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A 1-year follow-up case report of a biomimetic no post/no crown fiber-reinforced restoration of a structurally compromised tooth

José Antonio Castro Klenner[1,2], Priscilla Cardoso Lazari-Carvalho[3], Tomás Felipe Labarca Galecio[4], Marco Aurélio de Carvalho[3]

[1]Faculty, Department of Oral Rehabilitation and Implantology, School of Dentistry, Universidad Autonoma, Santiago, Chile.
[2]Master Student, School of Dentistry, Evangelic University of Goiás, Anápolis, Brazil.
[3]Faculty, Department of Oral Rehabilitation, School of Dentistry, Evangelic University of Goiás, Anápolis, Brazil.
[4]Master Student, School of Dentistry, Universidad de los Andes, Santiago, Chile.

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***Abstract*—** *Treatment of structurally compromised endodontically treated teeth (ETT) is still a controversial topic faced daily in clinical practice. A correct diagnosis and treatment planning is mandatory to accomplish success and survival of the restoration, but most importantly, to stop the cycle of death of the tooth. This 1-year follow-up case report presents a no post/no crown fiber-reinforced restoration of a structurally compromised endodontically treated tooth. A 65-year-old female sought treatment for her upper left first premolar that had had endodontic treatment and an old MOD amalgam filling from a long time ago before it broke down. The buccal cusp was fractured, leaving less than 50% of the coronal tooth structure. While a conventional approach would require a cast metal or fiber post and a full-coverage crown, a biomimetic approach was chosen for this case. Therefore, a biobase was used for dentin replacement, and a ceramic restoration replaced the enamel. The biobase was reinforced with polyethylene fiber at its base to reduce the stress generated in the hybrid layer. Reconstruction of the dentin core was carried out with a short fiber-reinforced composite resin, which has mechanical properties similar to dentin. The palatal cusp was maintained, and a vonlay preparation was made, covering the remaining cusp. For enamel replacement, a lithium disilicate ceramic was used. The follow-up of this clinical report presents success and survival for 1 year.*

I. INTRODUCTION

Structurally compromised endodontically treated teeth (ETT) comprise one of the most significant challenges clinicians face in private practice since the long-lasting restoration of these teeth is not as predictable as vital teeth.(Dietschi et al., 2007) Prosthetic failures are the most common reason for ETT extraction (Olcay et al., 2018); therefore, correct diagnosis and treatment planning when restoring these teeth should play an essential role in the success and survival. When root canal treatment is performed, the biomechanical behavior of the tooth is changed, and it differs considerably from a vital tooth.(Dietschi et al., 2007) The main reasons for the difference are, in the first place, the loss of tooth structure, followed by caries lesion, fracture, or cavity preparation, including the access cavity before endodontic treatment.(Dietschi et al., 2008; Dietschi et al., 2007)From a biomimetic perspective, preserving and conserving tooth

structure is paramount in maintaining the balance between biological, mechanical, adhesive, functional, and esthetic parameters.(Carvalho et al., 2018) Thus, a ferrule is crucial for the optimal biomechanical behavior of ETT.(Juloski et al., 2012) However, it is not always present, and thus the macro-mechanical retention of coronal structure is compromised.(Lazari et al., 2018)

The options to restore ETT have changed in recent decades due to improvements in adhesive dentistry, with the rise of adhesive materials and techniques. The traditional method for restoring an ETT with a cast metal post and core was challenged by luted fiber posts and build-up, and now, there are new approaches without using a post. These so-called "biomimetic approaches" aim to maintain the highest amount of tooth structure, using new optimized adhesive techniques to restore the biomechanical behavior of compromised teeth.(Magne et al., 2016)

