Technological Aspects, Numerical Simulation and Noninvasive Imagistic Approach on Resin Bonded Fixed Partial Prosthesis

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Abstract—Working with resin bonded fixed partial prosthesis could lead a rapid debonding in some cases. This study try to evaluate the possibilities to reduce the problems in that kind of fixed partial prosthesis.

Keywords—Integral ceramic, Resin Bonded Fixed Partial Prosthesis, Optical Coherence Tomography, Numerical Simulation

I. INTRODUCTION

For a conventional preparation with a reduction of tooth substance between 63% and 72%, a resin-bonded fixed partial denture (RBFPD) design may be prepared with a maximum tooth hard tissue loss of 3–30% [1]. Debonding might be minimized by using a retentive preparation design with slots and boxes [2]. The survival rates of these restorations, which were investigated up to 20 years now, vary between 60% (11 years) [3], 66% (20 years) [4], 83% (in 13 years) [5] and 95% (10 years) [2]. A non-precious metal framework may show corrosion, and different thermal expansion coefficients of tooth and metal may lead to stress in the adhesive bond and ultimate adhesive failure. This may be associated with the development of recurrent caries if the patient does not notice the defect in time. A cantilever design with just one retainer was reported to improve the survival probability of RBFPDs [6–10]. Thus, cantilever RBFPD would be preferred since this treatment modality would preserve sounder tooth substance if it has higher probability of survival as stated. Koutayas et al. [11] reported high fracture rates for two-retainer all-ceramic RBFPDs in contrast to comparable cantilever versions when cyclically loaded at 25 N. Clinical reports of a single-retainer RBFPDs showed promising results [8, 9, 12–14], and Kern [12] stated a 5-year survival rate of two-retainer alumina ceramic RBFPDs of about 74% and for the single retainer bridges of 92%.

The aim of this study is to investigate by technological steps, numerical simulation and optoelectronic noninvasive analysis for an integral ceramic resin bonded fixed partial prosthesis.

II. TECHNOLOGICAL APPROACH

A. Preparation Aspects

Ever since Rochette introduced the concept of adhesive prostheses in 1973, a lot of efforts were made in order to develop this less invasive technique. This technique consists in replacing one missing tooth using a fixed partial adhesive prosthesis. The advantage of this type of prostheses is the partial preparing of the pillar teeth. The pellicular preparing (just in the width of the tooth’s enamel) (Fig. 1 and 2) was recommended by R. Simonsen, Van Thomson and Barack. M. Românàu, after years of clinical studies regarding PPF adhesive aggregated recommends his own preparing methodology.

Fig. 1. Pellicular preparing recommended by M. Românàu, proximal norm.
B. Milling Procedure from Ceramic Units

On the cast model a RBFPD was made by a special composite resin (Fig.3). This structure will permit the milling from a ceramic unit the integral ceramic RBFPD (Fig. 4-6).

C. Milling Procedure from Titanium Units

The same RBFPD can be obtain from titanium after inserting a titanium unit in the Dakar system (Fig. 7). The ceramic used for the esthetic adjustments was D.Sign from Ivoclar (Fig. 8).

D. Pressing Technology

The ceramic used for pressing technology was Empress from Ivoclar. After the wax modeling (Fig. 9) the RBFPD was obtained by pressing a ceramic ingot into a mold in order to obtain the ceramic infrastructure. (Fig. 10-12).

After the infrastructure was obtained the ceramic touch was made by colors of Empress System from Ivoclar (Fig. 13-14).
Fig. 9. Wax modeling of RBFPD for the pressing technology.

Fig. 10. The wax infrastructure ready for investment.

Fig. 11. Pressing Technology in RBFPD.

Fig. 12. The integral ceramic infrastructures obtained by pressing technology.

Fig. 13. The pressed ceramic RBFPD on the model.

Fig. 14. Final aspect of the integral pressed ceramic RBFPD on the model.

III. NUMERICAL SIMULATION METHOD

The modeling was made by manually constructing a three dimensional model. This method implies quite a long time to generate the model and good skills in three dimensional objects generating softs. The modeling was made using GEOSTAR, a tool of the COSMOS numeric simulation program.

Two types of investigations were imposed by the complexity of the dental model. After the identification of the interest zone of the numeric dental model, it was done a numerical simulation concerning the zones mentioned before in order to increase the accuracy of the solution. These zones appear to be between the dental tissue and the adhesive fixed partial denture.

The entire dental structure was loaded with 250 N, uniform distributed on the entire surface considerate. Also, it was considered that this force is the normal component of the masticatory one. This means that it is a 5 N normal force, as well as a 15 N horizontal force on each element (Fig.).

Specific biomechanical condition were imposed to this three dimensional dental model, in which the intermediary dental tooth is not represented because of the target of this study. It was considered that the adhesive fixed dental prostheses was made by titanium, and for the dental tissues were considered the normal characteristics mentioned in dedicated literatures.

The computer completed the problem processing and the numerical solution revealed tension zones in the adhesive
fixed dental structure, as well as separated in the dental prosthesis and in the dental tissues.

For the interface between adhesive dental prosthesis and the dental tissues it was compared the maximal tension recorded ($\sigma_{\text{max}}$) with the admissible one ($\sigma_a$), the last one being specific to the dental prostheses material, here titanium. If $\sigma_{\text{max}} > \sigma_a$, than an additional support is recommended (Fig. ).

IV. OPTOELECTRONIC NONINVASIVE INVESTIGATIONS

For this study two systems were used, a time domain system (TDefOCT) working in en face mode at 1300nm and one spectral domain system (SDOCT) that works at 840 nm.

For the TDefOCT all prostheses were investigated with 100 slices per sample and 18 lateral degree. For details the scanning was performed at 8 lateral degree for a better visualisation. SDOCT system uses a wavelength band centred on 840 nm, has an axial resolution of less than 6 microns and an imaging speed of 20 frames per second.
As a conclusion, it is very important to evaluate the RBFPD by numerical simulation in order to observe the possible areas for debonding and in those area it is necessary to develop OCT investigations in order to estimate if there are any materials defects that could lead to a fracture or a rapid debonding of the prosthesis.

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