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Clinical study on the active tactile sensibility test of single-tooth implants

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Abstract

To compare the active tactile sensibility (AST) between natural teeth and implant dentures, and explore the risk factors. To establish a database of normal tactile thresholds of natural teeth, and integrate the results from experiments. 50 patients underwent posterior dental implant restoration. A healthy group was also enrolled as control. Patients were firstly placed in semi-supine position with soothed tension and wore ear pads and goggles. Next, T-scan II digital occlusal analysis system (Tekscan,USA). The test was performed in double-blind way and recorded by the third. Results were analyzed using SPSS software and P value less than 0.05 was considered as statistically significant. Active tactile sensibility showed no statistically significant difference between natural teeth and dental implants among males and females ($P > 0.05$). However, there was difference between the natural tooth and implant tooth ($P < 0.01$), and there was also statistically significant difference between the front tooth and the back of the natural tooth and implant tooth ($P < 0.01$). There is no significant difference in the determination of the active tactile sensitive threshold difference between the implanted tooth and the natural tooth, which could serve as a comprehensive guiding for clinical strategies of tooth implantation.

Keywords: active tactile sensibility; clinical bone sensation; implant dentures; natural teeth.

Practical application: The sensitivity of active tactile sensibility was compared to explore the risk factors associated with the active tactile sensitivity threshold of implant dentures.

1 Introduction

Previous studies have shown that there may be a sensory feedback around the implant to regulate jaw movements (Loucks & Nil, 2012; Inoue et al., 2004). If the implant could provide effective central and peripheral feedbacks to the chewing movement, the implant mediated sensory-motor interaction can help the patients to the closest function as before. An implant with a high tactile sensibility can be beneficial to improve the chewing efficiency of patients and can increase the jaw-unloading reflex sensitivity (including protective reflex and noxious reflex), to reduce the trauma and decrease the excessive load on the remaining teeth as well as the implant dentures.

The chewing function in human is a systematic, orderly and complex process in which the teeth, temporomandibular joints and chewing muscles cooperate with each other under the control of the central nervous system. In this process, the mechanoreceptors such as the nerve fiber endings in periodontal ligament can produce proprioceptive feedback and integrate some information (the nature of food, precise direction of force, and the exact size of force) into the central nervous system. This integration enables the adjustment of the movement of the joints and muscles and the production of the most accurate and effective forces (Trulsson, 2005). Teeth extraction can result in the loss of periodontal ligament and its internal receptors. Since there is no periodontal ligament around the implant, theoretically, it cannot transduce the information from chewing (Figure 1). However, whether the implant is a dental implant of a body (like a finger), the tactile sensation of the patients will recover when the osteointegration happens (Krafft et al., 2012; Fu et al., 2017; Aydin et al., 2008). This means that there are other sensory mechanisms than the periodontal ligament that can exert sensory motor function, which suggests that osteointegrated implants are not independent of human body; it can be fed back by the nervous system and become a part of human body with specific physiological functions.

In 2005, the concept of Osseopercetion was formally published, and has been described as a bone-anchored prosthesis which has the ability to sense mechanical stimuli that may be found in muscles, joints, mucous membranes, subcutaneous and periosteum tissues. The mechanoreceptor conductance is also known to be accompanied by changes in the neurobiological properties of the central nervous system in processing sensory motor information (Klineberg et al., 2005). The muscle spindle in the muscle can adjust the position and speed of the mandibular movement independently of the tooth during opening and closing of the mouth, the proprioceptor in the temporomandibular joint spasm can provide information such as the position of the mandible during exercise. The mechanoreceptors within submucosal connective tissue can sense the movement of the tongue during chewing, the pressure of the food, and the stretching of the mucous membrane. Moreover, the mechanoreceptors in the periosteum are related to the sense of the implant body, even the auditory receptors of the inner ear can sense the sound information of

