RSBO

ISSN:
Electronic version: 1984-5685
RSBO. 2017 Jul-Sep;14(3):156-61

Original Research Article

Comparative analysis of reflection photoelasticity in mandible's segment with or without base

Humberto Gennari Filho[1]
José Vitor Quineli Mazaro[1]
Marcelo Coelho Goiato[1]
Karina Helga Leal Turcio[1]
Andressa Paschoal Amoroso[1]
Rosse Mary Falcón Antenucci[1]

Corresponding author:
Humberto Gennari Filho
Faculdade de Odontologia de Araçatuba – Unesp
Departamento de Materiais Odontológicos e Prótese
Rua José Bonifácio, n. 1193 – Vila Mendonça
CEP: 16015-050 – Araçatuba – São Paulo – Brasil
E-mail: gennari@foa.unesp.br

[1] School of Dentistry of Araçatuba 1 – Araçatuba – SP – Brazil.

Accepted for publication: August 9, 2017. Received for publication: July 1, 2016.

Keywords:
photoelasticity; dental implant; tension.

Abstract

Introduction and Objective: To analyze if axial loads of 50 N and 100 N, applied on an implant of 3.75 X 10 mm (Conexão-Jaú, SP, Brazil) fixed on the central portion of a prototype of the mandible with and without support base, generate isochromatic fringes of different intensity and ways. **Material and methods:** The sample was a segment of the mandible with 115 mm in length, 30 mm height, and 12 mm in thickness, from a block of #7 rose wax. This matrix was adapted to a modified articulator in such way that its base could or not keep contact with the lower arm of the articulator, simply by modifying the support axis. An implant was put perpendicular to the segment of the mandible's body and then the photoelastic model obtained. The healing abutment was screwed to the implant to receive loads from 50 N to 100 N, with the model with or without contact of its base with the inferior arm of the articulator. **Results:** Alterations in the reflections of the colors was observed when the implants had been submitted to loads of 50 N and 100 N with or without supported base. **Conclusion:** Based on the results, it can be concluded that during the photoelasticity analyses alterations in the color standards occurred depending on the support of the sample and the applied load.

Introduction

A crucial factor that affects the result of implant treatment the trajectory of the oclusais forces, transferred to the bone-implant interface, through the prosthesis. The magnitude of these forces, surrounding the implants, depends on its design and on the structural and mechanical properties of the interface that must tolerate oclusal forces without adverse tissue response [1]. Thus, it is necessary that the implant design allows a distribution of the functional forces, inside of physiological levels, in the bone surrounding the implant.

The mechanical problems and the failures are frequently reported during the prosthetic treatments. "However, the mechanical and biomechanical aspects and the design of the prosthetic devices generally are significantly responsible for this, particularly during the treatment planning" [6]. The biomechanical set that the implant-supported prosthesis is a sufficiently common system in mechanical projects, whenever are the screw system. "So, to identify the efforts applied on the prostheses is of fundamental importance to assess the tensions involved in implants" [11]. Pesqueira *et al.* [9] and Zanatta *et al.* [12] cite that several studies have used experimental, analytical, and computational models by means of finite element model (FEM), photoelasticity, voltage meters, and associations of these methods to evaluate the biomechanical behavior of dental implants. These methods are used specially to assess the possibility of failure of a device, allowing to calculate the conditions existing in each point of the material (and deformities), or at least in points that are supposed to be critical. The failure occurs because the requests are higher than the resistance of the material, and knowledge of these critical points allows the improvement of the material used. Doyle *et al.* [4] compared qualitatively and quantitatively search results with the techniques of photoelasticity analysis and FEM. Mentioning that there was good agreement between the experimental and numerical methods, with similar trends in all models of the experiment. The result agrees with the study of Rossi *et al.* [10], who compared FEM with the properties of epoxy resin or the bone, and found that although the properties of the materials are different, the disposition of areas of tension was similar, reinforcing the geometric factor for the determination of results.

