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Original Article

Dentistry Section

Comparative Evaluation of Passive Tactile Sensibility Associated with Osseointegrated Implants in Various Regions of Partially Edentulous Arch-A Prospective Cohort Study

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ABSTRACT

Introduction: The extremely sensitive tactile sensors periodontal mechanoreceptors play a key role in sensory innervation of teeth. The oral kinaesthetic perceptual abilities in the absence of periodontal mechanoreceptive input can be achieved by osseointegrated prosthesis.

Aim: To evaluate the passive tactile sensibility associated with osseointegrated dental implant in various regions of the maxillary and mandibular arch.

Materials and Methods: A prospective cohort study was performed in SRM Dental College, Chennai, India between August 2013 to February 2015. Fifty patients who had single tooth replacement with functioning implants loaded six months before were included. A compressive force was applied along the long axis of the implant supported prosthesis using a push type force measuring gauge until the subject felt the first sensation of pressure and subsequently, it displayed the magnitude of force that provided the tactile sensation. The force measuring gauge used was Model: FG 5000 A form Lutron electronic enterprises co., ltd. The procedure was repeated thrice. The patient was guided to record the force perception on visual analogue scale with continuous force. The visual analogue scale has values 0-4 starting from no sensation, mild, moderate, intense and pain and the average force measured. The values of the force recorded were statistically analysed using the t-test, Statistical Package for the Social Sciences (SPSS) version 17.0 was used. The p-value of 0.05 was considered statistically significant.

Results: The overall mean value of maxilla was 23.12 N and the standard deviation was ±2.88 N. The overall mean value of mandibular was 22.44 N and the standard deviation of ±2.06 N and there was no significant difference in the threshold for passive tactile perception between maxilla and mandible.

Conclusion: The results showed that mandibular anterior teeth had least threshold for force applied than any other region of the mouth and the maxillary posterior had the highest threshold. The anterior region exhibited better passive tactile threshold measure when compared to posterior region.

Keywords: Oral kinesthetic perception, Osseoperception, Periodontal mechanoreceptors, Visual analogue scale

INTRODUCTION

Human teeth are innervated with highly sensitive tactile periodontal mechanoreceptors. These sensors provide information about tooth loads and are located in Periodontal Ligaments (PDL). The extraction of the teeth involves the elimination of these mechanoreceptors [1,2]. Histological, neurophysiological and, psychological evidence of osseoperception reveals that a peripheral feedback pathway can be restored when the teeth are replaced with osseointegrated implants [3-5]. Though the functional reinnervation around the implant is still not fully understood, the implant allows for perception of pressure and load through a process called osseoperception. The loss of PDL and the mechanoreceptors leads to functional and psychological disturbances [6]. Implant-supported prostheses restore the jaw function to the physiological discriminatory ability and oral stereognosis. The peripheral feedback for implants is contributed by rich jaw bone innervation that may help to sense mechanical deformation during implant loading [7,8]. There are numerous neurophysiological and psychophysical methods to record the oral tactile sensation. Neurophysiological examinations are complex and hence, the studies are scarce. The oral tactile sensation can be efficiently recorded by the Trigeminal Somatosensory Evoked Potentials (TSEP) after stimulation of the receptors in the oral cavity [9,10].

Owing to the complexity in the examination of the TSEP, psychophysical methods attained popularity and the studies are numerous [1,2,11].

In the psychophysical method of assessment, the psychological response of the patients was correlated to the physiological functions of the receptors by following well-defined methodologies to determine the threshold level of the sensory receptors. But, the psychophysical methods are influenced by the environment and the patient-related factors [1].

The psychophysical testing reveals an improved tactile and vibrotactile capacity with an osseointegrated implant. The recent consensus statement on osseoperception included the sensory-motor interaction and defined it as the sensation arising from mechanical stimulation of a bone-anchored prosthesis, transduced by mechanoreceptors that may include those located in muscles, joint, mucosal and periosteal tissues; together with a change in central neural processing in maintaining sensory-motor function [2]. Such tactile sensation from the osseointegrated dental implants can be best recorded on the visual analogue scale by psychophysical method.

The visual analogue scale is the tool to record the psychophysiological response to the force applied [11]. Thus, the aim of the study was to evaluate the passive tactile sensibility associated with osseointegrated dental implant in various regions of the maxillary and mandibular arch.