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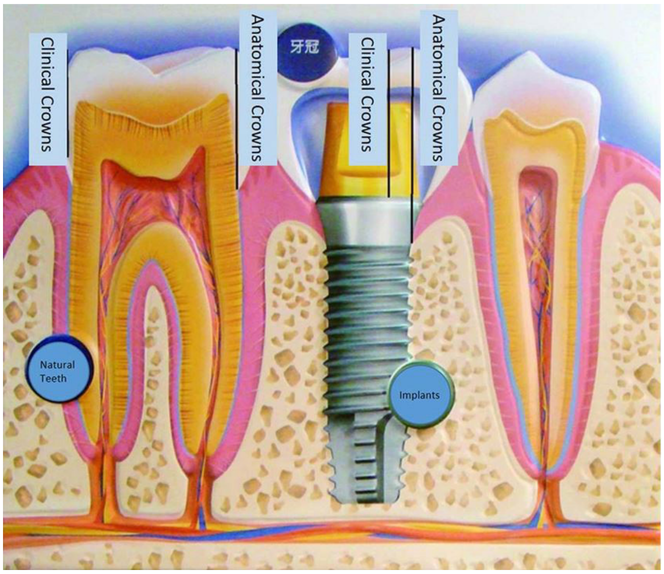

Figure 1. Anatomical crowns and clinical crowns for dental implants and natural teeth.

the bone conduction when chewing. When the periodontal ligament was lost, the above-mentioned receptors would revive multiple information from the chewing motion and then the central nervous system was re-adapted to the changes in the body, thereby establishing a new form of chewing movement. Patients who are clinically implanted with dental implants do acquire a special sensory perception about their implants. Histological and neurophysiological studies have confirmed the existence of "bone perception" (Joda et al., 2017; Linck et al., 2016), but the underlying mechanisms still need to be further explored. The conventional method of reducing the plane and crown of superstructure to prevent the implant from undergoing uncontrolled over-strength is not supported by sufficient clinical evidence currently (Jacobs & Van Steenberghe, 2006; Klineberg et al., 2012). Therefore, understanding the mechanism of bone perception on the implant superstructure's design and long-term return visits have positive guiding significance.

2 Patients and methods

2.1 Patients

Patients who had undergone posterior dental implant restoration from 2013 to 2016 (unilateral, requiring that both the maxillary teeth and the opposite side of the same tooth, and their jaw teeth are natural teeth) at our hospital and had no significant effect on experiment like system diseases, mental status, or psychological normality with good compliance were included in this study. Other criteria were showed as follows: (a) The jaw teeth and other posterior teeth of patients had no defects; (b) Teeth were complete without obvious shadow on the apex and with stable occlusion; (c) Patients did not require for bone grafting but needed the delayed planting methods and the ITI (SLA) standard implants. (d) Tracking for the status of the repair load after one month and a return visit for two years were required, during which implants were not loose, broken, porcelain collapse, and the retention rate was 100%.

For the healthy group, we selected subjects with complete dentition, bilateral chewing, good compliance, other than orthodontics and prosthetic restorations. They were grouped by age (18-35y, 36-55y, 55-60y), with a ratio at 1:1 for male and female.

The study was approved by our hospital. Informed consent was obtained.

2.2 Methods

The testing process was described in detail to the patients but the purpose of the study in case of subjective bias. The patients had to avoid eating and chewing 1 hour before testing. The T-scan II digital occlusal analysis system (Tekscan, USA) was used to examine patients with implant dentures who had contact with the jaw's natural teeth. Patients were placed in a semi-supine position (with stable light source illumination, independent chair position, and quiet and noiseless outside) with soothed tension and wore ear pads and goggles. The biting test paper (15 μM, Arti-Fol, Germany) was put through the patient's cusp staggered, advancement, and lateral marked teeth/denture occlusion sites. The computer randomly selected (double-blind to physician and the patient, and transmitted by a third party) a certain thickness of gold foil (including a 0 μM blank control group) and placed it on the jaw bite/denture occlusion site. The patients had normal closed occlusion to the cusp staggered position, and the third person recorded ATST results (each thickness repeated 5 times, the result was recorded as + or -). The detailed experiment procedure was showed as Figure 2.

