Imagistic Evaluation of the Polymeric Fixed Partial Prosthesis

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Longevity of fixed partial dentures fiber-reinforced composite restorations is dependent upon many different factors, including material, maxillary or mandibular arches, patient- and dentist-related. 25 metal polymeric and 25 integral polymeric fixed partial prosthesis were obtained for this study. The Rx investigation was performed by using the Fona X 70. The possible defects were investigated with the DIAGNOcam using the transillumination method. In contrast to conventional technology with an interdental light source, DIAGNOcam practically uses the entire tooth as a light propagation medium. the transillumination investigation detects more defects trapped in the polymeric materials in 20 from the 25 metal ceramic fixed partial prosthesis and in 16 from the considered 25 integral polymeric fixed partial prosthesis. In conclusion, a noninvasive evaluations method, such as transillumination, has a great capability to evaluate the internal structure of the polymeric material used for the fixed partial prosthesis considered. Most of these defects were identified in the occlusal, cervical and connector's areas of the fixed partial prosthesis and then could lead to fractures and failures of the prosthetic treatment.

Keywords: polymeric fixed partial prosthesis, transillumination, non-invasive method, material defect

The behaviour and longevity of fixed partial dentures fiber-reinforced composite restorations are influenced by material, prosthetic field, patient and the dentist. Oral hygiene, diet, prevention of oral pathology, fluoride availability, oral environment and patient concern for the oral health are also factors that has to be analyzed during prosthetic treatment. [1].

A condition imposed by FPD is the need for a considerable amount of hard tissue that has to be removed. This step will assure the proper insertion path and sufficient material thickness for masking the metallic structure and high strength of the FPD. During this first stage, the position of the pulp chamber has to be considered and also the needed time for grinding the tooth.

Multiphase polymer matrix fiber-reinforced composite FDPs including inlays and hybrid- retained designs consisting of 1 to 3 pontics has registered a succes rate of 93% after 2 years [2]. The literature is mentioning survival rate (100% at 12, 15 and 24 months) in case of 3 unit inlay retained reinforced composite FPD on short term. [3-5]. Other studies report a succes rate of 91.3% for retained adhesive composite fixed partial dentures reinforced by an UHMWP after two years and 78.3% after 3 years [6].

The present study is estimating a survival mean of 84 months (7 years). Pröbster and Henrich (1997) are reporting a percentage of 61% survival rate an 76% for metal framework of fixed partial dentures after 11 years [7]. Functional survival rate after 63 months is about 75% and 93% in fiber reinforced fixed partial prosthesis. It is not indicated to compare the survival rate of metal-ceramic to fiber-reinforced FPDs due to different mechanical properties. Costs and time-consuming are indicated to be comparated and also material colour, presence of an adhesive and tissue [8]. The lowest survival rate is ranged from 12-96 months of clinical service. In case of inlays the evaluation can be made at least after two years and has to face two types of failure [9].

The mechanical properties of fiber-reinforced composite restoration are different according to cast alloys and adhesive properties which can influence the survival rate. The estimate mean survival rate was higher than 55.03 months after Vallittu (2004) [10].

The removal of dental tissue and the bonding effect are important in avoiding the microleakage when are considered the residual dental structure and framework made out of different materials.

Different studies proved that fiber-reinforced fixed partial dentures may be a successful prosthetic option for a long-term provisional treatment in case of single tooth replacement [11].

Experimental part

In this study, were included 25 metal polymeric and 25 integral polymeric fixed partial prosthesis. The composite matrix of Solidex has a BIS-GMA resin (22% by weight), associated to inorganic ceramic micro-fillers (silicon dioxide and aluminum dioxide particles - 53% by weight) and co-polymers with multifunctional resin (25% by weight). Solidex composites (Japan) is transmitting the light similarly to Vintage Halo and Vintage porcelains and due to this characteristic, the layer technique corresponds to the one used for porcelain restorations. The built up order for Solidex composite is : Cervical Composite, Body, Incisal and possibly Translucent composite. Each layer of composite is light cured individually. The last light curing procedure is according to the manufacturer chart polymerization.

