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Abstract. Maxillary defects resulting from cancer, trauma, and congenital malformation affect the chewing efficiency and retention of dentures in these patients. The use of implant-retained palatal obturator dentures has improved the self-esteem and quality of life of several subjects. We evaluate the stress distribution of implant-retained palatal obturator dentures with different attachment systems by using the photoelastic analysis images. Two photoelastic models of the maxilla with oral-sinus-nasal communication were fabricated. One model received three implants on the left side of the alveolar ridge (incisive, canine, and first molar regions) and the other did not receive implants. Afterwards, a conventional palatal obturator denture (control) and two implant-retained palatal obturator dentures with different attachment systems (O-ring; bar-clip) were constructed. Models were placed in a circular polariscope and a 100-N axial load was applied in three different regions (incisive, canine, and first molar regions) by using a universal testing machine. The results were photographed and analyzed qualitatively using a software (Adobe Photoshop). The bar-clip system exhibited the highest stress concentration followed by the O-ring system and conventional denture (control). Images generated by the photoelastic method help in the oral rehabilitator planning. © 2012 Society of Photo-Optical Instrumentation Engineers (SPIE). [DOI: 10.1117/1.JBO.18.6.061203]

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1 Introduction

The term maxillectomy is used to describe the partial or total maxilla removal¹ due to pathologies treatments or trauma, resulting in maxillary defects.² These defects may lead to changes in speech, swallowing, and mastication, decreasing drastically the life quality of its users. The obturator prosthesis is frequently the choice of treatment because of the complexity of maxillary surgical reconstruction and uncertainty about restoration of the affected functions.¹⁻⁴

However, it is known that the stability and retention of maxillofacial obturator prostheses are a challenge for most patients, and it varies according to the defect size and configuration and remaining contour of palate and soft tissues.^{3,5} In order to solve this problem, the use of osseointegrated implants as sustentation components of prostheses provided a new rehabilitation alternative for those patients. Besides, several attachment systems associated with implants are frequently indicated for this kind of prosthesis, such as ball systems, magnet, and bars, and it is also possible to associate them with one another.^{6,7}

Several studies regarding stress distribution aim to provide information for planning of dental prosthesis.^{6,8} Photoelasticity method, through images, has been widely applied in dentistry and allows a direct observation of stress distribution on structures, based on the ability of certain colorless materials to exhibit color standards named isochromatic fringes when they are loaded and observed through a polarized light.^{8,9}

Based on the above considerations, the aim of this study was to assess the stress distribution on implant-retained palatal obturator prostheses associated with different attachment systems and on conventional obturator (without implants). The hypothesis of this study, by analyzing the images, is that the system with three individualized O-rings provides the lowest stress on the implants and support tissues.

2 Materials and Methods

An experimental maxillary model with oral-sinus-nasal communication was used to reproduce two similar laboratorial models confectioned with type IV dental stone (Durone; Dentsply Ind Com Ltd, Petrópolis, Rio de Janeiro, Brazil). One of the laboratory models was duplicated with fluid silicon in order to obtain the negative impression of the laboratorial stone model. Through this impression, the photoelastic model I was obtained (without implant).

The photoelastic model II was confectioned by placing three implants in the second model, which was perforated in the regions of upper incisive, canine, and first molar using a parallelometer. After perforation, the implants analogues with 3.75 × 13 mm and 4.1 mm platforms (Neodent, Curitiba, Paraná, Brazil) were inserted and fixed with Duralay acrylic resin (Duralay Reliance Dental MFG Co Worth, IC, USA), so that the analogue platform remains at the same level of the alveolar ridge.

The photoelastic resin PL-2 laboratory models, with and without implants, were used to fabricate the obturator prosthesis. Three prostheses were fabricated. One mucous-supported obturator prosthesis (without implants), whereas the other

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two obturator prostheses were associated with attachment system: O-ring and bar-clip. The obturator prostheses were fabricated with artificial teeth with cusp inclination of 20 degrees (TriluxVipi Produtos Odontológicos, Pirassununga, São Paulo, Brazil) and colorless heat-polymerized resin (Vipi Produtos Odontológicos, Pirassununga, São Paulo, Brazil) as to not influence the results of the method applied in the study.