The biobase concept consists of reconstructing the base of a tooth, specifically the dentin, through materials with mechanical properties similar to it, and optimized adhesive protocols that attempt to reduce the stress generated by the polymerization of resinous materials.(Deliperi et al., 2017) One of these protocols utilizes polyethylene fibers, which have been studied for use in vital and non-vital teeth, especially in in vitro studies.(S. Belli et al., 2006; Sema Belli et al., 2006; Erkut et al., 2008; Belli et al., 2007; Hasija et al., 2020; Sadr et al., 2020; Deliperi et al., 2017) Among the advantages attributed to the use of fibers is a decrease in the stress generated by the polymerization shrinkage on the hybrid layer, thus increasing bond strength (Sema Belli et al., 2006), a reduction of the microleakage in class II MOD restorations and in overflared root canals(Erkut et al., 2008; Belli et al., 2007), and an increase in fracture strength of ETT(S. Belli et al., 2006).

In vitro studies have shown that postless approaches might be beneficial for preventing catastrophic failures without losing mechanical performance on fatigue survival(Carvalho et al., 2018; Lazari et al., 2018; Magne et al., 2017).Nonetheless, this topic needs to be further investigated, with different kinds of tests, clinical reports, and clinical studies. Therefore, this clinical report presents a minimally invasive technique without a post and without a crown, maintaining the highest possible amount of sound tooth structure, reinforcing the dentin core with a short fiber-reinforced composite, and replacing the enamel with a ¾ lithium disilicate partial restoration (vonlay).

II. CASE DESCRIPTION

A 65-year-old female sought treatment in a private practice complaining about a broken tooth. She sought to restore her tooth, recovering both function and esthetics. The patient's past dental history revealed that her upper left first premolar had endodontic treatment and an old MOD amalgam filling from a long time ago before failure. Her medical, social, and personal history were found to be inconsequential. No relevant conditions were discovered during the extra-oral examination. The patient had general bone loss due to periodontal disease, and she was informed about this condition. On the other hand, good plaque control was observed as well as that the broken tooth was not affected by significant bone loss.

During the intraoral examination, it was observed that tooth 2.4 with the root canal obturation had been exposed to the buccal environment for at least two weeks. Additionally, the old amalgam filling and the buccal cusp were gone because of the failure. The radiographic examination showed previous root canal treatment with poor obturation in length (1 mm) and a big loose of coronal structure (Figure 1).

Root canal retreatment followed by dentin reconstruction(build-up) and enamel replacement with a ceramic partial crown was planned. The treatment plan was discussed with the patient, and informed consent was taken. For better access and moisture control, rubber dam isolation of the tooth was performed (Rubber dam; Nictone) (Figure 2). Carious tooth structure was then removed with diamond bur under water spray. The gutta-percha was removed 2 mm into the pulp chamber and then sealed with 1 mm of a light-curing glass ionomer liner (Ionoseal; Voco). Air abrasion with 27 μm aluminum oxide (Danville) was used for 10 seconds at 10 mm and 2 bar with a sandblaster (Microetcher II, Danville) (Figure 3). Dentin hybridization was performed with a two-step self-conditioning adhesive system (Clearfil SE Bond; Kuraray). The acidic primer was actively applied for 20 seconds and gently air-dried for 20 seconds for solvent evaporation. The bond was actively applied for 20 seconds, and the excess was removed with a dry microbrush. Light polymerization was performed for 40 seconds at 1000 mW/cm^2 of irradiance (Valo Grand, standard mode, Ultradent). A resin coating was made with a flowable composite resin (Clearfil AP-X flow, Kuraray)(Figure 4). Light polymerization was then performed again for another 40 seconds. A 2-mm-wide polyethylene fiber was used on top of the resin coating layer (Ribbond-THM, Ribbond), applied between the inner side of the palatal cusp and the floor of the remaining structure (Figure 5). The polyethylene fiber was moistened with a light-cured low