An indirect composite is SR Adoro® introduced by Ivoclar Vivadent, (Liechtenstein) and is used for the other 25 samples. The chemical composition consists of large filler

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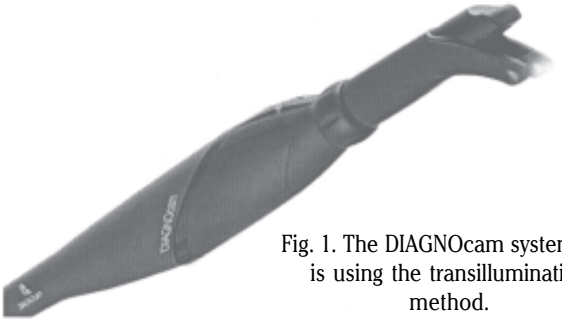

Fig. 1. The DIAGNOcam system that is using the transillumination method.

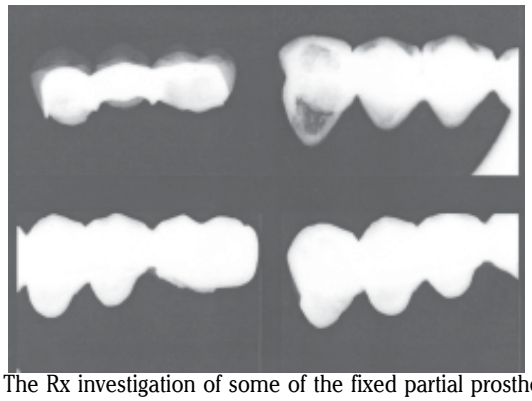

Fig. 2. The Rx investigation of some of the fixed partial prosthesis considered for this study: there are no defects inside the polymeric materials identified by this method

particles (about 1.5 μm) which are combined with microfillers by copolymers. Also contains Bis-GMA or triethylene glycol dimethacrylate (TEGDMA). Urethane dimethacrylate (UDMA) makes the material less susceptible to water absorption and solubility. The large filler particles involve high filler loading resulting in high physical stability and low polymerization shrinkage. However, this also leads to high wear and tear followed by rough surfaces. This factors are leading to increased plaque accumulation but this consequence can be canceled by adding large filler particles.

Fona X 70 device was used for the Rx investigation. Main feature of the system is the great energy obtained by combining the voltage potential of 70 kVp and the anodic current of 7 mA. The exposure time is from 60 ms to 3.2 s. The penetration power of the beam is 70 kVp and generates clear and grants sharp images with high radiographic contrast for optimal detail perception. The microprocessor in the timer assures consistent film blackening in a wide range of operating conditions. The AutoSet timer has a flat keyboard and is microprocessor controlled. It features automatic setting of exposure time from 60 ms to 3.2 s through object programmed selection according to tooth type. For this study the 3.2 s setting exposure was selected.

DIAGNOcam was used to investigate the defects localised into the material. DIAGNOcam is using transillumination as investigation method (fig. 1).Specific for DIAGNOcam is the use of the entire tooth as a light propagation medium. At places where there is a possible defect which blocks light propagation, a shadow will be spotted. This aspect is captured by an integrated video camera that relays the images in real-time to the computer screen. The DIAGNOcam device has a lighting laser diode, a wavelength of 780 nm and an optic power of 15 mW.

Results and discussions

Rx investigation of the all considered samples did not identify any defects into the sample polymeric material (fig. 2).

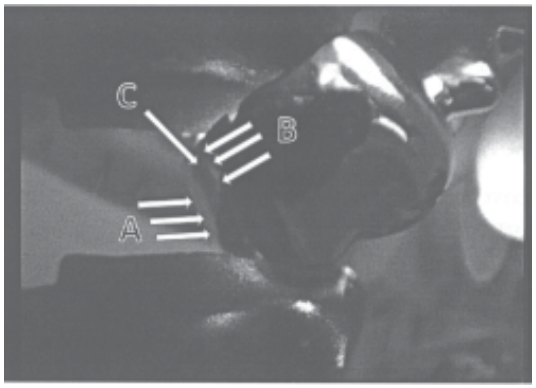

Fig. 3. Transillumination investigation of the interface between the polymer and metal components of the fixed partial sample number 4: polymer material (A); interface between the polymer and metal components (B); defect identified by transillumination inside the polymeric material (C)

