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Considerations about Tension Conditions in Fixed Prosthesis with Dento-Periodontal Support Respective Implant Support

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Abstract

The purpose of this study is to determine and compare the tensions between the fixed dental prosthesis (FDP) with dental support and the fixed dental prosthesis with implant support with the help of photoelasticity. Studying mechanical models of these types of dentures have resulted in a series of conclusions concerning the intimate mechanism of stress and behavior of and within the support structures. We have selected the case of vertical and parallel bridge abutments. Observations obtained experimentally by photoelasticity have predictive power of clinical successes in prosthetic treatment with fixed prostheses and are allowing easier understanding of the laws that influence the behavior of complex biomechanics: fixed dental prosthesis – support structure.

Key words: *photoelasticity, model, tension, dento-periodontal support, implant support*

Introduction

Partial edentulism is a pathological condition characterized by the absence of 1-15 teeth of a maxillary arch, and is associated with morphological and functional dental disorders (chewing, physiognomy, phonation, occlusion, and self-protection). Treatment of partial edentulism, particularly the short span one, is done using FDP to replace missing teeth and restoring the functions associated dental tooth loss. The FDP, as treatment for partial edentulism, were used even during the Phoenicians era (sec. VII BC). They made use of materials specific to those times, but their design is similar with the modern ones [1].

Nowadays the fixed dental prosthesis, together with the abutment teeth are forming a bio-mechanical inseparable complex structure [2].

The occlusal forces will load the abutments of the FDP, thus it will be necessary to understand the response of the dento-maxillary structure and the biomechanics of the prosthetic restorations under the load of mastication forces. The prosthetic structure can be pushed to a limit value (breaking limit state), and break if the occlusal load goes over a certain threshold, with a loss of its functions, but also irreversible damage to the abutment teeth. There are many situations where the abutment teeth need to be extracted after the removal of the compromised FDP, and a new treatment plan is necessary, involving a longer span FDP, removable partial (or complete) denture or an implant supported FDP.

Fig. 1. Missing teeth being replaced by natural teeth wired to the adjacent teeth in rudimentary FDP [3]

Fig. 2. Tooth supported FDP (panoramic x-ray)

The implants (in the implant supported FDP treatment solution) will transmit the occlusal forces to the surrounding biological structures. The force transmittal is done directly to the bone (the implants are actually anchylosed in the bone) rather than through a periodontal ligament system.

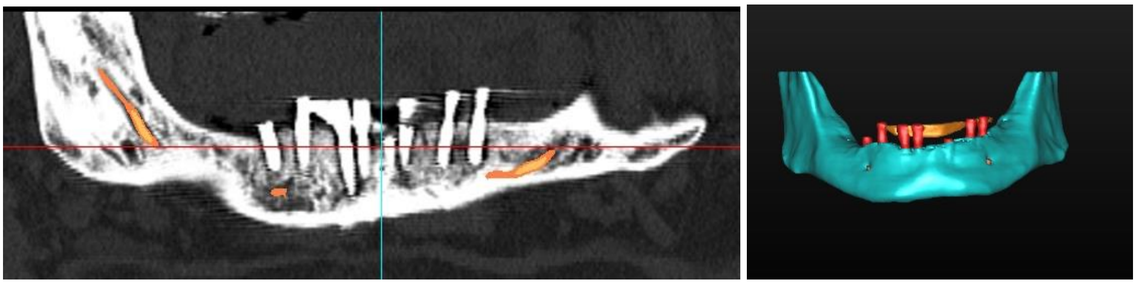

Fig. 3. Mandibular implants connected with a connecting bar (CT scan view)

Because both the implant based FDP and tooth based FDP are clinically acceptable solutions for the edentulous patient we used a mechanical model to study the advantages and disadvantages of both of them based on the tensions which appear during the mastication, and we used the modeling through photoelasticity method.

