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THE BIOMECHANICAL BEHAVIOUR OF BRIDGE AND DENTAL-PERIODONTAL AGGREGATE WITH THREE ABUTMENT TEETH

A. FRATILA[a*], C. VASILOAICA[b]
[a]*Department of Dentistry, Faculty of Medicine, "Lucian Blaga" University, Sibiu, Romania*
[b]*Faculty of Engineering 'Hermann Oberth', Lucian Blaga" University, Sibiu, Romania*

Upon the conception and achievement of a long term prosthetic treatment plan, the physician must be familiar with several factors. Among these, particular importance should be given to the allocation of the stresses due to the occlusal forces in the resistance structure formed by the dental-periodontal support (teeth, implants, alveolar bone) and the prosthetic restoration. In the clinical-radiological study we carried out, the prosthetic bridges restored the partial side edentation. In order to explain and predict the evolution of phenomena that occur in the whole bridge with support on three vertical abutment teeth, a material model has been developed and analyzed by using the photo-elasticity method. After the output of the clinical and experimental study is stored, it becomes a factor that can contribute to an optimal configuration of similar structures.

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1. Introduction

The partial edentation is a pathological state of the stomatognathic system characterized by the absence from the dental arch of 1 to 15 teeth. Partial edentation, regardless of its clinical form (low, large, extended), leads to local and regional complications (by disorder of masticatory, phonetical, physiognomical, occlusional functions) and at distance (behaviour, digestive changes); situation that requires early treatment [1].

The treatment of partial edentation, especially for ones on limited area, is made through dental bridges which replace the missing teeth on the arch and recover the affected functions of the dento-maxillary apparatus [2]. Dental bridges can be supported on natural teeth, dental implants or on mixed support of natural teeth and dental implants and transmit masticatory pressures to the jaw bone either through the natural teeth or through the osteotolerate implants [3]. The prosthetic treatment of the partial edentation through dental bridges represents a satisfactory therapeutical solution even tough objections against it have been raised in terms of biological sacrifice. A prosthetic work executed without the knowledge of the general biomechanical, bio-functional and bio-prophylactic principles in the treatment of partial edentation trough dental bridges is a therapeutical failure with repercussions on all the elements of the dento-maxillary complex.

For the conception of the treatment plan trough dental bridges the doctor needs to know the behaviour of teeth under occlusal forces as the complex bridge and dental-periodontal support does not represent an inert body under the action of mechanical laws [1]. On the prophylactic curative imperatives line it is obvious that the prosthetical works must restore, morphologically and functionally, the integrity of the dento-alveolar arches and must integrate in the systemic context (the dento-maxillary aparatus in the sense of inter-relationship between the components).

* Corresponding author: fratila.anca@yahoo.com

This means that restoring each element must be made without any prejudice to the morphology and functional requirements of the other components.

Out of the multitude of the clinical situations on partial edentation we have focused on the restoring through bridge of the partial edentation on the lateral side with three abutment teeth, because it is a strongly solicited area when chewing and the presence of the three support points complicate the modality of the transmission of the forces of mastication at this level [3]. The existing correlation between some of the structural features of the dental bridges and the way the tensions are distributed in the prosthetic device of the abutment teeth represent a useful study field for the dentistry medical practice.

In this respect we have used photo-elasticity for the study of the biomechanics of the dental bridges with three support points. This optical study method gives indications regarding the repartition of the strains produced under the action of a known stress on a photo-elastic model which is similar to the bio-mechanic complex bridge and dental-periodontal support [7].

2. Material and method

The conducted study has an interdisciplinary character and has been structured on two directions:

a. Clinical and radiological observations on the lateral side edentation treated through bridge supported on three abutment teeth. We have examined a lot of 198 patients with partial edentation restored prosthetic by incorrect fixed prostheses. The study has followed the emphasising of the presence of iatrogenic prosthetic factors (nature and tolerance of the restoring material, quality in clinical and technological manufacture of the prosthetic restoration, inappropriate choice of the number and topography of the abutment teeth) as well as the modifications appeared in the areas of periodontal irritation (superficial or deep periodontal).

b. In order to understand and explain the clinical and radiological observations obtained, researches through photo-elasticity have been used on experimental models restoring through bridge the side jaw edentation with three bridge abutment teeth, having similar loads to the ones presented in the mastication process.