viscosity resin (Fortify, Bisco) and then applied over a thin layer of non-polymerized universal composite resin (Clearfil AP-X, Kuraray). Light-polymerization was performed for 20 seconds. The dentin core was created using 2-mm increments of a short fiber-reinforced composite resin (everX Posterior, GC) (figure 6). Light-polymerization was then performed for 10 seconds after each increment. This composite was covered with a universal composite resin (Clearfil AP-X, Kuraray) and light-cured for 20 seconds (Figure 7). The tooth was covered with glycerin gel, and a final light polymerization was carried out for 60 seconds. Preparation was performed for a ¾ partial crown (vonlay) with a chamfer-type finishing line on the buccal and proximal margins of the tooth and a cusp reduction of 1.5 mm on the palatal cusp with a bevel of 1.5 mm width. The impression for the laboratory procedures was made with polyvinyl siloxane (President, Coltene). The ¾ partial crown (vonlay) was made of lithium disilicate according to manufacturer instruction (IPS e.max Press, Ivoclar) (Figure 8 and 9).

The bonding of the partial crown was carried out after restoration and preparation surface conditioning as follows: Partial crown surface conditioning: intaglio of the crown was etched with 9% hydrofluoric acid (Porcelain etch, Ultradent) for 20 seconds; rinsed with water for 60 seconds; cleaned with 35% phosphoric acid (Scotchbond, 3M ESPE) for 60 seconds; rinsed with water for 60 seconds; Silane (RelyX ceramic primer, 3M ESPE) was applied with a microbrush and heat dried with an air dryer for 60 seconds; low viscosity resin (Fortify, Bisco) application without light-polymerization. Preparation surface conditioning: rubber dam isolation; conditioning and cleaning of the preparation surface with 27 μm aluminum oxide (Figure 10); coating with a thin layer of a low viscosity resin (Fortify, Bisco) without light-polymerization. A light-curing veneer cement (RelyX Veneer, 3M ESPE) was applied to the intaglio surface of the partial crown and seated on the tooth preparation. Cement excess was removed and followed by 60 seconds of light polymerization for each side of the tooth (Figure 11). Air-blocking barrier and additional polymerization was carried out for 20 seconds.

Follow-up was done after 1 year. Both clinical and radiographic examinations were performed (Figure 12 and 13). Additionally, no problems were reported by the patient.

III. DISCUSSION

The biomechanical behavior recovery of ETT through restorative procedures is still a complex issue in modern adhesive restorative dentistry. Different approaches and techniques have emerged, and lately, the no-post/no-crown technique is gaining popularity among clinicians. The tooth death spiral(Simonsen, 1991; Elderton, 1988) explains the progression of tooth structure lost through multiple restorative procedures and reintervention that ends in tooth extraction. For this reason, minimal intervention dentistry has been gaining notoriety recently, both for vital and non-vital teeth.(Carvalho et al., 2018; Lazari et al., 2018; Magne et al., 2016) Improvements in endodontic treatment, restorative materials, and techniques have led to a better prognosis for ETT. One of the aspects to be discussed is the interruption or delay of the tooth death spiral by preserving and conserving sound tooth structure with modern adhesive partial restorations (extension preservation) instead of tooth reduction for full crowns (extension for prevention).(Carvalho et al., 2018)In this case, there was a loss of coronal structure of over 50%. If the conventional approach were chosen, a post would have been placed for core retention, and a full crown would have been retained. The no-post/no-crown approach has been studied in vitro over the years; however, there is still a lack of suitable studies.(Fedorowicz et al., 2012) Therefore, there is no consensus in the literature to support crown placement over direct restoration in severely broken-down ETT. Most sound dental tissue can now be preserved, and conserved and partial restorations can be adhesively bonded to the remaining coronal structure, particularly to the enamel substrate, directly or indirectly. (Carvalho et al., 2018) In this particular case, the palatal cusp was conserved and covered with an indirect restoration, preserving tooth structure and changing the biomechanical behavior from tensile to compressive forces.