2.3 Statistical analysis

The non-parametric Kruskal-Wallis test (the nonparametric) was performed based on relevant influencing factors such as implanting sites, locations (upper or lower jaws), implant diameter, length, loading time, patient age, and gender. Referring to the database of relevant measurement items from the normal population and assess the possible influence factor on the integration of the "physiological function" of the implant.

All statistical analysis was performed by the software statistical package for social sciences version 20.0 (SPSS, Chicago, IL). A result will be considered statistically significant when the P value was less than 0.05.

3 Results

3.1 Clinical features of patients enrolled

In total, 50 patients participated in the test and no patient was discharged because of incorrect perception. The total average age was 40.7 ± 11.7 years (aged 19-60 years). Within the group, 26 people were females (52%), and the average age was 40.6 ± 11.9 years old. The others were males (48%), and their average age was 40.5 ± 11.6 years old.

3.2 Comparison of active tactile sensibility between implants and natural teeth

Consequently, the difference of active tactile sensibility for implants and natural teeth were compared. As showed in Table 1, no statistically significant difference was found between

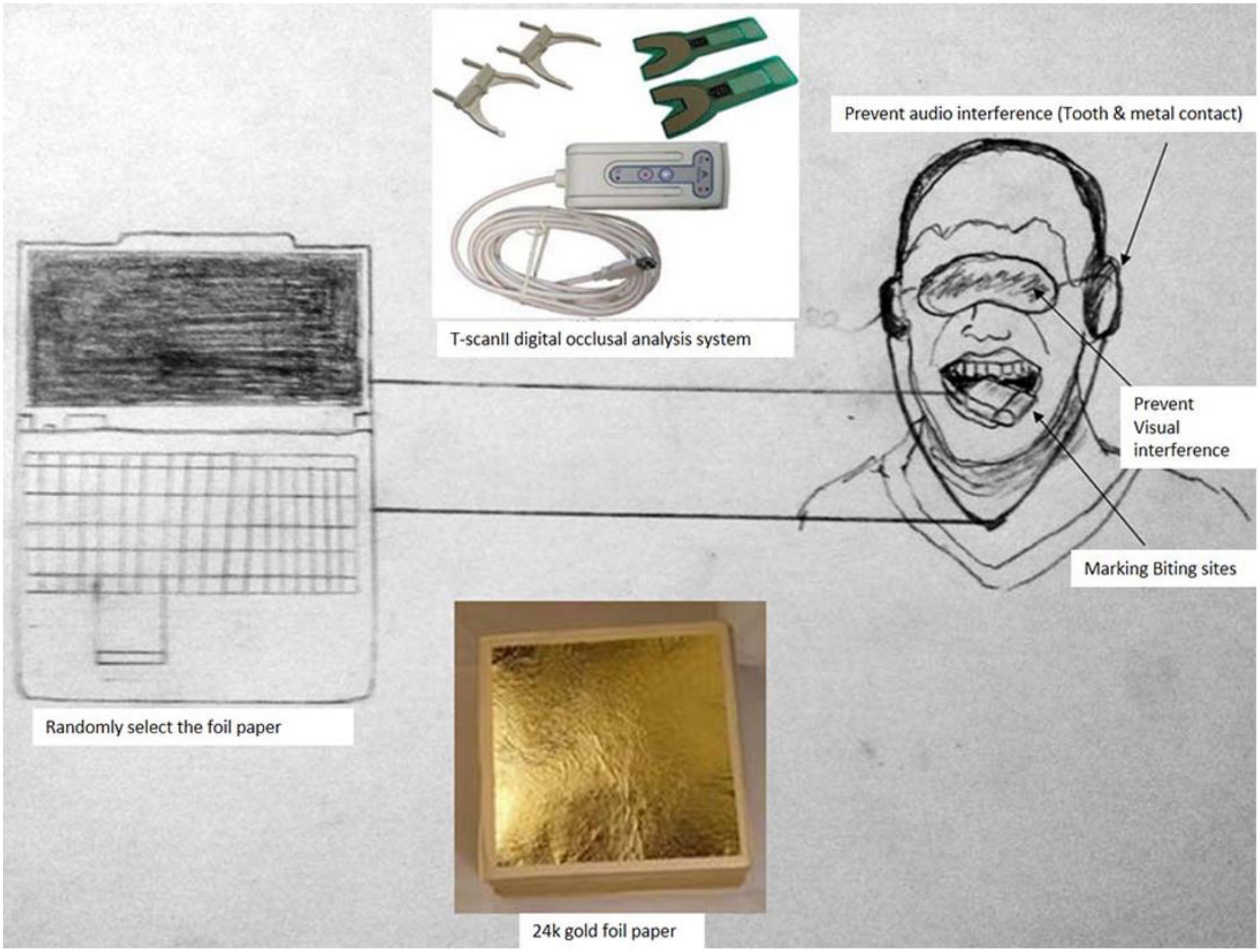

Figure 2. ATST flow diagram.

Table 1. Determination of the active tactile sensibility threshold for implants and natural teeth.

Group	Subgroup	Tooth type	Mean(um)	SD	CV(%)	*P**	95% CI (μM)	
Arch	Maxilla (n = 30)	Implant	46.13	3.15	6.83		44.96	47.31
		Tooth	31.8	4.82	15.16		30.00	33.60
		Difference	14.33	1.78	12.42	0.0001	13.27	14.93
	Mandible (n = 20)	Implant	46.7	3.45	7.39		45.09	48.32
		Tooth	32.7	5.04	15.41		30.34	35.06
		Difference	14	1.79	12.79	0.0001	13.6	14.94
Region	Anterior (n = 26)	Implant	45.92	3.42	7.45		44.54	47.30
		Tooth	31.54	5.10	16.17		29.48	33.60
		Difference	13.38	1.79	13.38	0.007	13.66	15.11
	Posterior (n = 24)	Implant	46.83	3.06	6.53		45.54	48.13
		Tooth	32.83	4.64	12.64		30.87	34.79
		Difference	14	1.77	7.22	0.003	13.25	14.75