MATERIALS AND METHODS

A prospective cohort study was performed at SRM Dental College, Chennai, India between August 2013 to February 2015. Informed consent was taken from the patients and Institutional Ethical Committee clearance was obtained before commencing the study (SRM/M&HS/SRMDC/M.D.S.-PG Student/203).

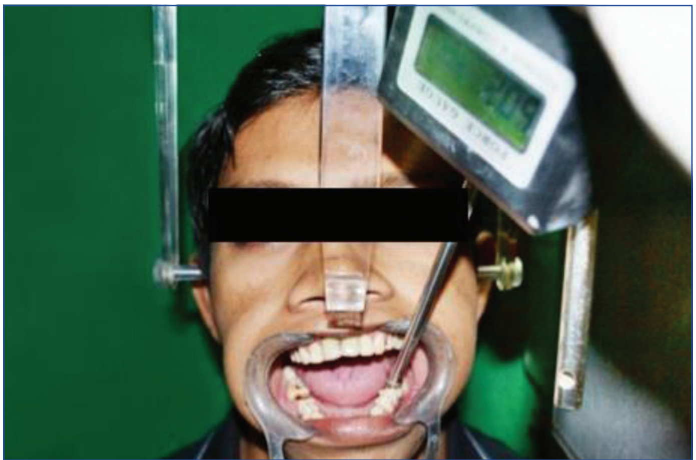
Sample size calculation: Using nMaster software with the power of 80% and level of significance alpha error 5%, the mean 2.5 and, standard deviation 1.39, we arrived at the sample size 42 and rounded it to 50 [12].

Inclusion and Exclusion criteria: Inclusion criteria prioritised functioning implants which were loaded at least six months earlier, owing to the better osseointegration over the functioning period. Irradiated patients or patients with any systemic condition such as rheumatoid arthritis, chronic kidney disease, respiratory disease, cognitive impairment, cancer or those who had mobile implants or implants with peri-implantitis were excluded.

Study Procedure

Thus, 50 subjects of both sexes of age group 20-70 years, who underwent single tooth replacements with dental implants (Two-piece, screwed abutment and restored with a cement retained porcelain fused to metal crown) either in anterior or posterior region of both arches were selected for the study. Implant mobility was checked based on surgeon's perception. An Orthopantomagram (OPG) was taken before the study to identify any underlying pathology such as horizontal or vertical bone loss, cysts, tumours etc. The patients were seated comfortably in a relaxed posture in an upright position in the center of the OPG machine and the patient's head was carefully secured in position.

A cheek retractor was placed in the patient's mouth to avoid any interference from the cheek and surrounding musculature during the procedure. Test loading was accomplished with the push-end of force measuring gauge (Model FG-5000 A, Lutron Electronic Enterprise Co Ltd.,: 150 9001 quality management system certified by SGS Technical services Pvt., Ltd.,) [Table/Fig-1].



[Table/Fig-1]: Showing force application.

Force Measurement

The force measuring gauge (push-end) was placed on occlusal/incisal surface parallel to the long axis of the implant and compressive force was applied directly on the restoration. Force application was subjective. Any contact between the lips and any other part of the muscles or device was avoided to overcome any false reading. The force application was progressively increased. During the application of the force, the patient was asked to respond at the first sensation of the application of the pressure.

The perception of the patient was recorded on Visual Analogue Scale (VAS) as 0-no sensation; 1-mild sensation; 2-moderate sensation; 3-intense sensation; 4-pain sensation; and the corresponding force values in the gauge were recorded for all cases [13].

The recording for each tooth was done thrice in the same position and the average force measured was tabulated. The forces recorded for each tooth at 0, 1, 2, 3 of VAS was tabulated as maxillary anterior (n=15), maxillary posterior (n=15), mandibular anterior (n=10) and, mandibular posterior (n=10).

STATISTICAL ANALYSIS

The values of the force recorded were statistically analysed using Student's t-test. The Student's t-test was used to compare the tactile sensation between two regions of the oral cavity. SPSS Windows version 17.0 was used. The p-value of 0.05 was considered statistically significant.

RESULTS

The forces corresponding to the passive tactile sensation were recorded to compare the threshold between the maxillary anterior and maxillary posteriors [Table/Fig-2]. [Table/Fig-1,2] shows that the threshold for passive tactile perception of posterior were found to be higher than anterior in the maxillary arch. Total mean of the maxillary anterior was found to be 20.81 N and standard deviation was ±0.85 N and the total mean for the maxillary posterior was 24.85 N, standard deviation was ±2.66 N. The p-value of 0.001 was considered statistically significant. The p-value was found to be significant in mild, moderate, intense, pain sensation groups (p<0.001).

