CAD-CAM single tooth lithium-disilicate restoration through combined endodontic, surgical and prosthetic therapies

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The restorative treatment of a severely decayed, unvital tooth requires often an interdisciplinary approach, and the aesthetic and the entity of the masticatory loads are often influencing the choice of procedures and materials. A case of a 45-year-old woman, with an incompletely treated, painful upper premolar is here presented, where the aesthetic needs and functional requirements led the clinician to choose a surgical and prosthetic rehabilitative path, selecting a lithium-disilicate, monolithic block as ideal material for the final restoration.

Introduction

In case of a serious tooth decay, the treatment often requires an inter-disciplinary approach. The dentist can be required to restore aesthetic and function of an upper tooth, where the aesthetic and the entity of the masticatory loads are often influencing the choice of procedures and materials and even the general prognosis of the tooth. In particular, the factors that had to be considered in this case were the position and size of the cavity, the requirement to complete an endodontic treatment and the size of the final restoration. Moreover, having planned a prosthetic crown, the authors also considered the requirement of endodontic post, the position of the bone crest in respect to the cavity margins, the length of the root, the status of the adjacent teeth, the overall oral hygiene and the patient's compliance and, as important consideration, the cost/benefit ratio to explain to patient. In many cases where the rehabilitation plan of a premolar includes different and complex procedures such as endodontic treatments, posts or extensive restorations, the dentist tends to choose an implant-supported prosthetic rehabilitation, because the costs of the alternative conservative treatments could be similar to those of the implant-supported ones, but the overall prognosis of a tooth-supported prosthesis may result, in the mind of professionals and in a certain part of literature,[1] lower than that of a crown over implant. In fact, the prognosis of different rehabilitations is strongly affected by many factors, mainly the dentist and his skills, but also the used materials.

However, considering the overall length in terms of months, the rehabilitative treatment

Figure 1: Initial situation. The patient reported generic pain in the second quadrant, where there was a restoration in temporary material on tooth number 25.

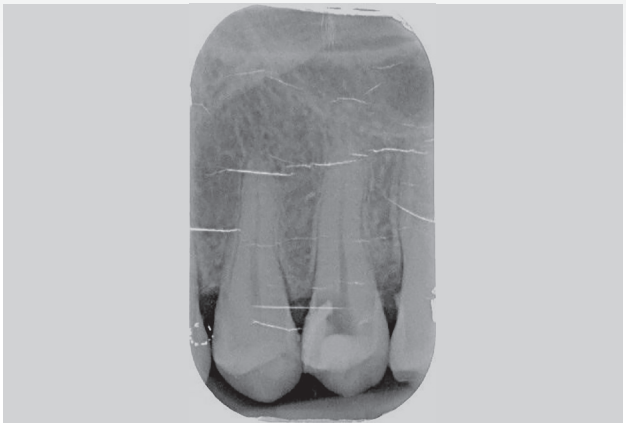

Figure 2: Initial radiograph showing endodontic dressing that had been present for some months, but the treatment was never completed. Note the depth of the caries lesion and the proximity of the interdental bone ridge, which may represent an obstacle for prosthetic rehabilitation.

of a natural tooth is usually faster and the conservative treatment represents always the best choice biologically, if allowed. In this case the right selection of the prosthetic material could be decisive.

Clinical case presentation

A 45-year-old female patient, B.S., referring intensive pain in her upper left dental arch, asked for a visit at the dental clinic of the IRCCS Istituto Ortopedico Galeazzi (Milan, Italy). During the anamnesis she told to be in good health status, without being affected by any chronic disease, and no smoking.

During the clinical oral examination, she didn't exhibit any mucosal lesions, she presented an optimal level of oral hygiene but there were a lot of incongruous restorations and an apparently provisional restoration on tooth #25.