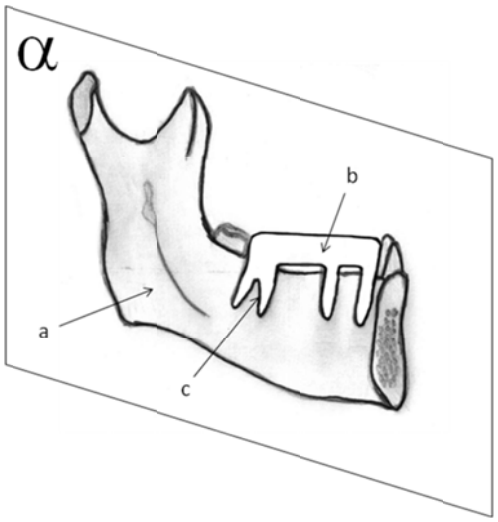

Fig. 1. Photo-elastic models. A mandibular half arch with laterally partially edentulous (a) bridge with support on three abutment teeth (b), artificial sockets (c).

A bidimensional model was made out of the Araldit plates of 8 mm width, reproducing on a scale of 1:1 a half mandibular arch with lateral side edentation (interlaced) and the piece of prosthetic restoration together with the dental-periodontal support of the abutment teeth (canine,

second premolar, second molar). The models have the shape resulted following the sectioning with a longitudinal plan α of the mandible with lateral side edentation with three abutment teeth (Fig. 1a). In the purpose of eliminating some disturbing factors, the representation of the prosthetic restoration together with the dental-periodontal support has been simplified through a bridge with triple abutment at the level of the canine, second premolar, second molar, and the profile of the rectangular bridge, non-arched (Fig. 1b).

In order to obtain photo-elastic models that replicate as closely as possible the conditions of the oral cavity, we used the indicated average values from the specialized literature that refer to the root morphology of the permanent lateral inferior teeth from the molar-premolar-canine region [4, 5]. Fixing the roots in the artificial sockets of the photo-elastic model support (Fig. 1c) was made with a Vinyl Polysiloxane (ELITE P&P LIGHT), which ensured a discrete mobility similar to the physiological mobility of the teeth.

The photo-elastic models were loaded through some soliciting parts which allow the transmission of axial and paraxial forces similar to the ones appearing in mastication. The loads were applied on several directions such as: abutment teeth, central body of the bridge body and on the entire occlusal surface of the prosthetic device. With the help of a mechanical device especially designed and made, they were reproduced similarly to the occlusal forces with the load of the photo-elastic models. This device allowed the forces with variable angels β (Fig. 3) in order to simulate as close as possible the transmission of the tensions that occur during chewing. Knowing the tensions that arise in models with the help of similarity relations real tensions can be established in the bridge dental-periodontal support aggregate.

The examinations were made with a circular flat polariscope in polarized light. The digital images were made with a Nikon D3000 camera with 18-55/3,5-5,6 lens and stored in the computer. Analyzing the images, the tensions appearing in the models have been evaluated qualitatively and quantitatively.

3. Results

Based on clinical and radiological study, we found a higher frequency of prosthetic iatrogenic factors which act directly on the marginal periodontium by a poor technical execution of the prosthetic restoration, placophilia of the prosthetic restoration material (42.4%), followed by their association with lack of occlusal adaptation of the fixed prosthetic restorations (22.7%).

Periodontal structures, due to the action of the microbial plaque enhanced by the presence of prosthetic iatrogenic factors, respond either by a chronic inflammatory reaction or by mixed-cofactorial lesions (inflammatory and traumatic). We included clinical aspects of chronic gingivitis from the study, chronic superficial periodontitis, deep chronic marginal periodontitis, which may be associated to occlusal trauma injuries.