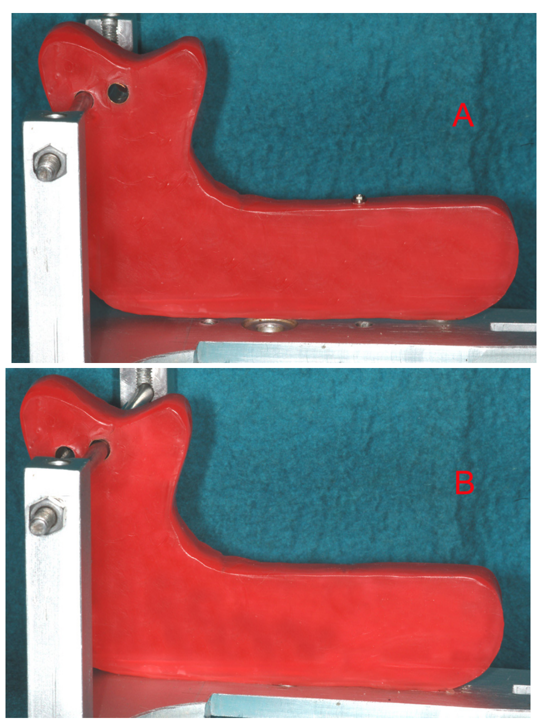
The biggest advantage of the photoelasticity method is the capacity to visualize the tensions in the complex structures, such as oral structures, to observe the standards of effort in the model, allowing that the investigator locates and quantifies the magnitude of the tensions. The photoelasticity method admits the general perception on the behavior of the tensions, demonstrating the amount, the quality, and the distribution of the forces in an object by means of fringes that appear as a successive and continuous series of colorful bands (isochromatic) in experimental model [3].

Undoubtedly, the form of sustentation of the photoelasticity patterns generated great uncertainty in the observation of the reflection photoelasticity, by the fact that the load applied on one determined point of the model causes tensions that disperse through its base. Obviously, when we have a suspended surface, without contact of its base, the model absorbs or concentrates the generated tensions, differently from the situation cited above.

To analyze if axial loads of 50 N and 100 N, applied on an implant of 3.75 X 10 mm (Conexão-Jaú, SP, Brazil) fixed on the central portion of a prototype of the mandible with and without support base, generate isochromatic fringes of different intensity and ways.

Material and methods

The sample was a segment of the mandible with 115 mm in length, 30 mm height, and 12 mm in thickness, from a block of #7 rose wax. This matrix was adapted into a modified articulator in such way that its base could or not keep contact with the lower arm of the articulator, simply by modifying the support axis.



Figures 1a and1b – Segment with changing the support axis

At that stage, the incorporation of the implant was performed with the aid of a delineator so it remains perpendicular to the body of the thread and the set included in duplicating silicone. After hardening of the material, the wax was removed with hot water, remaining only the implant inside the mold, which was filled with Epoxy resin (AL70060900 batch – Araltec Prods Quims Ltd.), as seen in figure 2. Elapsed 24 hours and after the resin curing, the specimen (mandible) was removed from the mold. In this phase, the photoelasticity model received the surface preparation procedure through sanding in polishing machine (Arotec-Brazil) with # 1200-grit sandpapers at 300 rpm, not to cause strain in specimens (figure 3).