Modeling Notions

For complicated physical objects one looks for the best means of research and knowledge of the laws that govern them, using modeling method. The essence of this method is to replace the actual object with one more convenient for study, research or design. The object model should reflect to some extent the primary object properties and peculiarities, and the analysis and experiments will be done from now on model. Certain data about the researched object, found through experimentation, will be then checked clinical and statistical.

The role of the models is to link theoretical thinking and objective reality. This is manifest in a bidirectional way, from objective reality and observation to theory, and from theory to objective reality. The model serves not only to verify the clinical solutions, but also to find new ways of developing a theory [4].

For the research and the modeling of our study we precisely defined the studied domain, we eliminated some non-significant aspects, and we admitted some simplifying hypotheses, which didn't influence the results.

In the most general aspect the model can be functional, computational or experimental. In this case we used an experimental model, which is a physical object that has reproduced in conditions close to reality the situation of the analyzed phenomenon.

Plastic models (DINOX) were obtained by casting in special molds and then machining them. When performing these operations we took into account their high fragility and low thermal conductivity.

The loads applied to the models had the same characteristics as the forces which are applied to the FDP abutments. The surface forces were applied to the model by mechanical devices permitting their measurement with the help of dynamometers and weight systems.

The load systems will satisfy the following conditions: will reproduce without characteristic changes the natural loads, will allow a discrete loading, will allow a separate or simultaneous application of the loads during the process, the direction of the forces was not modified, the formation of supplementary forces was avoided, and each load can be measured.

The models were studied in monochromic light between the polarizers of a circular plane polariscope, and the fringe pattern of isochromatics was photographed.

Experiment Description

The model represent an image of a part of a real system, so we started from a clinical case (Fig. 4). The support method used in modeling varied in relation to the dento-periodontal support or implant support for and FDP with two abutments.

Fig. 4. Posterior mandibular area- CT scan view

For the fabrication of the bi-dimensional models we have used Araldit plates with a thickness of 8mm, reproducing at a 1:1 scale a mandibular semi-arch and two FDPs in the posterior area, one with dento-periodontal support and the second one with implant support.

For the tooth borne FDP the support was linear on two vertical and parallel abutment teeth (bicuspid and molar - Fig. 4). The roots were fixated in the base with a addition silicone type elastic adherent substance (Vinil Polisiloxano Elite P&P Light), achieving the same type of mobility as real teeth [5].

For the implant borne FDP the support was linear as well on two implants. We used titanium tooth formed implants (Replace Select, Nobel Biocare) with TiUnite surface. The implants were inserted with the help of special drills, using an implant with 4.3 mm diameter and 13 mm length for the molar area, and a 3.5 mm diameter and 13 mm length for the bicuspid area. The prosthetic suprastructure was simplified, the implants being fixated in an photoelastic prosthesis without an abutment intermediary.

Experimental models have undergone forces similar with the chewing process with the help of a special device which was applied on various areas of the FDP. The examination was done with a circular polariscope. The digital images were taken with Nikon D3000 camera with a 18-55/3.5-5.6 lens. Through the images we were able to evaluate quantitative and qualitative the tensions which appeared in the models

The Analysis of Tensions for the Tooth Supported and Implant Supported FDP

In order to exemplify the tensions variations for tooth borne and implant borne FDP for similar loads through the photoelasticity, we presented a couple of cases, allowing the visualization of the isochromatic fields for a comparative analysis.