Occlusal trauma is a disorder that can cause lesions in any segment of the dento-maxillary apparatus [6], due to the existence of dysfunctional occlusal forces (supraliminary stresses as intensity, duration, direction, frequency) that exceed its adaptive capacity.

Among the factors favouring traumatic occlusion we have the incorrect prosthetic restorations due to the non-individualized occlusal modelling, the use of inappropriate materials for the prosthetic, insufficient number of support teeth.

We observed that the prosthetic restorations with extensions have the greatest traumatic potential. Supporting this observation are the data regarding the photo-elasticity analysis of the tensions in the bridge periodontal support with a single abutment teeth [7].

We also noted periodontal bone lesions by post occlusal trauma of the abutment teeth in the case of dental bridges supported on three abutment teeth. In the image we can notice the presence of a semiphisiognomic bridge supported on three abutment teeth (canine, second premolar, second molar). The response of the sustaining periodontal bone to the trauma caused by the occlusal non-functional stress (rigid bridge with three abutments) is an increasing opacity of the alveolar bone and the alteration of the specific image of the root at the level of the intermediate abutment (Fig. 2).

Fig. 2. Bridge with three abutment teeth. Mixed periodontal (cofactorial) lesions. Radiological: Condensation of the bone structure and altering of the characteristic image of the tooth root at the level of intermediate abutment.

As a consequence of strains movements on the prosthetics, in clinic some of these prosthetic restorations were partially or totally unconsolidated.

For the analysis of tensions within the bridge dental-periodontal aggregate with triple abutment, we present six cases resulting from the straining of the photo-elastic models on the direction of the abutment tooth (anterior, posterior and intermediate), in the centre of the two intermediate parts of the bridge body, but also all over the prosthetic restoration. Some images are presented in the following graphics.

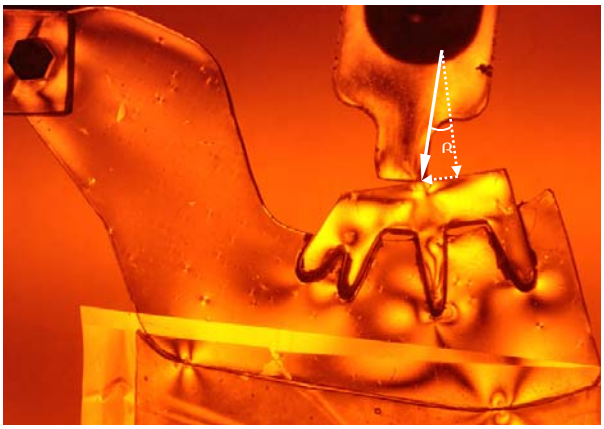

Fig. 3. Model with 3 abutment teeth with strain focused on the direction of the intermediate abutment tooth.

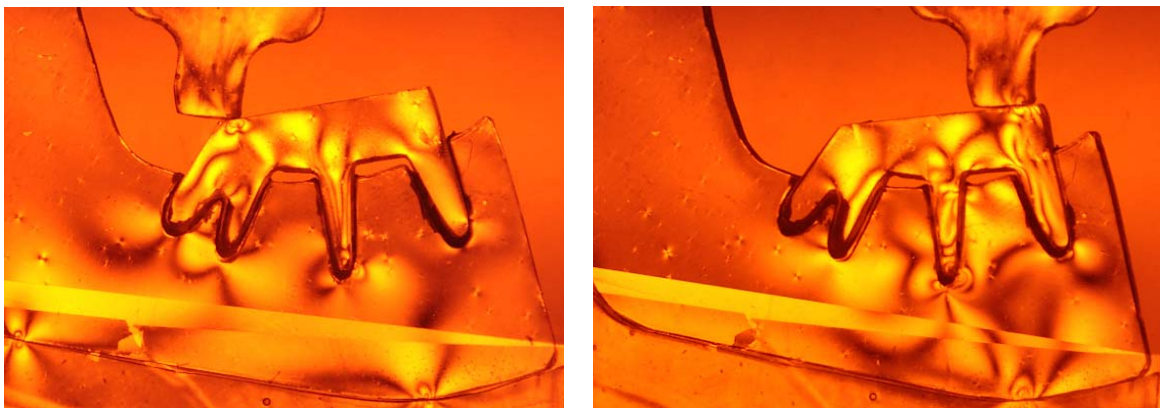

Fig. 4. Model with 3 abutment teeth with strain focused on the direction of the distal and mesial abutment tooth.