	Maxillary anterior (n=15)		Maxillary posterior (n=15)		
VAS	Mean	Standard deviation	Mean	Standard deviation	p-value
No sensation	2.042	0.095	2.098	0.193	0.149
Mild sensation	3.408	0.185	3.824	0.306	<0.001**
Moderate sensation	4.253	0.200	5.207	0.657	<0.001**
Intense sensation	5.211	0.299	6.49	0.794	<0.001**
Pain	5.903	0.322	7.229	0.883	<0.001**
Overall	20.81	0.855	24.85	2.66	<0.001**

[Table/Fig-2]: Comparison of passive tactile sensibility associated with osseointegrated implants in maxillary anterior and maxillary posterior region using t-test.
**highly significant

The forces corresponding to the passive tactile sensation were recorded to compare the threshold between the mandibular anterior and mandibular posteriors. [Table/Fig-3] shows that there were significant differences in passive tactile sensation between mandibular anterior and posterior teeth. The overall mean force was found to be 20.67 N and 23.77 N and the standard deviation of 0.6 N and 1.75 N for mandibular anterior and posteriors, respectively.

	Mandibular anterior (n=10)		Mandibular posterior (n=10)		
VAS	Mean	Standard deviation	Mean	Standard deviation	p-value
No sensation	2.10	0.171	2.045	0.088	0.59
Mild sensation	3.44	0.104	3.685	0.203	<0.001**
Moderate sensation	4.23	0.173	5.014	0.425	<0.001**
Intense sensation	5.131	0.21	6.186	0.547	<0.001**
Pain	5.76	0.295	6.844	0.674	<0.001**
Overall	20.67	0.6	23.77	1.75	<0.001**

[Table/Fig-3]: Comparison of passive tactile sensibility associated with osseointegrated implants in mandibular anterior and mandibular posterior region using t-test.
**highly significant

The forces corresponding to the passive tactile sensation were recorded to compare the threshold between the mandibular anterior and the maxillary anterior. [Table/Fig-4] shows that the overall mean for mandibular anterior was 20.67 N and maxillary anterior was 20.81 N. The p-value was 0.11.

VAS	Mandibular anterior (n=10)		Maxillary anterior (n=15)		p-value
	Mean	Standard deviation	Mean	Standard deviation	
No sensation	2.10	0.171	2.042	0.095	0.83
Mild sensation	3.44	0.104	3.408	0.185	0.37
Moderate sensation	4.23	0.173	4.253	0.200	0.76
Intense sensation	5.131	0.21	5.211	0.299	0.23
Pain	5.76	0.295	5.903	0.322	0.78
Overall	20.67	0.6	20.81	0.855	0.11

[Table/Fig-4]: Comparison of passive tactile sensibility associated with osseointegrated implants in mandibular anterior and maxillary anterior region using t-test.

The forces corresponding to the passive tactile sensation were recorded to compare the threshold between the mandibular posterior and maxillary posterior using Student's t-test. [Table/Fig-5] shows that the threshold for passive tactile perception for the maxillary posterior was found to be higher than mandibular posterior. The overall mean of the maxillary posterior was found to be 24.8 N and standard deviation was ±2.6 N. The overall mean for mandibular posterior was found to be 23.7 N and standard deviation was ±1.7 N. The p-value was found to be significant (p=0.03).

VAS	Maxillary posterior (n=15)		Mandibular posterior (n=10)		p-value
	Mean	Standard deviation	Mean	Standard deviation	
No sensation	2.098	0.193	2.045	0.088	0.116
Mild sensation	3.824	0.306	3.685	0.203	0.19
Moderate sensation	5.207	0.657	5.014	0.425	0.123
Intense sensation	6.498	0.794	6.186	0.547	0.44
Pain	7.229	0.883	6.844	0.674	0. 31
Overall	24.85	2.66	23.77	1.75	0.03*

[Table/Fig-5]: Comparison of passive tactile sensibility associated with osseointegrated implants in mandibular posterior and maxillary posterior region using t-test.
*significant

[Table/Fig-6] showed that the forces corresponding to the passive tactile sensation were recorded to compare the threshold between the mandibular and the maxillary arch irrespective of anterior and posterior position. [Table/Fig-6] shows that there was no significant difference in the threshold for passive tactile perception between maxilla and mandible at p<0.05. The overall mean value of maxilla was 23.12 N and the standard deviation was ±2.88. The overall mean value of mandibular was 22.44 N and the standard deviation of ±2.06 N which was statistically not significant.