This element was not stimulated with the cold test and the radiographic image revealed an incomplete endodontic treatment (Figs. 1-2). The element seemed to present a suitable root length for a conservative restoration, but the apical position of the carious lesion and the proximity of the interdental bone ridge didn't allow a correct rehabilitation with prosthetic crown, respecting the biological width.[2]

Considering the patient's factors (e.g. age, level of oral hygiene, absence of smoking or other risk factors) and status of the tooth (e.g. length of the root, endodontic access, periodontal status), it was communicated to the patient that the treatment plan would include an endodontic-prosthetic restoration through conservative therapies and CAD-CAM restoration in lithium-disilicate.[3-6]

Operational phases

The patient at the first appointment immediately required a quick solution for the pain, consecutive to an incomplete endodontic treatment and a partially removed carious lesion. So, the first step consisted in the removal of the decayed tissue of the distal face of the tooth 25 in its coronal portion and in the first third of the root.

The cervical limit of the decay was exposed; then the wall was restored with a glass hybrid material (EQUIA Forte™, GC) coated with the light-curable EQUIA Forte Coat™ to obtain a more resistant material even in case of occlusal loads.[7-9] A glass hybrid material was chosen because the apical edge of the tooth cavity was under the gingival margin, so it was impossible to obtain a correct isolation for a composite restoration: it's known that the glass hybrid materials can tolerate acid and humid environments more than composite.[7-9]

The glass hybrid EQUIA Forte was preferred to glass ionomer because better long-term results are reported in literature.[7-10]

After that, the tooth was endodontically treated. The tooth had only one root canal, processed with a hand file READY STEEL K-File™ (Dentsply Sirona) and for the shaping and refinement with mechanical file PROTAPER GOLD™ (Dentsply Sirona) at a working length of 20 mm.

The canal was sealed with a Thermafil™ cone (Dentsply Sirona) with an apical diameter of 0.30 mm (Figs. 3-4).

Figure 3: Root canal therapy completed under proper isolation.

Figure 4: Radiography of completed root canal therapy and reconstruction made completely in glass hybrid cement.

Figure 5: Clinical crown lengthening with a minimally invasive technique without mesial and distal discharges. Note the proximity of the reconstruction in glass hybrid material to the mesial bone ridge.

Figure 6: Suture at the end of surgical therapy. It was left in place for 7 days

Figure 7: Suture removal at 7 days. Post-surgical edema is still present.

The third step of the treatment consisted of the crown lengthening, necessary to expose an adequate part of the root to obtain, after healing, the correct adhesion of the composite for the pre-prosthetic restoration and the successive prosthetic rehabilitation.

After the surgical flap elevation of the tissue and the bone remodeling, the flap was repositioned apically and sutured with a vertical mattress suture anchored in the periosteum (Figs. 5-6). The suture was removed after 7 days (Fig. 7).

During the fourth phase, after waiting a postsurgical healing time of 4 weeks necessary for the correct maturation of the tissues (Fig. 8), the glass hybrid and coronal part of the endodontic material was removed with the Gates Glidden™ cutters (Dentsply Sirona) with 01-02-03 size. A glass fibre

Figure 8: Recovery 2 weeks after surgery. Note the disappearance of post-surgical edema. The provisional crown was placed after two weeks to allow the formation of an epithelial-connective seal in the area.

Figure 9: Prosthetic preparation of the dental element with BOPT technique. Note the minimal aggressiveness in the dental groove, recently traumatized by surgery.

Figure 10: First relining in acrylic resin of the provisional crown in PMMA obtained by digital scanning of the arches, suitable to condition the tissues after only 4 weeks from the operation, taking advantage of the reparative thrust that follows a periodontal surgery.

Figure 11: Provisional crown in PMMA finished and positioned. Composite reconstructions on teeth 24 and 26 have been replaced in order to construct correct contact points with the final crown

Figure 12: Final radiography after positioning of the endodontic post, composite reconstruction and insertion of the provisional crown in PMMA. Note the distance between the edge of the cement used to fix the crown, more radiopaque than PMMA, and the new bone ridge created with periodontal surgery.

post with a medium size truncated cone form, Anatomical Post (DENTALICA, Italy), was inserted and bonded with a self-adhesive dual-cure cement

(G-CEM LinkAce™ translucent, GC). The permanent composite restoration was completed with G-ænial Posterior™ shade A3 composite (GC) bonded with its respective self-etch adhesive (G-ænial Bond™).