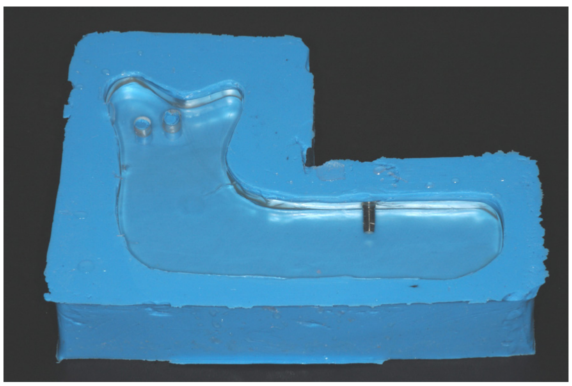


Figure 2 – Filling of the mold with epoxy resin

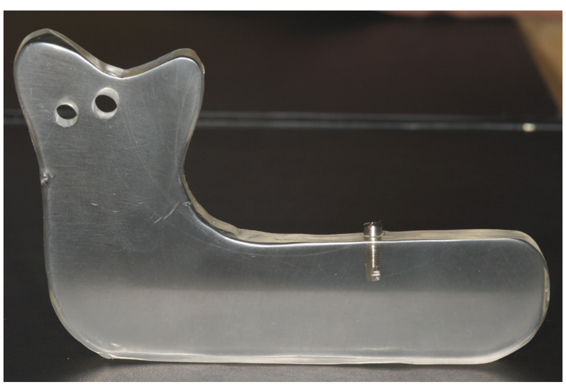


Figure 3 – Prepared photoelasticity model

A healing abutment was screwed (Conexão-Jaú, SP, Brazil) on the implant to receive the load, and the photoelastic model positioned in the articulator modified in such a way that the articulator axis surpassed the model, allowing the touch of the basis in the arm of the articulator. It should be noted that are different heights to accept different positions (figures 4a and 4b), which enabled the mandible to remain suspended by a device installed in the posterior portion of the articulator.

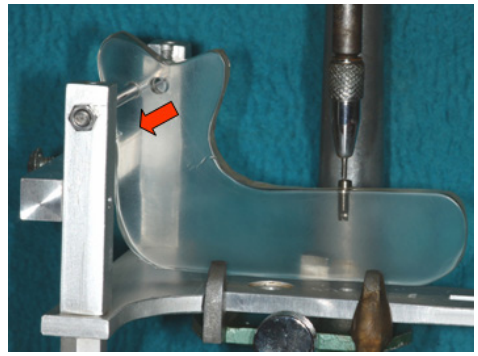


Figure 4a – Suspended mandible

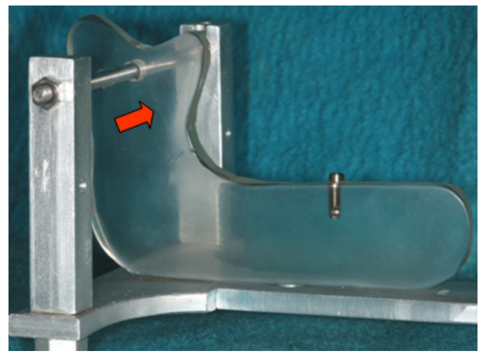
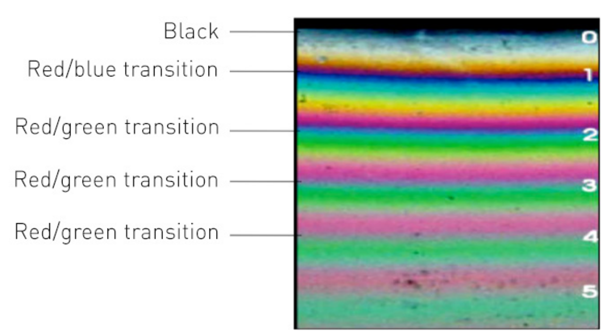


Figure 4b – Mandible with support

In this position, the set was placed in a container with mineral oil to the total immersion, with the goal of minimizing the refraction of light surface and facilitate the observation of isochromatic fringes, according to Frederick and Caputo [5]. The container was positioned between the filter and the filter polarizer. The light diffuser was coupled to the polarizer filter that allowed the white light source (Photoflood) focus evenly on the container with the photoelasticity model. The load applied ranged from 50 N to 100 N, in axial direction, and the reflection was caught by a digital camera (Nikon D70). In the second phase of the experiment, the axis surpassed the photoelastic model, raising its base in such a way that it did not touch the arm of the articulator, and again loads of 50 and 100 N were applied.

The counting of the fringes was made as follows:



Results

In the present study, after the application of loads of 50 N and 100 N in the mandibles with and without support (MSA), we observed discrete difference in the concentration of tension between them. In the mandible with support (MCA), the tension concentration was greater around the implants compared with mandible without support (MSA). for both loads (figures 5a, 5b, 5c and 5d).