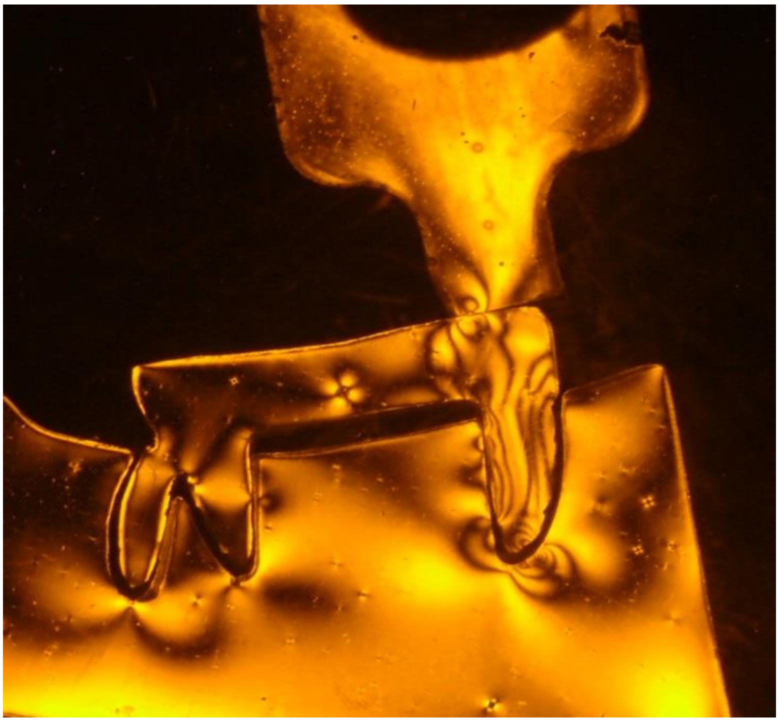

Fig. 5. Model with dento-periodontal support on two vertical abutments, and load applied on the bicuspid abutment

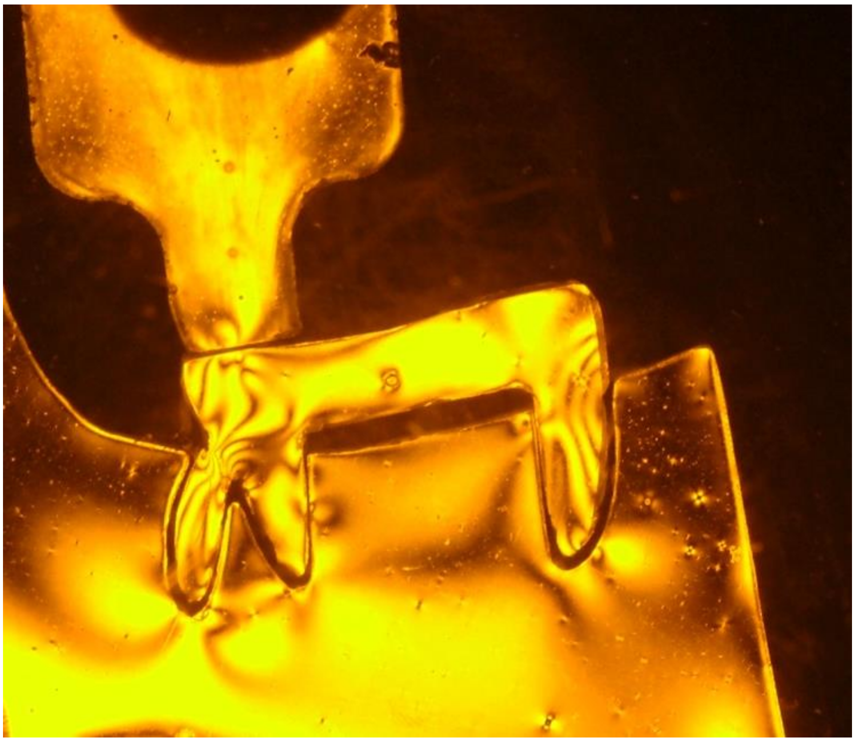

Fig. 6. Model with dento-periodontal support on two vertical abutments, and load applied on the molar abutment