After the restoration, the tooth was prepared with the BOPT technique[5-6] . A provisional PMMA crown, obtained with an optical scan done before the preparation of the element with a AADVA IOS 100 scanner (GC), was placed. During this phase the obsolete restorations of the teeth 24 and 26 were replaced. (Figs. 9-12)

After 4 more weeks, the prosthetic abutment was refined and the definitive dental impression was taken with poly vinylsiloxane-ether (PVS-E, Exa'Lence™, GC) (Figs. 13-14). The dental impression was sent to the laboratory, where it was optically scanned and a CAD-CAM path was set.

As a consequence of the newly surgically modified prosthetic margin, the appropriate length of the abutment for an adhesive cementation had been obtained, and the high aesthetic requirement and the contemporary need of containing costs with a monolithic crown, led the clinical choice to a lithium-disilicate crown with high translucency and suitable for the CAD-CAM technology.

The chosen material was the Initial LiSi Block™ (GC), because the ultra-thin structure of the Initial LiSi Block's has two important advantages: first of all, the block is easy to be milled with the use of chairside milling machine in the lab, and secondly this material doesn't require other steps in the

Figure 13: Final preparation of the tooth with the aim of taking the definitive impression. Note the total absence of bleeding despite having extended the preparation margins more apically than the first provisional.

Figure 14: Definitive impression in PVS-E. The impression was scanned by a laboratory scanner and an entire CAD-CAM path was created for milling the final crown.

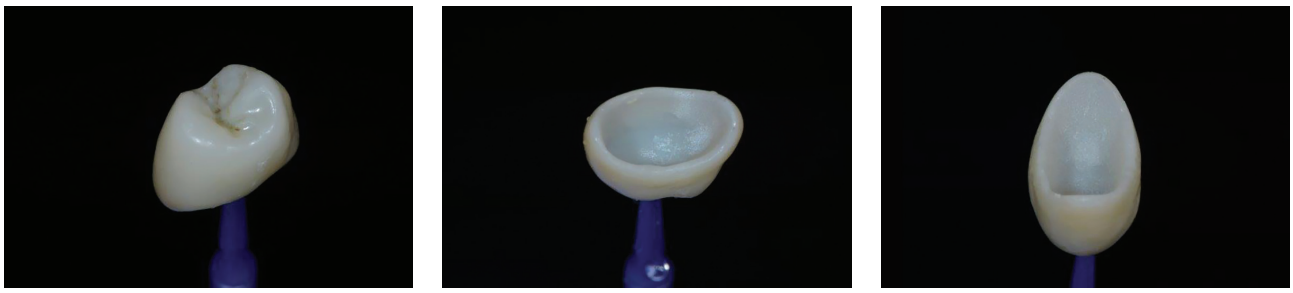

Figure 15, 16 &17: Views of the monolithic restoration in lithium disilicate, polished and finished.

Figure 18: Etching of the prosthetic abutment with orthophosphoric acid for 40"

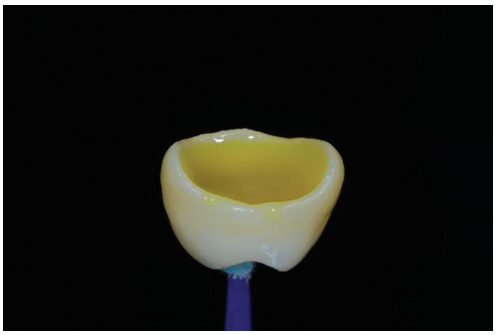

Figure 19: Treatment of the internal surface of the restoration with 9% hydrofluoric acid for 20". Being lithium disilicate, the restoration must be placed in hot water for at least 60" after etching to eliminate some lithium salts that could form on the inner surface and which could weaken the adhesive bonds.

oven to be sintered or glazed. In fact, Initial LiSi Block is the first completely crystalized lithium-disilicate block, so the time for its crystallization could be saved and the software for the finishing and glazing would not have to compensate for any material contraction due to the temperature in the crystallizing oven.

In this way, margins remain extremely thin and clear and it's particularly useful in this case. It's also possible to reduce costs compared to the use of a highly aesthetic and functional material.