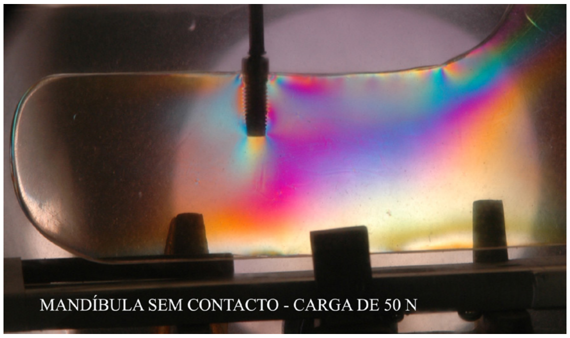


Figure 5a – Mandible without support and load of 50 N

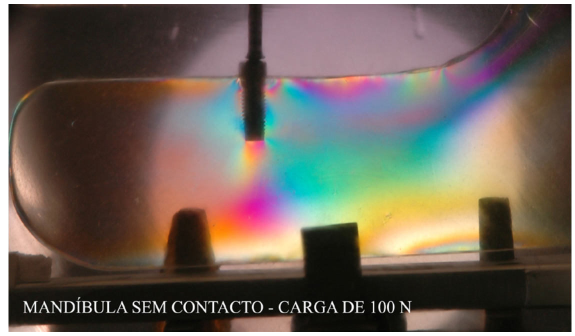


Figure 5b – Mandible without support and load of 100 N

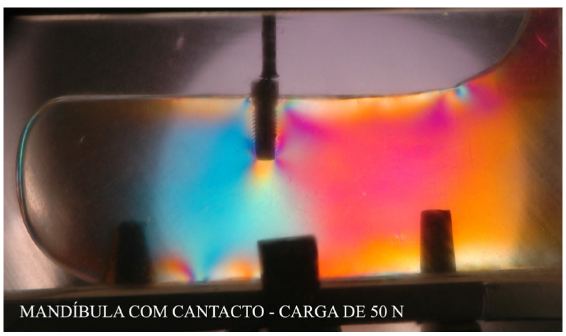


Figure 5c – Mandible with support and load of 50 N

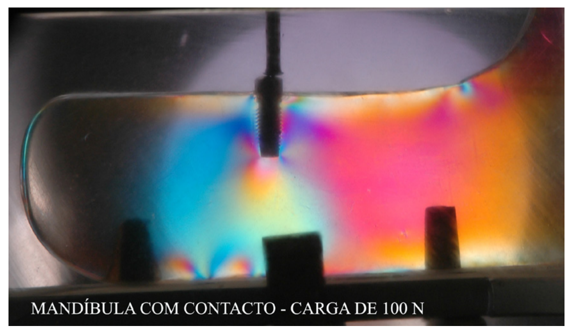


Figure 5d – Mandible with support and load of 100 N

The logic of this observation lies in the fact that, during application of the load, the contact of the base of the appliance with the base of the sample generated new reflections that expanded from the base to the interior of the sample, by modifying the colors and leading to unrealistic interpretations. Anyway, one can understand that in none of the pictures the reflections are similar, both with the increasing od the load and base support. Figure 6 shows, so equalized, the set of changes that occur with the implants, in which, even by applying the same charge, color variation occurs.

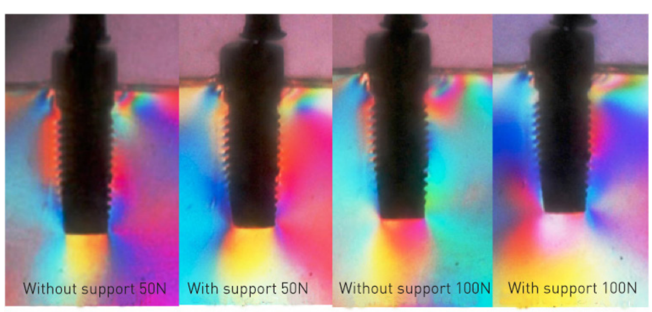


Figure 6 – Chromatic changes around the implants at different loads with and without support

Discussion

Campos Jr. *et al.* [2] highlighted the requirement for extreme care in the control of the variables inherent in the construction of models, such as linear dimensions and photoelastic material thickness, because all these measures have an influence on the result and in the composition of the spectrum, as shown in this study. In addition, as already stated Mahler and Peyton [8], the force applied to the standards in test produces internal tensions that are distributed according to the direction of these forces and to the shape and support pf the standards.

Undoubtedly, the form of sustentation of the PHOTOELASTICITY PATTERNS generated great uncertainty in the observation of the reflection photoelasticity, by the fact that the load applied on one determined point of the model causes tensions that disperse through its base. Obviously, when we have a suspended surface, without contact of its base, the model absorbs or concentrates the generated tensions, differently from the situation cited above.