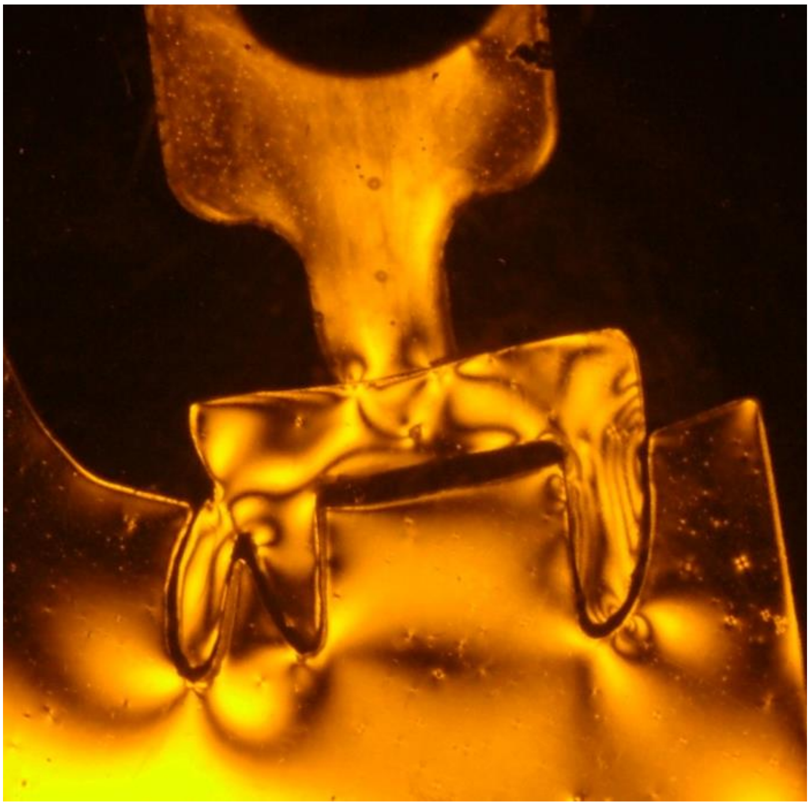

Fig. 7. Model with dento-periodontal support on two vertical abutments, and load applied in the middle of the FDP

Fig. 8. Model with implant support on two vertical abutments, and load applied on the anterior abutment

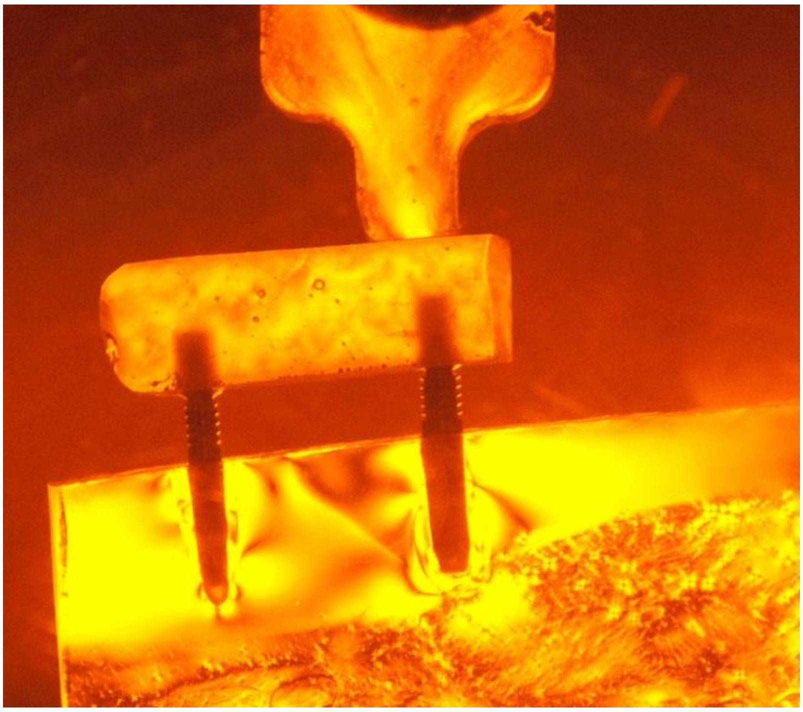

Fig. 9. Model with implant support on two vertical abutments, and load applied on the posterior abutment