Fig. 5. Model with 3 abutment teeth, strain focused at the level of the intermediate part of the bridge body (between the distal or mesial abutment and the intermediate abutment).

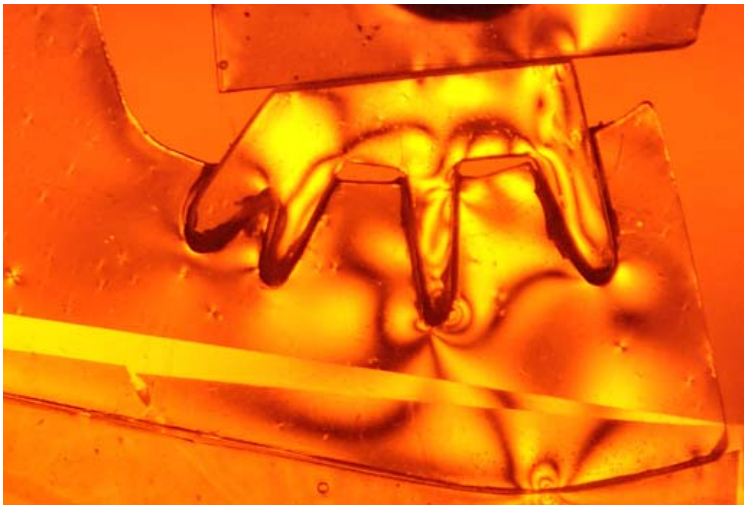

Fig. 6. Model with 3 abutment teeth, strain distributed on the whole occlusal surface of the prosthetic restoration.

As shown in the Fig. 3-6, the intermediate tooth is the abutment (support) where the greatest tensions occur in the case of all strain, whether they have the action focused on any of the abutments, or in any area of the intermediary, or with action distributed throughout the whole occlusal surface of the prosthetic restoration. As the dental bridge is a rigid aggregate, the intermediary abutment is identical to a connexion appearing inside a static indeterminate structure (beam on three supports). These bridges with three abutment teeth (or three pontic support) are subject to some destabilizing forces, the prosthetic restoration reaching a limit state which occurs around the intermediate abutment.

4. Discussion

Studies on the survival rate and the complications of indirect restorations that may occur at the level of the abutment teeth after having applied the fixed prosthetic restorations are presented in the literature [8, 9].

Concerns for elucidating the biomechanical mechanisms which influence the functional balance of the complex bridge and dental-periodontal support, came from a number of authors early at the beginning of the last century. Authors like Sadrin, Ante, Beliard, Duchange, Dubois, Tylman, Van Thiel have developed some hypothesis concerning the balance of the dental bridges with the help of mechanical laws [10]. The observations presented in the technical literature on the

biomechanics of fixed prosthetic restorations represent general considerations in the treatment of partial edentation through dental bridges. They must be applied individually depending on the clinical situation in order to achieve the success and longevity of the performed prosthetic treatment.

In the partial edentulous prosthetic restoration through dental bridges, every dentist realizes that there is a reciprocal relationship between biological factor (the chewing stereotype, the position of the abutment teeth, the dental occlusion, the dental morphology and the support tissue quality) and the laws of mechanics. Thus, in the functional balance of fixed prosthetic restorations, we stopped upon the dental bridge supported on three abutment teeth, as this clinical situation is special from a mechanical point of view. The behaviour of these bridges seems to be a safe solution; however, in reality, as also has been observed in the case of the photo-elastic models, this solution is not optimal. The life of this resistance structure is also influenced by individual mobility of the abutment teeth, apart of the loads that occur within mastication.

Observations obtained in vitro by various methods, such as the finite element analysis or computer programs, have a predictive power for clinical successes in the prosthetic treatment with fixed prostheses [11]. Starting from these observations we performed the analysis of the tensions through photo-elasticity in the bridge-and dental-periodontal support aggregate with three abutment teeth (conditions of the periodontal mobility are similar for the three abutment teeth).

