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ARTICLE

Comparison between two low profile attachments for implant mandibular overdentures

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Abstract *Objective:* In this research it was aimed to evaluate stress distribution on the implants supporting a complete overdenture in addition to compare between two different types of low-profile attachments for implant-retained mandibular overdenture with two techniques (with/without using connecting bar).

Materials and methods: Two 3D finite element models were constructed simulating supported lower complete overdenture with two implants and with two implants and bar. Where, models components were modeled in 3D on commercial general purpose CAD/CAM software. Four runs were carried out, two runs on each model, as linear static analysis.

Results: Using bar is generally preferred for mucosa and cortical bone, while its effect can be considered as negligible on overdenture. On the other hand, it slightly increases the stresses on spongy bone. Using bar ensures the same level of energy transfer to the spongy bone and increases its maximum Von Mises stresses by about 50%. In addition, increase in maximum Von Mises stress was noticed by about 1% on cortical bone.

Conclusion: Using bar is not recommended for patients with flat ridge.

1. Introduction

Millions of people throughout the world are edentulous. Because they have lost a body part, up to 32 body parts to be exact, edentulous people are physically impaired, according to the World Health Organization (WHO) criteria [3,9]. A reduced tooth number can make mastication more difficult. For that reason patients are more likely to practice forms of food avoidance or dietary restriction. In particular they tend to avoid hard and tough foods that are difficult to chew; this has been described in patients with oral impairment [26,31].

The use of dental implants over the past 25 years has significantly influenced treatment planning in dentistry. Successful treatment with dental implants not only includes an esthetic and functional replacement but also treatment that requires minimal maintenance [15]. Removable implant-retained overdentures provide easier access for oral hygiene and easy modification of the prosthesis base [10,22]. The estimated

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interarch space required for an implant-retained overdenture measured from the implant shoulder to the incisal edge is approximately 12–14 mm [19,24,29]. Patients with well-preserved alveolar ridges having lost teeth due to caries may have inadequate interarch space for an implant-retained overdenture. Limited interarch space often restricts the prosthetic armamentarium to low-profile attachments and prevents the use of O-ring attachments [30]. When this happens the patient is no longer able to insert the prosthesis, the dentist must intervene and change the deteriorated plastic material [7,13,23,28].

Occlusion, masticatory force, the number of implants, and implant position within the prosthesis affect the forces acting on the bone adjacent to implants. An applied mechanical force produces stress and strain in the bone causing deformation of its structural arrangement. A hypothesis of the remodeling of cortical bone as a response to mechanical loading, a bone with dental implants demonstrates a higher bone turnover rate during remodeling compared to the dentate situation. Increased bone turnover may result from repair stimuli caused by compressive and tensile loading in tissue adjacent to the implants. The excessive force acting on the implant caused bone reduction in the surrounding area followed by fibrointegration, resulting in possible implant loss [12].

Retention of the mandibular implant-supported overdentures is commonly achieved by ball attachments, clip on bar connecting the implants, or magnetic attachments. These retentive attachments generate forces and stresses that differ from those seen with natural teeth supported by periodontal ligament. If these stresses exceed the physiological limit they may lead to several undesirable results. Also the long-term function of a dental implant system will depend on the biomechanical interaction between; bone and implant [18]. In case of bar system, the forces of occlusion will primarily be transferred to the posterior residual ridge and theoretically cause more resorption in that critical area. In the ball attachment system, however these forces will be distributed more evenly throughout the edentulous arch [6].

The distribution of forces in peri-implant bone has been investigated by finite element analyses in several studies. Recently, stress distribution in bone correlated with implant-supported prosthesis design has been investigated primarily by means of two-dimensional (2D) and three-dimensional (3D) finite element analyses (FEAs). Studies comparing the accuracy of these analyses found that, if detailed stress information is required, then 3D modeling is necessary. The 3D FEA is considered an appropriate method for investigation of the stress throughout a 3D structure, and therefore this method was selected for bone and implants stress evaluation in this study [5,25]. Three-dimensional (3D) finite element analysis (FEA) has been widely used for the quantitative evaluation of such stresses on the implant and its surrounding bone [11]. Current techniques employed to evaluate the biomechanical loads over implants generally comprise photo-elastic stress analysis, two or three-dimensional finite element stress analysis (FEA) and strain gauge analysis (SGA) [5,11,14,25].

Hence, the aim of this study is to evaluate the exerted stresses on the implants comparing between two different types of low-profile attachments for implant-retained mandibular overdenture with two techniques. In-vitro study was shot in this research as the attachments are recently launched in the markets. Thus it is preferred to investigate this new attachment outside the patient's mouth for better understanding of its effect on bone. In addition in-vitro study can be done with less ethical and safety concerns.

2. Materials and methods

Low profile attachments for implant retained mandibular overdenture are used for completely edentulous patients with limited interarch space (the estimated interarch space required for an implant-retained overdenture measured from the implant shoulder to the incisal edge is approximately 12–14 mm), that could be done in two different techniques.

In this study, the first one utilizes two threaded dental implants (Dentium Superline – Dentium Inc., Samsung-dong, Gangnam-gu, Seoul, Korea) with nominal diameter of 3.4 mm, a length of 12 mm where, the root form dental implant had a nominal platform diameter of 3.7 mm, a length of 12 mm and the shape of internal hex with body diameter of 3.4 mm. Two low profile attachments OT Equators square head (Rhein83 srl, Bologna, Italy) with 2.1 mm length and diameter of 4.4 mm that are compatible with the implants were also used.

In the second technique, two threaded dental implants with two low profile attachments OT Equators square head compatible with the implants were used. In addition a nickel-chromium alloy bar was fabricated to connect the two low profile attachments. Finally, the overdenture(s) fabricated from acrylic resin is to be placed over each attachment (with/without bar).

Thus, two 3D finite element models were constructed under ANSYS software (ANSYS Inc., Canonsburg, PA, USA) environment simulating supported overdenture with two implants and with two implants and bar. Where, each model component was modeled in 3D on commercial general purpose CAD/CAM software "AutoDesk Inventor" ver. 8.0 (Autodesk Inc. San Rafael, CA, USA). These components were exported as SAT file format then imported into the finite element package. Meshing and assembly of model components are illustrated in Figs. 1–3, where different colors represent different materials as ANSYS screen shots. All material properties used in this study are tabulated in Table 1. The meshing software was ANSYS version 9.0 and the used element in meshing all three-dimensional models is an 8 node brick element (SOLID45), which has three degrees of freedom (translations in the global directions) (Kohnke P, 1994 [17]). Mesh density is another relevant parameter. As the geometries are complex, improving the mesh has the usual effect of improving the results for the discrete model (increasing the obtained stress levels accuracy in regions of high stress gradients). Another effect of increasing the number of elements is to reduce sharp angles created artificially by the process of substituting the geometric model by the mesh, reducing artificial peak stresses by improving the representation of the actual geometry, mesh density is tabulated in Table 2. A grid sensitivity study was performed to choose the most convenient number of elements (in terms of computational time and results accuracy), which assured an accurate description of sharp angles and curves.

Linear static analysis was performed. The solid modeling and finite element analysis were performed on a personal computer Intel Pentium Core 2 Duo, processor 3.0 GHz, 4.0 GB RAM. Four runs were carried out, two runs on each model (without and with bar). Two types of vertical loading; first one 150 N at the central fossa of lower six tooth (L6), and