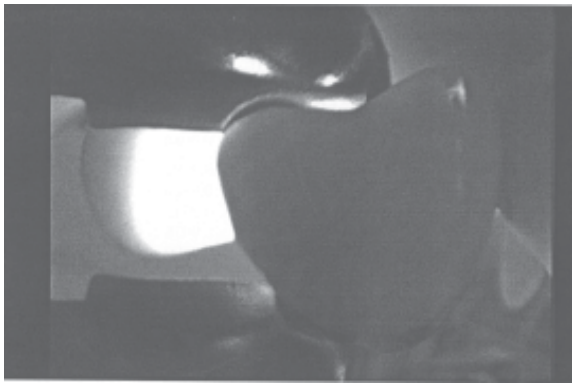

Fig. 4. Transillumination investigation of the interface between the polymer and metal components of the fixed partial sample number 7: no defect is detected inside the polymeric material

Transillumination investigation is more accurate and detects more defects trapped in the polymeric materials. 20 from the total of 25 metal ceramic fixed partial prosthesis were presenting defects. The defects were localized in the cervical area and in the connector areas (fig. 3 and 5). 14 from the 20 metal polymeric prosthesis have showed material defects. Only for 6 samples from the 20 ones metal polymeric prosthesis have presented defects. In case of these 6 samples the defects were identified in the occlusal areas. Some of the evaluations performed by transillumination did not revealed any defects (fig. 4). If the metallic infrastructure of this type of fixed partial dentures is not respected the evaluation has to be repeated because the results are not really accurate (fig. 6).

In case of the integral polymeric fixed partial prosthesis, the defects were localized in 16 from the total of 25 integral polymeric fixed partial prosthesis. Nine integral polymeric fixed partial prosthesis did not show any defects (fig. 7). Many material defects were localized in the areas with high risk for failure, more specifically in the cervical and connectors areas (fig. 8). Erpenstein et al. [12] registered an 84% success rate in 15-year for C+B restoration. The resin reconstructions were still functional and well adapted. The results in case of resin veneers restorations are quite different. In the present study, the esthetics of the crowns were considered satisfactory. Stains of gingival margin, loss of transparency, reduced translucency, and regular color mismatch could affect the aspect of these restorations. After four years the overall degradation of conventional veneers was confirmed by long-term clinical researches [13, 14]. These *in vitro* studies show that non-

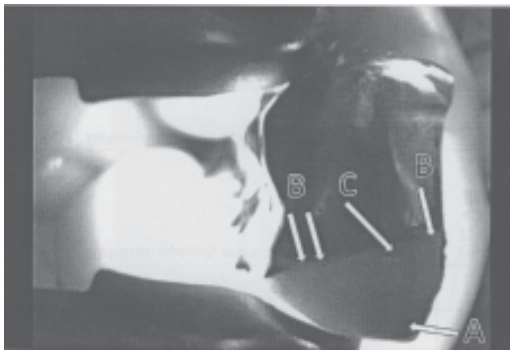

Fig. 5. Transillumination investigation of the interface between the polymer and metal components of the fixed partial sample number 4: polymer material (A); interface between the polymer and metal components (B); defect identified by transillumination inside the polymeric material (C).

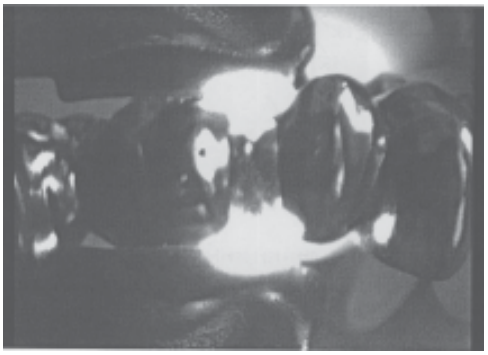

Fig.. 6. Transillumination investigation of the interface between the polymer and metal components of the fixed partial sample number 11: no defect is detected inside the polymeric material because of the wrong positioning of the fixed partial prosthesis related to the Diagnocam system..

precious metallic framework may lead to corrosion phenomena and/or the loosing of the bonding interface of the veneer. These aspects are identified after long-term clinical performance. Different studies belonging to specific literature confirm that metal-polymer crowns from non-precious alloys are modifying their transparency and translucency.

