AFM Investigation of Metal - Composite Resin Interfaces

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Metal-composite crowns or metal-polymeric crown are an intermediary option from the mechanical and esthetical characteristics between acrylic resin and ceramic materials. Same as in the case of other types of fix partial dentures, the esthetic veneer may present fissures or fractures. The replacement of a fix partial denture is time consuming and involves high costs. In specific clinical cases, the metal-composite fix partial dentures can be repaired with plastic materials like diacrylic composite resin. Metal-acrylic and metal-ceramic fix partial dentures can also take advantage of the diacrylic composite resin in similar situations-fracture. The repairing maneuver can be considered temporary for a longer period of time. The key of reparation's success is the interface integrity between the two materials. Imagistic investigation methods, like Atomic Force Microscopy gives important information about the surface roughness of different materials. The purpose of the present study is the investigation of the new interface obtained after the direct reparation of metal-composite crowns with diacrylic composite resins.

Keywords: crown, acrylic resins, ceramic materilas

Luna-Wing is a composite resin designed for crowns, fix partial dentures on metallic infrastructure or metal free restoration, jacket crowns, inlays, onlays and implant over-structures [1-5]. New composite resins have excellent characteristics which indicate them in direct restorations and indirect restorations. The improved mechanical strength, and low water absorption, low solubility indicate them in implantology, Luna-Wing is a composite resin with such an indication [6,7].

Polymerization can be initiated chemically or by light-curing. In this case the initiator substance is usually a mixture of camforchinone and amine which activates the polymerization of the resin by exposure to visible light (460-480 nm) [8-11]

The interfaces between different natural or artificial materials remain the weak point of fix partial dentures. Reparation protocols were elaborated for metal-acrylic, metal-composite and metal—ceramic crown along time with diacrylic composite resin. The vast applicability of composite resin has many benefits but in case of reparation, the interfaces may still by the origin of failure [12-15].

Experimental part

Fifteen metal composite crowns were made for this study. All the crowns were made after the same cast of a superior dental arch. The natural crown of the upper central incisor from the right half arch (1.1) has to be protected with a fix partial denture. It was chosen a metal-composite crown as therapeutical solution.

After the preparation of the abutment, the impression was taken with a polymeric impression material. For each crown was made a working cast. The crowns have a metallic core obtained through melting-pouring method. The metallic core was made from Co-Cr alloy. The composite resin Luna-Wing (Yamamoto Precius Metal Co., Ldt) was used as physiognomic material.

The bond between metallic frame and DCR veneer is stable and superior to metal-acrylic resin. Though, fracture of esthetic veneer may be initiated by high occlusal stress, technological errors and error in polymerization technique. These factors initiate at first fine fissures that are converted in fissures. The fissures are frequently located on the occlusal surfaces, cervical area and incise margin. These areas are facing higher occlusal stress.

The fracture of esthetic veneer was simulated by removing with a grinding green instrument the DCR. The esthetic material was removed from the labial face of each crown. The defect was created in the third middle of labial face on cervical incise direction until the metallic frame was exposed (fig. 1). During preparing the defects into the esthetic component three crowns became improper for this study.

Fig. 1. Preparation of simulated fracture on the labial face

Luna-Wing is a composite resin designed for a vast variety of fix partial prosthesis, associated with metal or metal free restoration. Before reparation procedure, the metallic exposed surface was sand-blasted in order in increase the contact surface and cleaned with vapours under pressure.

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Fig.2. Application of primer on metallic core

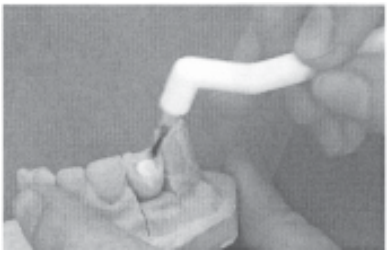

Fig. 3. Opaque layer

Fig.4 The first light-cured layer of composite resin

Before adding the composite resin paste the primer is applied on the metallic surface and light-cured for 90 s (fig. 2, 3).

The opaque paste was applied into a thin layer and light –cure for 180 seconds with a 3M ESPE Elipar FreeLight 2. Composite resin paste was chosen to match the colour of the remained mesial and distally diacrylic composite resin. The paste was laid in thin layers (fig.4). Each layer was light cured separately for 60 s . The aesthetic aspect was very good for all the crowns because it was used the same material and shade.

The final light-cure is made after the application of air barrier Twiny in a very thin layer. There are needed 60 s for drying this final layer and then light-cured for 180 s as final light-cure. The crowns were removed from the cast and thermo polymerised at 110^{o} for 15 min without water (fig. 5).

All the samples were investigated with Atomic Force Microscope. The interested area was the new interface obtained after the reparation procedure. The interface surface roughness was analyzed in contact mode. The oscillation amplitude of the catilever determines the surface roughness providing information about the sample surface characteristics.

Results and discussions

The analyzed surface in reduced but gives precious information about the surface roughness and the continuity of it. The macroscopic evaluation of the reparation didn't identify any defects of the new interface.

AFM investigation emphasizes a discontinuous interface characterized by an alternated positive and negative relief. 3D reconstruction of the scanned surface were made on a surface of 2.27 μm/2.27 μm. Though the surface is reduced the divers and rough surface structure is evident [15-19]

The scanning emphasized material defects, gaps, irregular surface of the interface and porosities at all the samples [20] To some samples it was identified lack of marginal adaptation between the two masses of the same Luna-Wing composite rein. Defects and surface roughness were evident into the superficial layers of the interfaces.

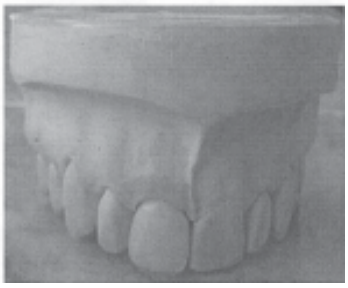

Fig. 5. Final aspect of the repaired crown with Luna-Wing system

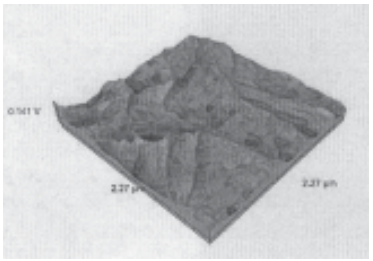

Fig.6. 3D reconstruction of investigated surface

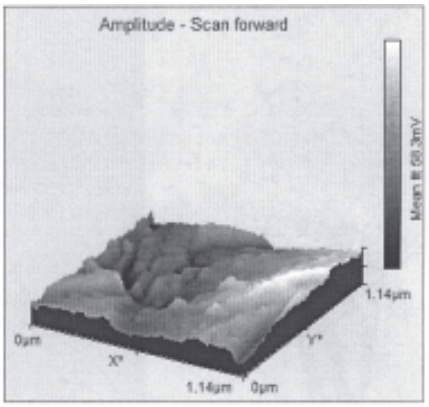

Fig.7. 2D map 3D_1micro

Conclusions

AFM microscopic imagistic investigation is evaluating only the surface structure and mainly the roughness of the materials. If the spotted negative relief, and gap-like defects are present in the deep layers of the interface a fissure is very probably to be initiated due to occlusal stress. Advanced researches that are have the possibility to evaluate the behavior and the deeper layers of the interfaces are needed [21-24].

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