Hobkirk and Havthoulas [7] cite that the support mechanism for the mandible is complex both physiologically and anatomically as any mechanical model can only be an approximation of the real-life situation. However, in the face of solid evidence, there is no evidence of comparative experiments on human subjects in which the deformation patterns in a model are similar in nature to those that occur in vivo. The hypothesis of this study shows that the mandibles without basic support may represent more closely the actual clinical condition, through the dynamic force that occurs in mandibular movements. Therefore, it may be noted by the results that the studies of photoelasticity using the models with base support can show a fringe intensity slightly greater than actually could be related in vivo.

The mandible stiffness is related to the dimensions and properties of the bone, and a thinner cortex tends to be associated with greater deformation. Therefore, in the models, is likely to underestimate the effects of in vivo phenomenon, both in relation to mechanical principles as in effect on the stiffness of the mandible in deeper regions of the bone.

Given the considerable variety of chewing forces used by patients with implant-supported prostheses and the significant differences in mandibular anatomy from individual to individual, absolute forces detected may not be directly related to the clinical situation.

Thus, the use of models to examine the distribution of the force around the mandibular implant-supported prosthesis, which ignore the physiological support mechanism of the mandible, can give rise to results of questionable clinical validity.

It should be noted, in this study that the base of the mandible without contact is colorless, while that with contact features reflection points generated by the support of the appliance.

By comparing the loads of 50 N, we observed that those with contact are little more sparkling and expanded, unlike from the loads of 100 N, where the differences are even more significant, but without interfering in the distribution of tensions around the implant.

Thus, care must be taken when such analysis method is used, considering possible changes in the patterns of color, especially when using loads of 100 N or more.

Conclusion

Based on the results of this study, we can conclude:

• During the photoelastic analyses, changes in the patterns of colors occurred depending on the support of the sample;

• The greater the force applied the greater the difference in the patterns of colors;

• Regardless of the differences in the patterns of colors, it was possible to detect and analyze the stresses induced in the samples with and without support.

References

1. Brunski JB. Biomaterials and biomechanics in dental implant design. Int J Oral Maxillofac Implants. 1988;3(2):85-98.

2. Campos Jr. A, Passanezi E, Nahás D, Janson WA. A fotoelasticidade na pesquisa odontológica Parte I: campo de aplicação. Estomat Cult. 1986; 16 (1):20-5.

3. Cehreli M, Duyck J, De Cooman M, Puers R, Naert I. Implant design and interface force transfer: a photoelastic and strain gauge analysis. Clin Oral Impl Res. 2004;15(2):249-57.

4. Doyle BJ, Killion J, Callanan A. Use of the photoelastic method and finite element analysis in the assessment of wall strain in abdominal aortic aneurism models. Journal of Biomechanics. 2012;45(10):1759-68.

5. Federick DR, Caputo AA. Effects of overdenture retention designs and implant orientations on load transfer characteristics. J Prosthet Dent. 1996;76(6):624-32.

6. Fernandes CP, Glantz POJ, Svensson SA, Bergmark A. Reflection photoelasticity: a new method for studies of clinical mechanics in prosthetic dentistry. Dental Materials. 2003;19(2):106-17.

7. Hobkirk JA, Havthoulas TK. The influence of mandibular deformation, implant numbers, and loading position on detected forces in abutments supporting fixed implant superstructures. J Prosth Dent. 1998;80(2):169-74.

8. Mahler DB, Peyton FA. Photoelasticty as a research technique for analysing stress in dental structures. J Dent Res. 1955;34(6):831-8.

9. Pesqueira AA, Goiato MC, Gennari Filho H, Monteiro DR, Santos DH, Haddad MF et al. Use os stress analysis methods to evaluate the biomechanics of oral rehabilitation with implants. J Oral Implantol. 2014;40(2):217-28.

10. Rossi AC, Freire AR, Prado FB, Asprino L, Correr-Sobrinho L, Caria PHF. Photoelastic and finite element analyses for occlusal loads in mandibular body. Anat Res Int. 2014.

11. Skalak R. Biomechanicals considerations in osseointegrated prostheses. J Prosth Dent. 1983;49(6):843-48.

12. Zanatta LC, Dib LL, Gehrke SA. Photoelastic stress analysis surround different implant designs under simulated static loading. J Craniofac Surg. 2014;25(3):1068-71.