Biomimetic adhesive restorative dentistry bases its principles on the adhesion of materials with similar properties to dentin and enamel to protect the tooth structure through bonded partial restorations. This type of approach has been studied in recent years with good results(Carvalho et al., 2018; Lazari et al., 2018; Magne et al., 2016; Magne et al., 2017; Murphy et al., 2009; Rocca and Krejci, 2013), but, it is still a field of investigation that needs more clinical studies. In adhesive restorative dentistry, and especially regarding ETT, the main objective is that the remaining tooth structure should last as long as possible. In case of a failure, it should be reparable in order to preserve the tooth.

Cast metal posts have a much higher elastic modulus than dentin. When the tooth is in function, the stress is concentrated on the root; therefore, it is more likely that the fracture mode is catastrophic, causing tooth extraction, the most problematic complication of ETT.(Olcay et al., 2018; Figueiredo et al., 2015) Fiber

posts have an elastic modulus similar to dentin. Thus, the stress is distributed more favorably along the root, decreasing the risk of catastrophic failures.(Figueiredo et al., 2015; Akkayan and Gülmez, 2002) Nonetheless, it has been shown that the incidence of catastrophic failures between cast posts and core and fiber posts do not significantly differ.(Figueiredo et al., 2015) In the present case report, no post approach was taken. A biobase on the tooth was created with a polyethylene fiber on the base in a palatal-buccal direction. The use of polyethylene fibers in dentistry has been studied over the past two decades, with confronting results. The benefits of using them have been described in some studies. (S. Belli et al., 2006; Sema Belli et al., 2006; Erkut et al., 2008; Belli et al., 2007) In this case, the polyethylene fiber was used on the bottom of the biobase, connecting the palatal cusp to the pulpal chamber floor to decrease the stress generated by the polymerization shrinkage on the hybrid layer thus increasing bond strength, as related in some in vitro studies.(Sema Belli et al., 2006) In addition, it has been demonstrated in in vitro studies that the polyethylene fiber reduces the microleakage in class II MOD restorations and in overflared root canals.(Erkut et al., 2008; Belli et al., 2007) Another property attributed to the polyethylene fibers in in vitro studies is the increase in fracture strength of ETT.(S.

Belli et al., 2006) This finding contrasts with another in vitro study, where the use of polyethylene fiber did not enhance the biomechanical behavior of teeth with no endodontic treatment.(Magne et al., 2012) The build-up was made using a short fiber-reinforced composite (SFRC) on a layering technique to replace dentin. SFRC is a dental restorative composite resin intended to be used in high stress-bearing areas as a stress-breaker restorative material. Mechanical testing has shown significant improvements in the load-bearing capacity, flexural strength, and fracture resistance of SFRC compared to conventional particulate filler composite resin.(Fráter et al., 2014) In the SFRC material, E-glass fibers are randomly oriented and possess isotropic features, leading to possible reinforcement in multiple directions.(Bialy et al., 2021) A review found that combining the SFRC as a bulk base with conventional composite improved the loadbearing capacity and failure mode of the material combination compared to plain conventional composite restoration. Furthermore, the biomimetic restoration technique of using SFRC showed promising characteristics, and therefore, might be recommended as an alternative treatment option for large cavities.(Garoushi et al., 2018) Despite this, more clinical studies are needed to support using polyethylene fibers and SFRC in different clinical situations.

IV. FINAL CONSIDERATIONS

Adhesive restorative dentistry has changed in recent years. Improvements in materials and techniques are paving the way to restore teeth in a less invasive way, respecting the remaining tooth structure, and attempting to restore the tooth to its original biomechanical behavior. The main objective of the intervention is to postpone the tooth death spiral. Considering new materials and techniques, clinicians must be cautious when applying new protocols lacking high-level evidence. Therefore, clinical studies are still needed to support these new techniques and the biomimetic approach to restoring teeth. Nevertheless, the follow-up of this clinical report presents success and survival for 1 year with the mentioned approach.

V. FIGURE LEGENDS

Fig.1. X-ray of tooth 2.4 before endodontic re-treatment.

