Osseoperception in Implants Supported Prosthesis - A Review

Dr Lakshya Kumar, Dr Balendra P. Singh, Dr Jitendra Rao, Dr Kamleshwar Singh

Department of Prosthodontics, Faculty of Dental Sciences, C.S.M. Medical University, Lucknow, Uttar Pradesh, India.

Downloaded 8 February, 2012

Since the advent of Professor Per-Ingvar Brånemark sensational revelation about Osseo integration, a whole new era has began where prosthetic rehabilitation of most of external parts of the body without much loss of function is possible. Osseoperception is the term given to the patient-reported with feeling of heightened perception of the environment with osseointegrated prostheses. In other words the implant placed in bone allows a person to perceive pressure, load, position and balance through a process called Osseo perception.

The sensory – motor and tactile discriminative capabilities are improved with the implant supported prosthetic in comparison to the tissue born denture prosthesis yet these are less than the dentate status. However, it is also likely that an appropriately designed implant-supported restoration, being fixed to bone, more closely resembles the dental status before tooth loss, and this may more appropriately restore optimal motor and sensory function of the masticatory system.

This brief review article is to give a general view about neurophysiological capability of Osseo integrated implants in medical and dental field.

Keywords: Implant supported prosthesis, osseoperception, Mechanoreceptors, Tactile discriminatory capabilities.

INTRODUCTION

Central nervous system (CNS) controls the oral motor functions, which relies on information from the sensory organs in the orofacial structures. Periodontal mechanoreceptors provide feedback of magnitude, direction, and rate of occlusal load application for sensory perception and motor function [1,2]. These periodontal neural receptors play an important role in oral tactile function, the impact of tooth extractions on the sensory feedback pathway may be considerable [3]. The loss of periodontal mechanoreception influences the control of jaw function and the precision of magnitude, direction, and rate of occlusal load application [4].

Conventional complete denture prostheses do not carry enough sensory information to restore the necessary natural feedback pathways for motor function. Regardless of the technical excellence of such prostheses, they are inherently unstable during normal functional jaw movements [5].

Dental implant is a popular method of replacing one or more missing teeth. To ensure a long term function, it is important that implant prostheses harmonize functionally and biologically with the stomatognathic system [1]. Knowledge on how the brain utilizes sensory signals to regulate oral motor behaviours is a prerequisite for understanding the functional consequences of many clinical treatments. For example, when a natural tooth is replaced by a dental implant the periodontal ligament disappears and the information from periodontal receptors about tooth loads is no longer available for the regulation of oral motor functions.

Osseoperception is defined as mechanoreception in the absence of a functional periodontal mechanoreceptive input but derived from temporomandibular joint (TMJ),
muscle, cutaneous, mucosal, and/or periosteal mechanoreceptors, and which provides mechanosensory information for oral kinesthetic sensibility in relation to jaw function and artificial tooth contacts. It is apparent that, with loss of dental and periodontal mechanoreception, other peripheral receptors dominate in afferent projections to the sensory motor cortex and provide the neural basis for perceptual abilities of patients with implant-supported prostheses [6].

History

Brånemark introduced the term osseointegration that described the science of implanting man-made, load bearing devices directly into the bone, whereby the fixture bonds with the surrounding tissue. During the 1950s it had been shown by him that chambers made of the metal titanium could become permanently incorporated with bone [7]. That is, the living bone could become so fused with the titanium oxide layer of the implant that the two could not be separated without fracture. Today, osseointegration is also a feature of leg, arm and facial prosthetics, in addition to hearing aid connections [5].

Since 1965 the method of osseointegration has been in successful clinical practice for dental application and to date there have been million patients who have been treated with dental implants due to edentulousness worldwide [7]. Currently the same method is also used for treatment with bone anchored hearing aids, for anchorage of prostheses, the term osseoperception was proposed (P-I Brånemark, personal communication) to recognize oral mechanoreceptors. These sensors provide information about tooth loads and are located in periodontal ligaments. In the context of implant-supported prostheses, the term osseoperception was proposed (P-I Brånemark, personal communication) to recognize oral kinesthetic perceptual abilities, in the absence of a functional periodontal mechanoreceptive input.

In 1979 Harldson characterized sensory feedback in patients with osseointegrated Fixed partial dentures and concluded that "osseointegrated Fixed partial dentures have been restored to a level of functional capacity of the masticatory system equal to that in individuals with a natural, but reduced dentition of the same extension as in the osseointegration group[8].

Oral tactile function has been studied extensively [9-12] for comparison of implant-supported prostheses with natural teeth and complete dentures. The presence or absence of periodontal mechanoreception must have a direct bearing on tactile discrimination. Passive discrimination is dependent on periodontal mechano-reception and is assessed by the application of controlled forces to a tooth, while active discrimination is based on objects placed between teeth, and involves a number of mechanoreceptor inputs located in teeth, periodontium, jaw muscles, and temporomandibular joint (TMJ) capsules and ligaments [5].

Perceptions of static jaw position and velocity of jaw movement (whether imposed or voluntarily generated) and forces generated during contractions of the jaw muscles constitute oral kinesthetic and propioceptive sensations. While there has been extensive study of the neural basis of limb kinesthetic sensibility [5], we have much less understanding of the neural mechanisms of oral kinesthesia in dentate individuals and even less understanding of the neural basis of kinesthetic perception in patients with implant-supported prostheses who lack periodontal mechanoreception.