The three obturator prostheses were adapted to the photoelastic models with and without an attachment system. Each assembly (prosthesis/photoelastic model with and without an attachment system) was positioned in a circular polariscope into a glass with mineral oil, to minimize the refraction of white light (Photoflood 500 WGE Lighting General Electric, Cleveland, Ohio, USA) that uniformly focuses on the recipient with the photoelastic model. Thus, a load of 100 N at 10 mm/s was applied in the region of incisive, canine, and first molar on the opposite side of the communication. The images were recorded by a digital camera Nikon D80 (Nikon Corporation, ChitodaKu, Tokyo, Japan) and transferred to a computer for qualitative analysis by the software Adobe Photoshop CS version 8.0.1 (Adobe Systems, San Jose, California, USA).⁵

Photograph records of all models were qualitatively analyzed to verify the direction and intensity of stress based on other studies.^{10,11} In this sense, the higher the fringes order (N) and fringes number are, the greater the stress intensity is. Additionally, the closer the fringes are among each other, the higher the stress concentration is.

The analysis was divided according to the number of fringes with high intensity (green-pink transition) and to the stress distribution area. All images were evaluated by the same person.

3 Results

Based on the images, it was possible to observe a greater number of high stress fringes on the bar-clip system, followed by the O-ring system and conventional obturator (without implants), respectively (Table 1).

Regarding stress distribution in the model without implants, the fringes were located on the region of alveolar ridge crest (Fig. 1). In the models with implants, regardless attachment

Table 1 Number of photoelastic fringes according to the crowns in which the load was applied.

Attachment system	Axial load		
	Crown		
Conventional	16	13	11
O-ring	0	1	1
Bar clip	3	4	4
	5	6	6



Fig. 1 Model without implants.

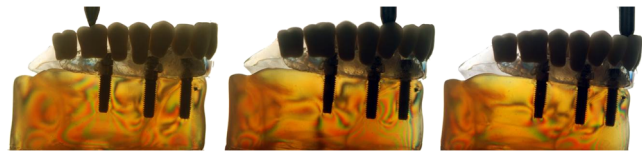


Fig. 2 Model with O-rings.



Fig. 3 Model with bar-clips.

system, the photoelastic fringes were observed at the apical region of the implants (Figs. 2 and 3).

4 Discussion

The hypothesis that the system with three individualized O-rings provides the lowest stress on the implants and support tissues was accepted, since this system exhibited lowest stress values.

The palatal obturator prostheses aim to seal the communication among the oral, nasal, and orbital cavities, allowing the restoration of the speech, mastication, swallowing, and aesthetics, to provide a better quality of life to the patients.^{4,5} And according to the results, the conventional obturator prosthesis (without implants) exhibit low stress values (Table 1 and Fig. 1).

However, the stability and retention of these prostheses have been a problem for the prosthodontists and the patients^{3,4,12} because specific anatomic conditions in each case of maxillary surgical resection demand distinctive planning since the extension and location of surgical resection, as well as the mucosa and bone condition, are determinant aspects for the planning, in order to reach a medium retention in a palatal obturator prosthesis.

So, the use of implant-retained palatal obturator prostheses to rehabilitate partial or total maxillectomized patients has been growing since it provides higher retention and stability of the prostheses, reducing their moving which can lead to lower stress on bone support.^{2-5,7,13} In our study, the O-ring attachment system for the implant-retained obturator prostheses exhibited lower stress values when comparing it with the bar-clip system (Table 1 and Fig. 2).

These results corroborate with some studies¹⁴⁻¹⁶ which consider that the O-ring attachment system (Fig. 2) transfers less stress to the implants in comparison to the bar-clip system (Fig. 3), because the O-ring system reduced stress and provided great stability. According to the authors, it can result from stress absorption by the female component of the system, which generally presents a rubber ring into a metallic capsule that may absorb or homogeneously distribute the stress they are submitted to.

Most of the failures related to total implant-retained prostheses happen due to the excess of stress transmitted to the implants and attachment systems. The systems fatigue may cause fracture on the implants components, overload them and the bone tissue, which would also result in a possible loss of osseointegration, generating prostheses instability and loss retention.^{2,5,7} The photoelasticity method analyzed through

images aims to support the selection of a better retention method with dental implants to reach the correct rehabilitation planning for these patients with oronasal communication.

5 Conclusion

The photoelastic method is efficient for better oral rehabilitation planning.

The system with three individualized O-rings provided the lower values of stress in the implants and support tissues, reaching, in this way, the biomechanical success of the implant-retained palatal obturator prostheses.

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