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Original Article

Stress on external hexagon and Morse taper implants submitted to immediate loading

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ABSTRACT

Background/Aims: This study aimed to evaluate the stress distribution around external hexagon (EH) and Morse taper (MT) implants with different prosthetic systems of immediate loading (distal bar (DB), casting technique (CT), and laser welding (LW)) by using photoelastic method.

Methods: Three infrastructures were manufactured on a model simulating an edentulous lower jaw. All models were composed by five implants (4.1 mm × 13.0 mm) simulating a conventional lower protocol. The samples were divided into six groups. G1: EH implants with DB and acrylic resin; G2: EH implants with titanium infrastructure CT; G3: EH implants with titanium infrastructure attached using LW; G4: MT implants with DB and acrylic resin; G5: MT implants with titanium infrastructure CT; G6: MT implants with titanium infrastructure attached using LW. After the infrastructures construction, the photoelastic models were manufactured and a loading of 4.9 N was applied in the cantilever. Five pre-determined points were analyzed by Fringes software.

Results: Data showed significant differences between the connection types ($p < 0.0001$), and there was no significant difference among the techniques used for infrastructure.

Conclusion: The reduction of the stress levels was more influenced by MT connection (except for CT). Different bar types submitted to immediate loading not influenced stress concentration.

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1. Introduction

The immediate loading technique has been widely used in oral implant rehabilitations in order to reduce treatment time.[1] This technique eliminates the necessity to wait during a healing time, permits the use of a provisional prosthesis after the implant insertion, and keeps the implants in function during healing.

In edentulous arches, this technique requires more caution. The stress levels around implants used in immediate loading are dramatically higher than for delayed loading.[1] Considering that all implants are available to support a denture, the presence of overload conditions can compromise the overall osseointegration process. Therefore, the best adaptation between the implant and the prosthesis is always clinically desirable.[2,3] A deficient fit may induce tensile, compressive, and bending forces during the prosthesis attachment, which may result in further mechanical complications.[4] The relationship between passivity and suitable distribution of occlusal loads among implants, prosthetic components, and bone tissue is essential for the success of the implant-supported prostheses rehabilitation.[5–7]

Rehabilitations in the complete dental arch offer the greatest risk since a larger number of implants and the curved shape of the infrastructure can induce higher values of misfit between implants and prosthetic components. In addition, this type of prosthesis has been commonly used in definite rehabilitations for many years, with a good predictability for clinical success.[8] However, the decreased probability of stress induction on implants in the provisional technique is important to achieve successful osseointegration.

The manufacturing techniques used in infrastructure and impression methods are essential to ensure the precise representation of the implant position, to obtain a passive adjustment of the components and reduce the stress levels around the implants. There are some options to perform the prosthesis infrastructure for immediate loading technique. The laser welding method was proposed to minimize the metallic infrastructure distortion that occurs in monoblock castings.[2,3,9] Many studies have been developed to investigate techniques employing welding to reinforce bars and the resulting passivity, and to determine where less stress may be induced on the bone tissue.[2,4]

Another prosthetic alternative to immediate loading is the IOL DIEM system (3i Implant Innovation-USA). This system is a provisional rehabilitation treatment with an innovative absence of metallic infrastructure,[10] aiming to reduce the stress during the implant-healing phase. This system is composed of cylinders with distal extension to support the cantilever, while the whole structure was manufactured with acrylic resin. The advantages of this technique are lower cost; a reduced clinical time that minimizes functional and psychological problems; increased patient's satisfaction; and substantial clinical interest.[11] A high success rate of 98.9% has been claimed for the immediate-loading technique even in the absence of metallic infrastructure.[12]

Another relevant aspect reported in the literature is the effect of the prosthetic connection type on the stress distribution, suggesting that the internal Morse-taper (MT) connection provides a better fit between implant and pillar, increasing the contact area, when compared to the external hexagon (EH). This adjustment improves the biomechanical function, reducing the stress level on the peri-implant tissue.[13–15] Thus, the implant connection can influence the stress transmitted by the bar in a relevant manner. To date, studies in the literature have not evaluated the influence of different frameworks used for immediate loading on the stress distribution around EH and cone MT implants.

The purpose of this study was to evaluate by means of the photoelastic method the influence of different frameworks used in immediate loading (distal bar (DB), casting technique (CT), and laser welding (LW)), associated with EH and MT implants on the stress distribution in the peri-implant bone. The working hypothesis is that different framework types could influence the stress distribution differently on the peri-implant bone tissue, in both implant connection types.

2. Materials and methods

Two polished metallic shaped matrix arches measuring 35.0 mm × 60.0 mm × 20.0 mm were used (Fig. 1). Five micro-unit abutment analogs (4.1 mm; Conexao Prosthetic System, Aruja, SP, Brazil) were installed in the following sequence: two in the first premolar region (A and E), two in the canine region (B and D), and one in the central region of the matrix (C). This procedure was in accordance with the classical Branemark protocol simulating a real clinical situation for the manufacturing of a mandibular prosthesis.

A prosthetic laboratory performed the DB, CT, and LW framework types. Each bar type was associated with each EH or MT implant, and submitted to a unilateral loading on the cantilever extension. The study was composed of six groups with three framework types and two connection types ($n = 2$). The metallic infrastructures were fixed on the metallic matrices and the complete set was embedded in silicone (ASB-10; Polipox, Sao Paulo, SP, Brazil). Photoelastic models were performed in these silicone impressions.

External Hexagon Master Porous (Conexao) and Morse taper Ar-Morse Porous implants (Conexao) with regular platforms of 4.1 mm and 13 mm in length were screwed to the respective

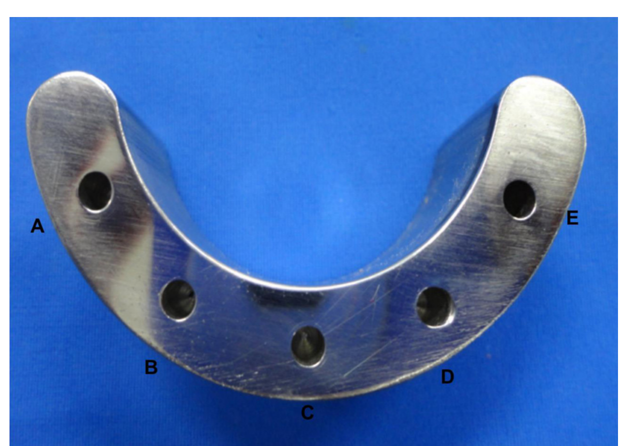

Fig. 1 – Implant positions on the metallic matrix.