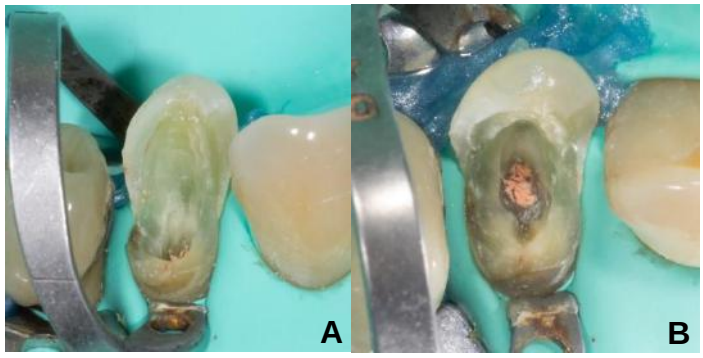

Fig.2. Rubber dam isolation of tooth 2.4. A: Buccal aspect. B: Occlusal aspect.

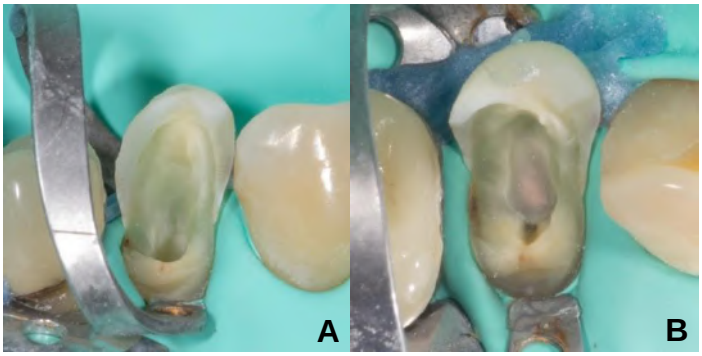

Fig.3. Endodontic treatment was sealed, and air abrasion was done. A: Buccal aspect. B: Occlusal aspect.

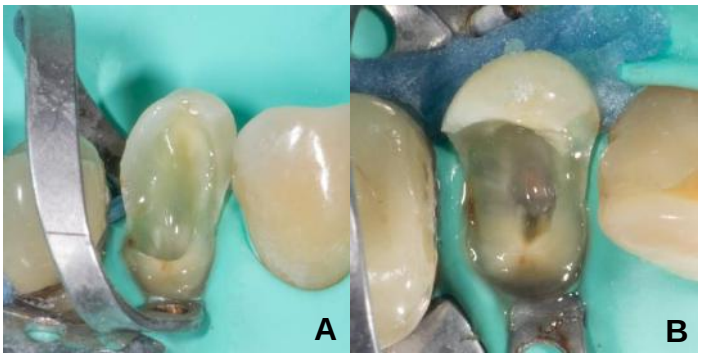

Fig.4. Polymerized self-etch adhesive and resin coated. A: Buccal aspect. B:

Occlusal aspect.

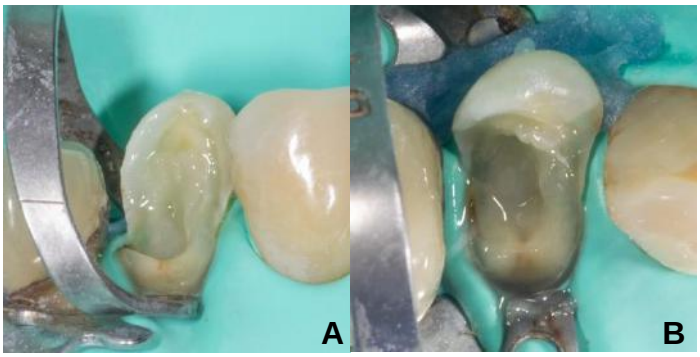

Fig.5. Polymerized polyethylene fiber (Ribbond THM, Ribbond) between the inner side of the palatal cusp and the floor of the remaining structure. A: Buccal aspect. B: Occlusal aspect.