Gender	Male (n = 26)	Implant	46.67	3.37	15.59		45.33	48.01
		Tooth	32.52	5.07	13.78		30.51	34.53
		Difference	14.15	1.95	6.80	0.051	13.24	14.93
	Female (n = 24)	Implant	46.00	3.13	14.87		44.65	47.36
		Tooth	31.74	4.72	12.20		29.7	33.78
		Difference	14.26	1.74	12.42	0.024	13.51	15.01

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

natural teeth and dental implants among the males and females ($P > 0.05$). However, there was a statistically significant difference between the natural tooth and implant tooth of the mandible ($P < 0.01$). Statistically significant difference was also found between the front tooth and the back of the natural tooth and implant tooth ($P < 0.01$).

According to the equivalent test method, the 95% confidence interval was inconsistent. There was a certain clinical difference in the 95% confidence interval between the maxilla and mandible. There were certain clinical differences between the front teeth and the back of the natural tooth and the implant tooth with 95% confidence interval. In addition, there was no certain clinical difference intervals for men and women with 95% confidence. Taken together, there is no significant difference in the determination of the active tactile sensitive threshold difference between the implanted tooth and the natural tooth ($P > 0.05$). (Figure 3)

4 Discussion

In this study, we firstly compared the active tactile sensibility between natural teeth and dental implants integrating clinical features such gender, implanting sites and location. Additionally, a group of normal population was also included. We found no significant difference in the determination of the active tactile sensitive threshold difference between the implanted tooth and the natural tooth among different genders. While active tactile sensibility showed statistically significant difference between different implanting sites and locations. Our results together proposed that there was no significant difference in the determination of the active tactile sensitive threshold difference between the implanted tooth and the natural tooth, which could be of great help for tooth implantation strategies.