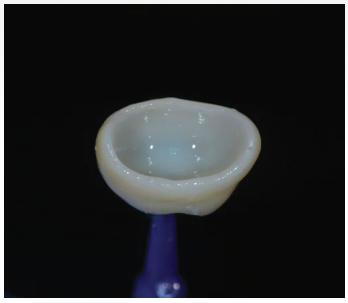

Figure 20: Application of the silane coupling agent to be left in place for at least 60"

Figure 21: Adhesive cementation with adhesive composite resin. The absence of bleeding, the respect of the manufacturer's instructions and the control of the prosthetic margins during the procedures is fundamental for the maintenance and the good outcome of the cementation.

Figure 22: Final palatal view. Note the excellent integration of the margins also on the palatal side.

Additionally, the ultra-thin structure of the Initial LiSi Block permits easily polishing of the restoration even after the occlusal adjustments, leaving the area extremely uniform and smooth. This reduces the finishing times, the brightness lasts longer and the occlusal contacts produce less abrasion of the restoration and of the antagonists (Figs. 15-17).

Regarding the luting phase, the tooth abutment was etched with 37% orthophosphoric acid for 15 seconds (Fig. 18), rinsed and then dried with compressed air. The definitive crown was etched with 9% hydrofluoric acid for 20 seconds (Fig. 19), rinsed and dried with compressed air. According to manufacturer's instruction, it is not recommended to etch Initial LiSi Block for more than 20 seconds, in order to preserve all properties of the material. Since the acid etching with the hydrofluoric acid may result the formation of crystals of lithium salts on the inner surface of the crown,[10] it's important to put the crown in hot water for 1 minute after the acid removal, to eliminate the crystals and prevent any interference with the adhesive cementation, and then it must be carefully dried. Before the placement of the adhesive cement, a specific coupling agent was placed on the internal surface of the crown, in order to obtain a stronger adherence between the ceramic and the luting resin. For this reason, G-Multi Primer (GC) was selected and applied (Fig. 20). The luting phase was finally performed with the G-CEM LinkForce™ (GC), after the placement of the dedicated adhesive system (G-Premio Bond) on the tooth, blowing them with compressed air for 20 seconds, without curing them before the luting phase in order to allow a correct fit of the crown. Each crown surface was cured for 40 seconds (120" in total in order to correctly cure both adhesive and resin cement even through the ceramic) and the excesses of the luting material were finally removed.

Discussion

At the end of the procedures, the restoration was precisely seated at equigingival level of the margins, it appeared to be morphologically integrated in the dental arch, with correct contact points and with a good chromatic match with the adjacent elements (Figs. 21-24). Upon X-ray examination, it was possible to see that the subgingival margins were also integrated, without any step or any plaque-retaining area that could be a problem for the home dental hygiene (Fig. 25). The patient didn't refer pain anymore and was completely satisfied with the prosthetic rehabilitation, that she found perfectly integrated at both functional and chromatic levels. She also found the colour of the prosthesis was better than her natural teeth.

CAD-CAM technology and chairside procedures, including the milling process that takes place completely inside the dental clinic, are actually a solid reality and these kind of digital machines are easily available for many years[8].

The required time for the a complete crown production inside the dental clinic, from projecting, milling to finishing, may vary depending on the material: the required production time ranges normally from 1 hour (for the simplest materials) to more than 4 hours (for the materials that after milling require more tests and passages in finishing furnaces. For this reason, and due to the diffusion of CAD-CAM procedures in laboratories as well, chairside procedures are actually less

Figure 23: Final occlusal view.

Figure 24: Final occlusal view at higher magnification.

Figure 25: Final radiography of the restoration in its position. It can be seen that margins were excellently integrated and the biological width was respected.

appreciated by many dentists, who see them as a possible waste of time, diverting dentists from the real clinical activity

However, the reliability of modern CAD-CAM systems and new materials allow dentists and laboratories to make new choices, even in the name of a smoother workflow and cost control, when possible. A millable material that has considerable aesthetic properties is in any case indispensable, whether a clinician decides for a full chairside procedure, or for sending the impression to the laboratory. Also the "monolithic" materials cannot actually afford to be opaque, not very natural and not very translucent, because very few professionals and patients are inclined to accept aesthetic compromises in modern times.