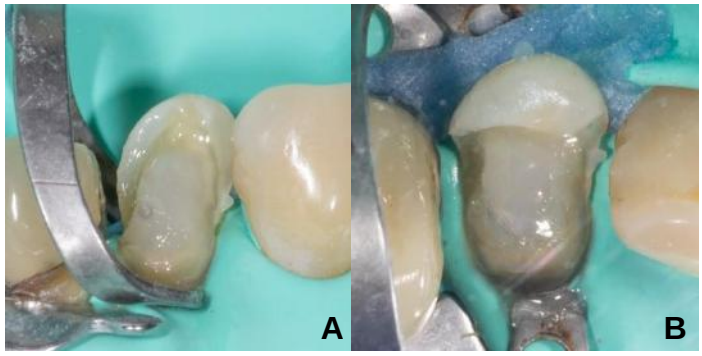

Fig.6. Build-up with short fiber-reinforced composite (Ever X, GC). A: Buccal aspect. B: Occlusal aspect.

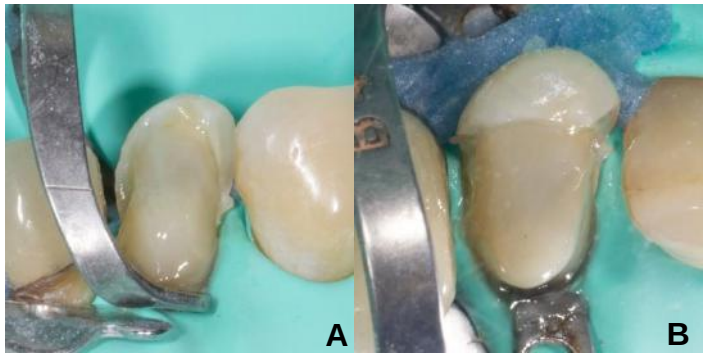

Fig.7. Short fiber-reinforced composite covered with a universal composite resin (Clearfil AP-X, Kuraray). A: Buccal aspect. B: Occlusal aspect.

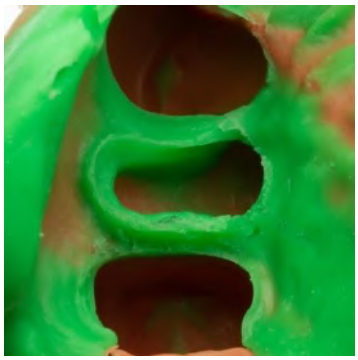

Fig.8. Impression with a polyvinyl siloxane (President, Coltene).

Fig.9. The ¾ lithium disilicate crown (IPS e.max Press, Ivoclar).

Fig.10. Final preparation of the biobase and absolute isolation for bonding.

Fig.11. The ¾ ceramic crown bonded to the biobase.

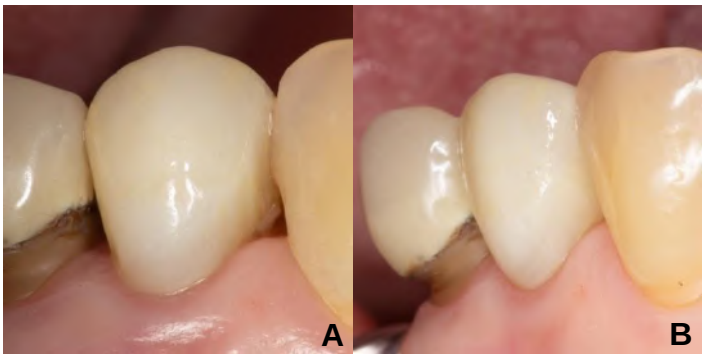

Fig.12. One-year follow-up of indirect restoration. A and B: Buccal aspect.

Fig.13. X-ray of 1-year follow-up of indirect restoration.

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