At every type of load (concentrated on one of the abutment teeth, on any area of the intermediaries, distributed on the whole surface of the prosthetic restoration) the strain field is uneven. The only tooth, on which high stress occurs, no matter what strain type, is the central intermediate abutment. The apical area of the central abutment is strongly solicited and tends to move the prosthetic piece around it. The dental bridge is a rigid structure with superior mechanical properties compared to the dental-periodontal aggregate. A variable movement may occur that subdues the abutment teeth from the terminal side of the bridge to some compound strains that will favour the decementation of the prosthetic restoration and the destabilization of the abutment teeth in the alveolar bone. The results of the study are also confirmed by other authors [3, 12], the complex being similar to a balance with a support point at the level of the intermediary tooth.

In the C. Ueda study [13], it was concluded that at the occlusal strain of a fixed prosthesis supported by three implants, the loads are distributed in the long axis of the implants when they are parallel and focusing on the apical area of the lateral implants when the central implant has an inclination.

In our experimental research we have concluded that at the level of the central intermediate abutment there is a higher concentration of tensions because from a biomechanical point of view, the behaviour of teeth is different from that of inert objects (implants). The explanation is given by the physiological mobility of the teeth, which we took into account through the grip of the bridge with their dental-periodontal support aggregate in alveolar socket with an elastic substance.

To support our observations obtained through photo-elasticity we have the results from the clinical and radiological studies. The mastication (chewing) forces that load the bridge and dental-periodontal support aggregate produce compound strains due to bending, torsion, tension, compression, shear efforts. A fixed prosthesis subject to strain can bend and lead to the mobilization of the abutment tooth in the socket [14]. The increased periodontal mobility of the intermediary abutment compared to the other abutment teeth at the extremity of the restoration, will favour an arching motion of the bridge with the deepening of the intermediate abutment and the consequent decementation of the dental bridge [3].

Similar clinical manifestations appear to the bridge with extension because the extension from a mechanical point of view acts like a lever. Therefore, due to the overstraining problems such as decementation of the prosthetic restoration can occur, loss of vitality and fracture of the abutment teeth and of the prosthetic restorations [15, 16]. The explanation of this phenomenon is that this construction can be assimilated with a cantilever [7].

In literature it is recommended that in restorations with prostheses on three abutment teeth to be used articulated systems at the level of the intermediate abutment tooth in the case that it does not show any pathological mobility [2]. This solution must still be argued experimentally.

The clinical and experimental study allowed a better understanding of the biomechanical aspects and of the role of the fixed bridge type used in the treatment of partial edentation.

5. Conclusions

The functional balance of the dental bridges supported on three abutment teeth represents a more special clinical situation from a mechanical point of view. Radiological it's been show the occlusal traumatic lesions at the level of the central intermediate abutment (widening the periodontal space, the condensation of the bone structure and eliminating the characteristic image of the tooth root at the intermediate pontic, apical pilling). For adding to and completing the observations obtained from the clinical and radiological study there are the results obtained through photo-elastic modelling.

The qualitative analysis through photo-elasticity of the tension field in the experimental models reproducing rigid bridges with three abutment teeth, one intermediate central abutment teeth, confirms the unfavourable prognosis of this type of prosthetic device. The behaviour of these bridges from a mechanical point of view, although it seems safe, because of the fact that the bridge is a rigid ensemble in which the middle abutment is stuck between the two other abutment teeth, it can look like a beam with three supports.

The study through photo-elasticity reveals the non-uniform distribution of tensions. The only tooth at the level of which there appear important tensions irrespective to the type of strain is the central intermediate abutment. Its apical area is highly stressed, with a tendency of the prosthetic restoration to swing around the intermediary abutment.

The results obtained experimentally through photo-elasticity have a predictive power of clinical successes in the prosthetic treatment through fixed prostheses and allow easier understanding of the biomechanical laws that influence the behaviour of the bridge and dental-periodontal aggregate.

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