The finding indicates that fiber originally innervating the tooth and periodontal ligament are still present in the inferior alveolar nerve. Linden and Scott succeeded to stimulate nerves of periodontal origin in healed extractions sockets, which implies that some nerve endings remain functional [13,14].

DISCUSSION

Research suggests osseoperception is secondary to nerve ingrowth into remodeling bone, as controlled by neuro-peptides such as calcitonin gene-related peptide [15]. The evidence available on the plasticity of the CNS provides a possible neural basis for our understanding of the accommodation of patients to the changes in dental status. The CNS has specialized mechanism for obtaining information about the positions and movements of limbs and forces of limb muscle contraction, i.e., limb kinesthesia. The mechanism is solely derived from mechanoreceptors activated during limb movements and likely to operate for oral kinesthetic perception also. To control oral motor behaviours such as biting, chewing, speech and oral manipulation, the brain relies on information from sense organs in the orofacial structures [16,17,18]. Natural teeth are equipped with extremely sensitive tactile sensors – periodontal mechanoreceptors. These sensors provide information about tooth loads and are located in periodontal ligaments. In the context of implant-supported prostheses, the term osseoperception was proposed (P-I Brånemark, personal communication) to recognize oral kinesthetic perceptual abilities, in the absence of a functional periodontal mechanoreceptive input.

This input is derived from temporomandibular joint (TMJ), muscle, cutaneous, mucosal, and/or periosteal mechanoreceptors, and provides mechanosensory information for oral kinesthetic sensibility in relation to jaw function and artificial tooth contacts. The contributions of these different mechanoreceptors to osseoperception in patients with implant-supported prostheses are unclear. Although periodontal mechanoreceptors may remain functional in bone in the vicinity of the implant fixture, it appears unlikely that these mechanoreceptors make any contribution to osseoperception [13,14].

Mechanoreceptors Providing Osseoperception

Muscle mechanoreceptors

The principle mechanoreceptors associated with muscle,
GTOs (Golgi Tendon Organ) are slowly adapting receptors. They clearly play an important role in regulating muscle contraction and are the most appropriate mechanoreceptors for signaling intramuscular tension (McCloskey, 1978; Proseke, 1981; Clark and Horch, 1986) [15,5,19]. These receptors, together with corollary discharge, are likely to make important contributions to the sense of intramuscular tension generated during voluntary contractions such as biting.

Cutaneous receptors

Cutaneous receptors in the hairy skin overlying the TMJ may also respond to skin deformation occurring during condylar movements. This somatosensory input may provide important proprioceptive information for the control of facial muscle that is known to lack definitive muscle spindle innervations [5]. It is also likely that orofacial cutaneous mechanoreceptors exhibit response properties that include low thresholds to applied mechanical stimuli and graded increases in firing rate with the magnitude of the applied mechanical stimulus. Such response properties may therefore provide information to the CNS concerning jaw position and movement.

Mucosal mechanoreceptors

Where natural teeth are present, periodontal mechanoreceptors are important for refined interdental discriminative function. With implant-supported prostheses opposing complete dentures, a contribution to oral kinesthetic perception could come from the activation of mucosal receptors beneath the complete denture and possibly periosteal and/or mucosal mechanoreceptors in the vicinity of the implant fixture [20]. As with facial cutaneous receptors, intra-oral mucosal receptors have not been characterized electrophysiologically; however, they too are likely to show low thresholds and graded responses to mechanical stimuli that could contribute to assessments of position and velocity of jaw movement at tooth contact, as well as force of muscular contraction by their activation beneath complete dentures during occlusal loading.

Periosteal mechanoreceptors

Existing mechanoreceptors in the periosteum may also play a role in tactile function upon implant stimulation. It is evident that oral implants offer another type of loading and force transfer than teeth, considering an intimate bone-to-implant contact with elastic bone properties instead of the characteristic viscoelasticity of the periodontal ligament. Thus, forces applied to osseointegrated implants are directly transferred to the bone and bone deformation may lead to receptor activation in the peri-implant bone and the neighbouring periosteum.

The identification of objects of various shapes placed between the teeth in the absence of other sensory inputs is known as oral stereognosis. In comparison of teeth and implants latter confirmed the superior stereognostic ability and its marked reduction, to a similar degree, in both complete dentures and implant overdenture subjects. Oral stereognosis is guided by periodontal and intradental mechanoreception high degree of precision [21]. Osseoperception has been quantified using vibrametry as a measure of neural sensory function, as reported in Prosthetics Orthotics International, 2000.

CONCLUSION AND SUMMARY

It is possible, that after removal of periodontal input and provision of implant-supported prostheses, plastic changes occur in somatotopic maps in the face motor and somatosensory cortical regions. These plastic changes may be directly associated with the individuals ability to accommodate to their new prostheses. Further, the extent of these changes, together with specific treatment differences and individual oro-dental characteristics, may explain why some individuals experience more difficulty than others in the process of accommodating to either fixed or removable prostheses. It is likely that the better the quality of the prostheses in optimizing esthetics, form, and function, the more readily will the sensory-motor system adapt.

Neurophysiological and psychophysical evidence of osseoperception have been collected, making the assumption more likely that a proper peripheral feedback pathway can be restored when using osseointegrated implants. This implant-mediated sensory-motor control may have important clinical implications, because a more natural functioning with implant-supported prostheses can be attempted [22]. It may open doors for global integration in the human body. This proves once again that the term “dental” is too limiting for the profile of our research activities.

REFERENCES