It is known that a highly tactile-sensible implant is critical for the recovery of the appropriate sensory-motor control and mastication efficiency (Abarca et al., 2006; Jang & Kim, 2001; Enkling et al., 2010). However, the reliability of the active tactile sensibility in the implant is controversial and a database of the normal population is urgently needed. Investigators have found different levels for implant ATS for the tooth tactile perception capacity, which may greatly affect the assessment of the patients (Enkling et al., 2007; Tzakis et al., 1990). Therefore, it is necessary to figure out the risk factors associated with the active tactile sensitivity threshold of implant dentures and improve the active tactile sensibility test.

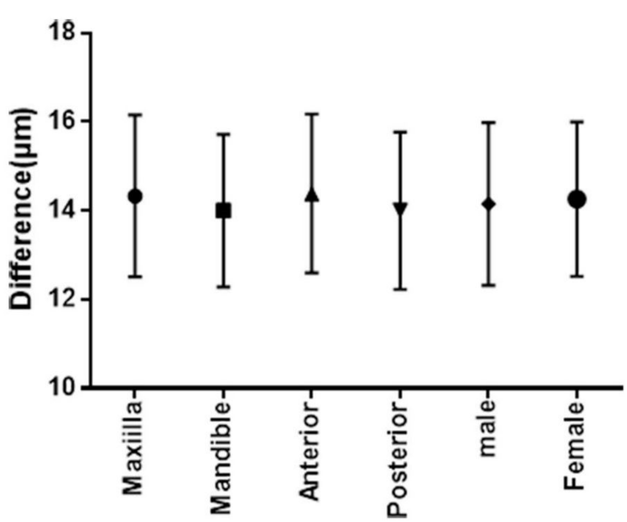

Figure 3. Determination of differences in active tactile sensitive thresholds between implants and natural teeth between groups.

Currently, researches on bone sensation is mostly concentrated on the peripheral afferent nerve. Studies about tactile perception ability of implants and susceptors' threshold confirmation were almost reported using histomorphological observations, electrophysiological experiments and psychophysiological experiments (Trulsson, 2006; Trulsson & Gunne, 1998). Here, we detected the tactile perception ability using psychophysiological experiments, which showed obvious advantages. Firstly, psychophysiological experiments are non-invasive and relatively easy to carry out. Secondly, this type of experiment includes passive tactile sensibility and active tactile sensibility. In the passive tactile sensitivity test, the subject's tested tooth or implant was subjected to external forces (vibration, current, etc.), and the threshold value was expressed in terms of the applied force (Newtons) (Enkling et al., 2012; El-Sheikh et al., 2004; Hsieh et al., 2010). Passive tactile sensitivity experiments were performed on a single type of receptor, demonstrating the presence of tactile receptors in the bone tissue surrounding the implant. Regarding to the active tactile sensitivity test, it requires the subject to bite or bite off the metal film sensor or food between the maxillary and mandibular teeth, observing the change information of force, electromyogram, and mandibular motion trajectory during this process. The threshold was expressed in terms of film thickness (μM). It is closer to the detection of the function of natural teeth, because the sensitized receptors are not only near the implant in the bone, but also include various types of receptors in the musculature of muscles and joints. Therefore, the active tactile sensitivity test was more relevant to the clinical practice of oral cavity. Finally, compared with passive tactile sensitivity experiments, there are few reports on active tactile sensitivity experiments. In those published literatures, the population size was small, and the test results were contradictory (Enkling et al., 2010). In addition, considering the recent relevant researches of oral medicine at domestic and overseas in this field, we improved the active tactile sensitivity test method. Some subjects-related special factors in the above-mentioned experiment, such as the subject's gender, age, and sensory sensibility, are generally less considered, and these factors may affect the result of the experiment.

5 Conclusion

In conclusion, in our study, the sensitivity of active tactile sensibility was compared to explore the risk factors associated with the active tactile sensitivity threshold of implant dentures. At the same time, we established a database of normal tactile thresholds for natural teeth, integrated the test results with the database, and provided a theoretical basis for the clinical establishment of bone sensing routine detection projects and their feasibility.

Ethical approval

The study was approved by the School & Hospital of Stomatology, Tongji University, Shanghai Engineering Research Center of Tooth Restoration and Regeneration. Informed consent was obtained.

Conflict of interest

The authors declare that they have no conflict of interest.

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