Moreover, from the dentist's point of view, polishing procedures after possible occlusal adjustments should not require much time, neither dedicated instruments and burs, which mean expenses for the clinic and less time to dedicate to dental activities.

Conclusions

An ideal monolithic material must have some fundamental characteristics, in order to make it an adequate choice for aesthetic and functional rehabilitations:

- High mechanical strength.
- Adequate translucency.
- Ease of processing and milling.
- Availability of different shades.
- Possibility of effective and durable luting with the most common adhesive systems or cements.
- Easy polishing phase involving few steps and burs.
- Availability for the most common chairside and laboratory milling machines (compatibility).

There is not an ideal, universal material that could be chosen for all prosthetic procedures. By the way, while selecting the material that could appear clinically ideal for a specific case, only a good mix of these characteristics can determine a clinical success of a prosthetic rehabilitation procedure with monolithic materials and, ultimately, full patient satisfaction.

References

1. F.C. Setzer and S. Kim; Comparison of Long-term Survival of Implants and Endodontically Treated Teeth J Dent Res. 2014 Jan; 93(1): 19–26. doi: 10.1177/0022034513504782 Ruskin JD, Morton D, Karayazgan B, Amir J. (2005). Failed root canals: the case for extraction and immediate implant placement. J Oral Maxillofac Surg 63:829-831 Lundgren D, Rylander H, Laurell L. (2008). To save or extract, that is the question. Natural teeth or dental implants in periodontitis-susceptible patients: clinical decision-making and treatment strategies exemplified with patient case presentations. Periodontol 2000. 47:27-50

2. Lanning SK, Waldrop TC, Gunsolley JC, Maynard JG. Surgical crown lengthening: evaluation of the biological width. J Periodontol. 2003 Apr;74(4):468-74.

3. Khaled Al-Omiri M., Mahmoud A. A., Rayyan M.R., Abu-Hammad O. Fracture resistance of teeth restored with post-retained restorations: An overview. Journal of Endodontics. 2010;36(9):1439–1449. doi: 10.1016/j.joen.2010.06.005.

4. Barcellos R. R., Correia D. P. D., Farina A. P., Mesquita M. F., Ferraz C. C. R., Cecchin D. Fracture resistance of endodontically treated teeth restored with intra-radicular post: the effects of post system and dentine thickness. Journal of Biomechanics. 2013;46(15):2572–2577. doi: 10.1016/j.jbiomech.2013.08.016.

5. Loi I, Di Felice A. Biologically oriented preparation technique (BOPT): a new approach for prosthetic restoration of periodontically healthy teeth. Eur J Esthet Dent. 2013 Spring;8(1):10-23.

6. Serra-Pastor B, Loi I, Fons-Font A, Solá-Ruíz MF, Agustín-Panadero R Periodontal and prosthetic outcomes on teeth prepared with biologically oriented preparation technique: a 4-year follow-up prospective clinical study. J Prosthodont Res. 2019 Apr 8. pii: S1883-1958(18)30193-2. doi: 10.1016/j.jpor.2019.03.006.

7. Türkün LS, Kanik Ö.; A Prospective Six-Year Clinical Study Evaluating Reinforced Glass Ionomer Cements with Resin Coating on Posterior Teeth: Quo Vadis? Oper Dent. 2016 Nov/Dec;41(6):587-598. Epub 2016 Aug 29.

8. Basso M, Nowakowska J.K, Del Fabbro M. Long-term Dental Restorations using high-viscosity Coated Glass ionomer Cements. Abstract 2494-IADR 2011, San Diego, USA

9. Lohbauer U1, Krämer N, Siedschlag G, Schubert EW, Lauerer B, Müller FA, Petschelt A, Ebert J.Strength and wear resistance of a dental glass-ionomer cement with a novel nanofilled resin coating.Am J Dent. 2011 Apr;24(2):124-8

10. Hesse D, Bonifácio CC, Bönecker M, Guglielmi Cde A, da Franca C, van Amerongen WE, Colares V, Raggio DP. Survival Rate of Atraumatic Restorative Treatment (ART) Restorations Using a Glass Ionomer Bilayer Technique with a Nanofilled Coating: A Bi-center Randomized Clinical Trial. Pediatr Dent. 2016 Jan-Feb;38(1):18-24.

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