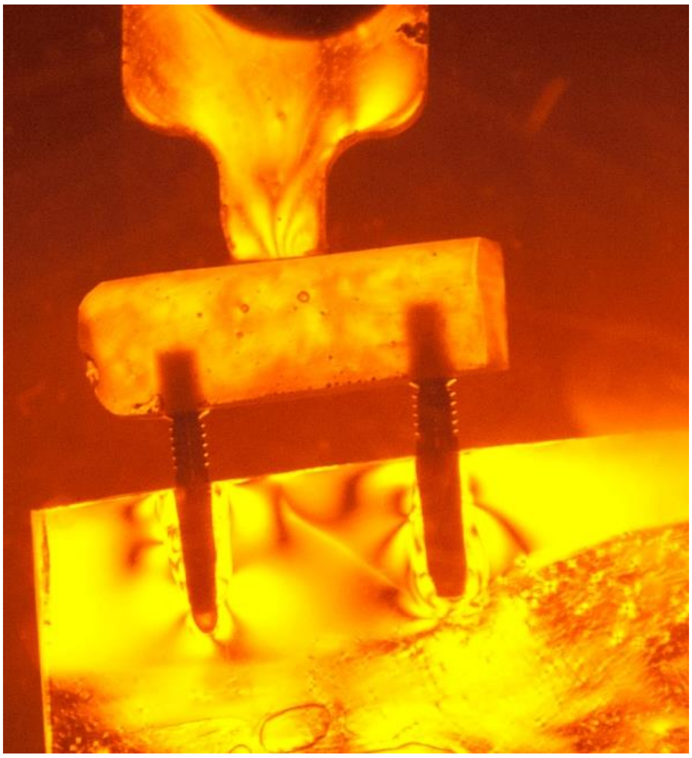

Fig. 10. Model with implant support on two vertical abutments, and load applied on the middle of the FDP

Conclusions

1. The two constructive forms with tooth support (figs. 5, 6, 7) and implant support (figs. 8, 9, 10) can be analyzed based on the magnitude of the support reactions (roots, implants, and alveolar bone) producing the tensions visible on the above images.
2. The constructive structure used (tooth borne FDP and implant borne FDP) is actually a system formed by the interconnected individual parts, and these individual components are not acting as separate units. Each load, regardless of the application point, will affect the whole prosthetic restoration.
3. For the tooth borne FDP the tension is higher on external aspect of the alveolar bone than the internal aspect. A midpoint load on the FDP will produce a symmetric distribution of the tensions. The tensions will be greater on the bicuspid area (mono-radicular tooth) than on the molar area (two-rooted tooth)
4. The loading of the implant borne FDP will result in tensions manifesting mostly on the alveolar bone surrounding the affected implant.
5. The difference between the teeth and the implants is the presence / absence of the periodontal ligament. As a result the forces applied on the tooth on an eccentric direction will be transmitted with a more uniform distribution over the cortical aspect of the dental socket. For this reason the teeth will be able to support greater and eccentric forces then the implants, which, lacking the periodontal ligament, will transmit the applied forces directly to the bone. For this reason dental implants can be more prone to failure when overloaded, or when the forces applied are off the long axis of the implants
6. This study shows the importance of maintaining healthy biological structures, and using the implant therapy only when it is strictly necessary.

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Considerații privind stările de tensiune la protezele fixe cu suport dentoparodontal respectiv implantul dentar

Rezumat

Scopul studiului este de a determina și compara cu ajutorul fotoelasticității stările de tensiune din modelul proteză dentară cu suport dentoparodontal versus proteză dentară cu suport implantar. Prin studierea modelului mecanic al acestor tipuri de proteze dentare au rezultat o serie de concluzii referitoare la mecanismul intim de solicitare și comportare în structurile de suport. Am selectat situațiile cu stâlpi de punte paraleli și verticali. Observațiile obținute experimental prin fotoelasticitate au putere de predicție a reușitelor clinice în tratamentul protetic prin proteze fixe și permit înțelegerea mai ușoară a legilor biomecanicii care influențează comportarea complexului proteză dentară –structură de sprijin.