active tactile sensitivity with carbon sheets in the premolar region. A lip retractor facilitated the interposition of the carbon sheets to prevent contact of the leaf with other regions. (B) Miller tweezers with carbon sheets in thickness were randomly evaluated (0,12, 24, 40, 80, 100, 200 µm). (C) Evaluator 1 performing the test and evaluator 2 performing data collection

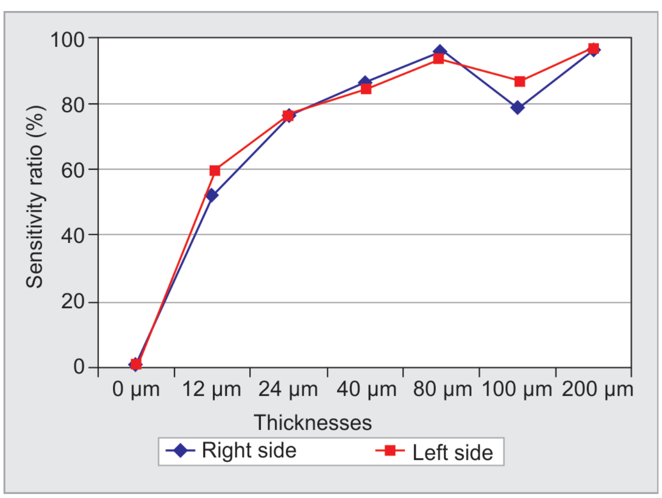

Fig. 2: Line chart showing the linearity of perception on both sides

The 12 µm thickness presents statistically significant difference only between the 80 and 200 µm thicknesses ($p < 0.001$). The other comparisons showed no statistically significant difference (Table 1).

Left Side

As the right side, when comparing the carbon thickness to the left side, a significant statistical difference was observed between the 0 µm thickness and the other analyzed thicknesses (12, 24, 40, 80, 100, and 200 µm, $p < 0.0001$) evidencing that the natural dentition can perceive a difference in thickness from 12 µm equally for both sides.

The 12 µm thickness presents a statistically significant difference only between the 200 µm thicknesses ($p < 0.001$). The other comparisons showed no statistically significant difference (Table 2).

Taking into account that the study aimed to evaluate the active tactile sensitivity in participants with complete natural dentition and based on the results, it can be concluded that the 12 µm thickness is noticeable in occlusion and can be differentiated from other thicknesses in natural dentition and that there is no difference between the tactile sensitivity of the right and left sides.

Discussion

The sensitivity function at the periodontal ligament and its correlation in the maintenance of occlusion has been studied for decades,[1–3,6] however, to date, there are no reports of studies evaluating active oral tactile sensitivity in individuals with complete

Table 1: Comparison of proportionality of sensitivity between right side thicknesses

Thickness (µm)	*12*	*24*	*40*	*80*	*100*	*200*
0	$p = 0.0027$*	$p < 0.0001$*	$p < 0.0001$*	$p < 0.0001$*	$p < 0.0001$*	$p < 0.0001$*
12		$p > 0.9999$	$p = 0.0301$	$p = 0.0001$*	$p = 0.9123$	$p < 0.0001$*
24			$p > 0.9999$	$p = 0.0136$	$p > 0.9999$	$p = 0.0042$
40				$p > 0.9999$	$p > 0.9999$	$p = 0.7493$
80					$p = 0.0676$	$p > 0.9999$
100						$p = 0.0232$

*Indicates evidence of statistically significant difference ($p \leq 0.002$), corresponding to the Bonferroni correction application for the significance of 21 multiple thickness comparisons: $\alpha' = \alpha \div 21 = 0.05 \div 21 = 0.002$) between the proportionality of sensitivity to the thickness indicated on its row and that on its column

Table 2: Comparison of proportionality of sensitivity between left side thicknesses

Thickness (mm)	*12*	*24*	*40*	*80*	*100*	*200*
0	$p < 0.0001$*	$p < 0.0001$*	$p < 0.0001$*	$p < 0.0001$*	$p < 0.0001$*	$p < 0.0001$*
12		$p > 0.9999$	$p = 0.3838$	$p = 0.0031$	$p > 0.9999$	$p < 0.0001$*
24			$p > 0.9999$	$p > 0.9999$	$p > 0.9999$	$p = 0.1025$
40				$p > 0.9999$	$p > 0.9999$	$p > 0.9999$
80					$p > 0.9999$	$p > 0.9999$
100						$p > 0.9999$