Another author, Peter Rammelsberg reported (2005) the clinical performance of metal-free polymer crowns. He made the report after 3 years in service of the 14 crowns placed on anterior teeth and 14 crowns on posterior teeth After one year 9 crowns and after two/three years 10 crowns could not be re-assessed (patients were at an unknown address, did not agree to further examinations, etc). A number of 10 complications occurred during the 3 year observation period. Three total fractures, three partial fractures and three loosened crowns were registered. One crown exhibited a small hole-like defect on the occlusal surface. A total of four crowns had to be replaced due to failure through fracture -three total fractured and one partial fractured. Loosened crowns could be recemented, and two partial fractures were polished intra-orally. The crown with a hole-like defect was intra-orally repaired with composite material. Kaplan–Meier survival curve indicated a probability of survival of 96% after 3 years. Though the complications were registered for the anterior and posterior teeth, the ones observed in the molar region were predominantly in the maxilla. For the lower jaw, only posterior crowns (first and second molars) showed complications. From the total of four failures three were total failure and only one failure was partially. Crown fractures have also been reported as the main reason for failures of all ceramic crowns (Dicor, Empress). Partial

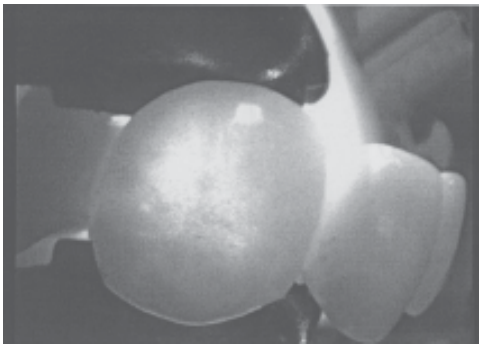

Fig.. 7. Transillumination investigation of the interface between the integral polymeric fixed partial sample number 9: no defect is detected inside the polymeric material.

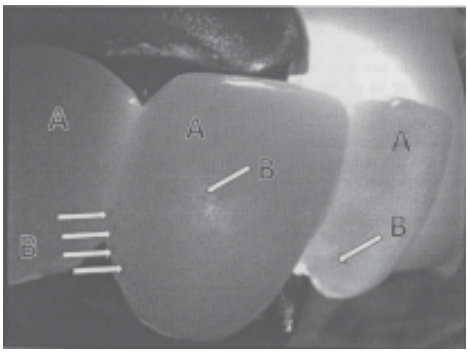

Fig.. 8. Transillumination investigation of the interface between the integral polymeric fixed partial sample number 17 polymer material (A); defects identified by transillumination inside the polymeric material (B)

fractures occurred predominantly in metal ceramic crowns.

In vitro and *in vivo* studies have investigated the fracture resistance of composite crowns. Glass-fiber framework seems to increase the fracture strain of polymers. The high fiber content does not necessarily lead to greater flexural strength because failures of these dental restorations seem to be affected by a variety of factors such as polymer matrix, the fibers or the interface. The flexural strength of reinforced crowns and of crowns without network stabilization nevertheless lies above the expected mastication forces of approximately 500 N. The clinical performance of polymer crowns in this study did not show any clinically relevant influence of fiber reinforcement on the stability of posterior single crowns. The only total failure as a consequence of fracture was registered in the reinforced group.

The association of iatrogenic factors with periodontal breakdown has been recognized, the relationship between dental restorations and periodontal health has been thoroughly investigated for many years and through many studies. The main conclusion of all these studies developed in a long period of time is that composite material has some negative effects on the quantity and quality of subgingival plaque.

In the present study, the clinical performance of polymer crowns revealed no clinically relevant influence of fiber reinforcement in case of the stability of posterior single crowns. The single total failure caused by a fracture appeared in the reinforced group.

The association of iatrogenic factors with periodontal breakdown has been spotted. The relationship between dental restorations and periodontal health has been thoroughly investigated for many years and its importance was demonstrated by many studies. It has been reported that the composite material has some negative effects over the quantity and quality of subgingival plaque.

Optical Coherence Tomography is another successfully non-invasive imagistic investigation method that can acquire images of incipient and advanced carious lesions, can investigate the microleakage of dental restorations the integrity of fixed partial dentures made out of different materials. The endodontic fillings, status of dental implants, integrity of complete dentures and dental prosthesis can be the investigation according to this method [16].

Conclusions

Noninvasive evaluations methods especially trans-illumination, have an increased capacity to evaluate the internal structure of the polymeric material used in this study for the fixed partial prosthesis. Most of these defects were identified in the key areas that assure the succes of the prosthetic restoration. These areas are the occlusal, cervical and connectors areas of the fixed partial prosthesis.

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