VAS	Maxillary arch (n=30)		Mandibular arch (n=20)		p-value
	Mean	Standard deviation	Mean	Standard deviation	
No sensation	2.07	0.16	2.07	0.13	0. 849
Mild sensation	3.64	0.33	3. 58	0.20	0.170
Moderate sensation	4.79	0.69	4.68	0.51	0.263
Intense sensation	5.94	0.89	5.73	0.68	1.17
Pain	6.66	0.95	6.37	0.76	0.57
Overall	23.12	2.8	22.44	2.06	0.112

[Table/Fig-6]: Comparison of passive tactile sensibility associated with osseointegrated implants in maxillary and mandibular arch using t-test.

DISCUSSION

The functioning of the oral apparatus is very much dependent on the input of the neural network by proprioception and perception. The loss of an individual chewing unit can lead to the non integration of the proprioception and perception which in turn handicaps the neural system [2]. The sensory and motor responses go hand in hand in neuro-muscular activity of the masticatory system. When missing teeth are replaced, the successful outcome of the treatment is also dependent on the proper integration of the proprioceptive feedback and motor responses. Tooth extraction damages the sensory feedback pathway owing to the loss of PDL and its richly innervated mechanoreceptors [2]. Unanchored removable prostheses cannot compensate for the normal tooth loading compared to the anchored (osseointegrated) prosthesis as the mucosal mechanoreceptor functions are less efficient than the periodontal mechanoreceptors [2]. The direction, magnitude and, the rate of occlusal load is best perceived by the periodontal mechanoreceptors. With tooth extraction, all these fine proprioceptive control mechanisms are lost. Still, the oral tactile function can be restored with dental implants [14].

The tactile function with implant-supported prosthesis is extensively studied (Haraldson T et al., 1979; Lindquist LW and Carlsson GE 1986; Carr AB and Laney WR 1987) and compared with natural teeth and complete dentures [14-16]. The periodontal mechanoreceptors have varied active and passive discriminative ability of forces. Passive discrimination of the receptors was assessed by the application of controlled forces to the tooth. Active discrimination involves the presence of an object between the teeth and does not solely depend on periodontal receptors. The input from the teeth, periodontium, jaw muscles, TMJ ligaments and, capsules also play a role in active discrimination [16].

Various studies by Karayiannis AI et al., Jacobs R and van Steenberghe D indicate that passive tactile sensation of an implant-supported prosthesis is higher than that of a natural tooth. In this study, the passive tactile sensibilities associated with osseo-integrated implant-supported prostheses were recorded in various regions of the oral cavity of partially edentulous patients and compared the sensibilities within the anterior and posterior region of the same arch and between the maxillary and mandibular arches [12,17]. Experiments involving electrical stimulation in cats demonstrate that some sensory innervation exists in the alveolar bone comprising of both unmyelinated and myelinated sensory fibers [17]. The unmyelinated (type C) fibers have a conduction velocity of 1 to 2 m/s. The free endings also characterise the C fibers endowing the mandibular alveolar bone and might play a role in sensory impulses. The myelinated (type A) fibers have conduction velocities ranging between 3 and 11 m/s. Some of the A fibers are found to be connected to the encapsulated endings, Ruffini's corpuscles. These sensory formations are found in osteoblasts in the tissue connecting between canine to the first premolars which act as force sensors. Studies show that these sensory innervations are not present only in the alveolar but also the spongy bone apart from the PDL. Histological findings show the presence of specialised Ruffini mechanoreceptive terminals in the immediate vicinity of the implant. They were predominately myelinated fibers. The unmyelinated fibers were also present under the implant thread. Repetition of histological studies after implant loading revealed the increase in the number of free nerve endings [18,19]. Hence, an implant-supported prosthesis osseintegrated with bone has better osseoperception than the unanchored prosthesis. The intensity of osseoperception varies with the quality and quantity of available bone [20,21].

Limitation(s)

The study was performed based on VAS which is more a subjective measure. This could influence the results.

CONCLUSION(S)

The anterior region exhibited better passive tactile threshold measure when compared to posterior region. There was no significant difference in sensation between maxillary and mandibular arches. The result showed that mandibular anterior teeth have least threshold for force applied than any other region of the mouth and the maxillary posterior had the highest threshold.

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