*Indicates evidence of statistically significant difference ($p \leq 0.002$), corresponding to the Bonferroni correction application for the significance of 21 multiple thickness comparisons: $\alpha' = \alpha \div 21 = 0.05 \div 21 = 0.002$) between the proportionality of sensitivity to the thickness indicated on its row and that on its column

natural dentition, with various dental carbon thicknesses (12, 24, 40, 80, 100, and 200 µm). Thus, this research aimed to evaluate the lowest thickness detected in individuals with complete natural dentition, as well as to observe if there is a difference between the various thicknesses analyzed. It was observed in the results that perception was linear, on both sides. In addition, it was observed that the natural dentition can perceive a difference in thickness from 12 µm since the comparison of thickness with the placebo test (0 µm) showed a statistically significant difference between the six thicknesses analyzed.

In clinical dental practice, the use of carbon strips has the function of occlusal adjustment in natural teeth, restorations, fixed prostheses, removable proptosis. This can be defined as a treatment modality where the simultaneous occlusal contacts can be checked, harmonizing the relations between the cusps to balance occlusal stress.[12] Mcnamara[13] established that the main objective of an occlusal adjustment is to achieve a stable and atraumatic occlusal relationship between the upper and lower teeth, in addition to a physiological occlusion. A physiological occlusion is a balance of the stomatognathic system, dental occlusion, the temporomandibular joint, and the neuromuscular system. With all these objectives described, it can be concluded that the main objective of occlusal adjustment therapy is to improve the functional relationships of the dentition so that the teeth and the supporting periodontium receive a uniform functional stimulation, resulting in the necessary conditions for the health of the neuromuscular system temporomandibular joint.[14]

According to Jacobs and van Steenberghe,[6] the use of metallic materials during occlusal evaluation may mask the results due to the fact that metals have the characteristic of thermal conductivity. Thus, in our study, we opted for the use of dental carbon sheets, as it is a clinical material for occlusal adjustments. In addition, we use different thicknesses produced by the same manufacturer to minimize biases related to the material composition.

During the tests, it was decided not to use headphones, as we believe it could be a distracting factor for the participants, corroborating with other authors.[8,14,15] In addition, we performed a placebo test with the same number of repetitions applied to the other thickness, which differs from many other studies.[15] Thus, we were able to delimit the real absence of interdental thickness detection in dentate participants.

The test was performed in both hemiarch (right and left) of participants in order to reduce the possibility of variations in the same individual. The carbon sheet thicknesses were randomly chosen to avoid a participant learning curve that could lead to false-positive results in the detection of thin thickness sheets.

One of the limitations of our study would be the use of carbon sheets since no other work used this material, which can make it difficult to compare with precision the findings. Previous researches used gold foils[8,15] and copper foils.[16] Another limitation inherent in the type of assessment is that it is not possible to equate muscle strength during bite for all volunteers.[6,16] Therefore, future studies applying electromyographic analysis may contribute to evaluating the correlation between tactile sensitivity and occlusal force. However, this fact does not minimize the results achieved with these results, since all participants' occlusion had similar dentition at the moment of the analyses and the measurements were performed at the same oral region.

A better understanding of active oral tactile sensitivity will contribute to numerous clinical applications in dentistry, including immediate loading protocols, occlusal adjustment in dental rehabilitations, implant-supported or unsupported prosthesis design, survival of prosthetic rehabilitation, and balance of their interaction with the stomatognathic system. In addition, knowledge about the active tactile sensitivity threshold can improve chewing efficiency, inhibitory reflex response in the chewing muscles, preventing traumatic occlusion, as well as decreasing the risk of prosthesis and restorative overload.[17] Therefore, we believe that assessing the effectiveness of natural dentition in discerning fine tactile stimuli is of significant value in dentistry.

Based on this study, the 24 μm carbon tape is preferable for adjustments in natural dentition including occlusal adjustment in teeth restorations, fixed prostheses, and removable prosthesis.

Conclusion

Based on the results, we concluded that the thickness of 12 μm is noticeable in occlusion and can be differentiated from other thicknesses in natural dentition. In addition, there is no difference between tactile sensitivity on the right and left sides.

Clinical Significance

The results from this research can contribute to a better understanding of active oral tactile sensitivity to improve numerous clinical applications in dentistry, including occlusal adjustment in dental rehabilitation, dental implants prosthesis design, and survival of prosthetic rehabilitation.

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