

Dentistry Topics

Restoration of endodontically treated teeth

Carla Castiglia Gonzaga¹
Edson Alves de Campos²
Flares Baratto-Filho^{2, 3}

Corresponding author:

Carla Castiglia Gonzaga
5300, Professor Pedro Viriato de Sousa St. – Campo Comprido
Zip code 81280-330 – Curitiba – PR – Brazil
E-mail: carlacgonzaga2@gmail.com

¹ School of Dentistry, Sao Paulo State University – Araraquara – SP – Brazil.

² School of Dentistry, Positivo University – Curitiba – PR – Brazil.

³ School of Dentistry, University of Joinville Region – Joinville – SC – Brazil.

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Abstract

The restoration of endodontically treated teeth is one of the most challenging situations of the dentist's clinical practice, because it involves procedures related to several areas, such as Endodontics, Operative Dentistry, and Prosthetics. These restorations aim to replace the structures lost during endodontic surgery and access to both the pulp chamber and root canal system during the instrumentation, as well as the removal of the carious tissue and temporary restorations. It is also important to remember that the prognosis of endodontically treated teeth depends not only on endodontic treatment success itself, but also on the amount of remnant tooth tissue and the definitive restoration that will be placed onto the dental element.

Effects of the endodontic treatment on tooth structure

Devitalized teeth due to endodontic treatment show some different features compared with vital teeth. This occurs because these teeth, generally, present previous history of carious lesions (small or very extensive), previously performed restorative treatment, eventual fractures and traumas, as well as the endodontic therapy itself.

To plan and perform the restorative treatment of endodontically treated teeth, properly, it is important that the dentist know these alterations and their effects, predicting possible interurrences and planning the most correct approach for each case treatment.

Resistance loss and fracture risk

It is well established that teeth undergoing endodontic treatment have smaller resistance and higher fracture risk. These tooth fractures are relatively frequent in daily clinical practice. However, it is important highlighting that the increase of fracture susceptibility does not directly depend on the endodontic treatment itself. Other factors can effectively contribute to this phenomenon, for example, loss of crown structure and tooth-reinforcing structures, dentin dehydration, deleterious effects of irrigant solutions and intracanal medications on dentin, and reduction of proprioceptive response.

Generally, these teeth suffer a great volume loss of coronal and root dentin due to factors, such as caries, and previous endodontic treatments or restorations. This dentinal tissue volume loss itself can lead to the weakening of remaining tooth structure, which become more prone to fracture occurrence. Additionally to volume loss, during more extensive carious lesions, important tooth-reinforcing structures are also lost, e.g., marginal ridges and pulp chamber roof, further contributing to the weakening of tooth remnant.

Over the years, the increase of endodontically treated teeth's fracture susceptibility has been attributed to the increase of dentinal fragility due to humidity loss. During endodontic treatment, pulp tissue (which presents hydrophilic features) is removed; root canal lumen and dentinal tubules are disinfected and dehydrated prior to obturation. Therefore, the loss of pulp tissue's water content and free water of root dentinal surface, dentinal porosities and tubules may contribute to increase the biomechanical impairment of endodontically treated teeth. Literature has reported that dentin's moisture content of endodontically treated teeth is about 9% smaller than that of vital teeth. However, studies have emphasized that, despite of this difference, it is important to preserve the greatest possible amount of dentin to assure the structure integrity of teeth undergoing endodontic therapy. This corroborates the fact that tooth structure loss is the main reason for increasing the fracture susceptibility of endodontically treated teeth.

At concentrations varying from 0.5-5.25%, sodium hypochlorite is commonly used as irrigant solution during endodontic therapy to pulp tissue dissolution and root canal disinfection. Literature reports several sodium hypochlorite side effects on dentin's physicochemical properties (flexural strength, modulus of elasticity, and microhardness). Additionally, to assure a fast and complete disinfection, some clinicians alter the concentration, volume, and flow rate of irrigant solutions, as well as their temperature and expiration dates. Such alterations aggravate sodium hypochlorite's side effects on root canal dentin, increasing the possibility of damages.

Ethylenediaminetetraacetic acid (EDTA) is also an endodontic irrigant solution used to remove the smear layer formed after root canal instrumentation. Similarly to sodium hypochlorite and other acids, EDTA is also capable of affecting dentin by decreasing its hardness, for example. Studies have also demonstrated that, when used together, EDTA and sodium hypochlorite create

defects on dentin and decrease its mechanical properties, due to the removal of the inorganic and organic phases. These evidences indicate that the intensive use of irrigant solutions at high concentrations and some intracanal medications can deleteriously affect dentin's physicochemical properties, which may lead to dentinal substrate weakening, locally.

In vital teeth, proprioceptive sensibility limits the load applied on dental elements. However, there are evidences that pulpless teeth show reduced levels of proprioception, consequently result in decreasing of normal protection reflex. Tooth tissue loss inherent to endodontic treatment promotes a significant decrease of tooth's proprioceptive response, which can contribute to increase the susceptibility to cracks and fractures.

Color changes and translucency decrease

Endodontically treated teeth frequently show color alterations, and, patients were not aesthetically satisfied when these occur in their anterior teeth. Tooth darkening is mainly caused by restorative materials left inside pulp chamber, after endodontic treatment. To prevent tooth darkening, any filling material should be carefully removed from pulp chamber and from 2 mm short of enamel-cementum junction. Additionally, filling materials containing iodoform or silver are more prone to cause tooth color change.

Restorative treatment planning of endodontically treated teeth

Restorative treatment of endodontically treated teeth may vary, ranging from a relatively small direct restoration to more complex indirect restorations involving the placement of an intraradicular post and core and the indirect restoration itself.

Some factors may directly influence on the option for the restoration type, e.g., the amount of coronal remnant after endodontic treatment and patient's prosthetic need. Also, the clinician should verify whether the tooth would be used as a removable or fixed partial denture abutment. Moreover, the tooth's periodontal and supporting tissues status should be also checked.

It should be clear that, the restorative treatment planning of tooth undergoing endodontic therapy must be carefully executed and, sometimes, it would involve a multidisciplinary team.

Restoration of endodontically treated teeth

The best period to perform the restoration of endodontically treated teeth is a very controversial issue, mainly those presenting a periapical lesion. Therefore, in these cases, the restorative treatment can be either performed immediately after endodontic treatment ending or after a certain time period to wait the regression of periapical lesions. Studies evaluating the time influence on definitive restorations of endodontically treated teeth have shown that the prognosis of teeth with permanent restorations (direct amalgam or composite resin restorations and indirect restorations with or without intraradicular post and core) placed immediately after endodontic treatment ending was better than tooth receiving temporary restorations (zinc oxide and eugenol cements and plaster-based cements). Literature has also reported that marginal microleakage of teeth with temporary restorations is higher than teeth with definitive restorations, suggesting that definitive restoration should be performed as soon as possible after endodontic therapy conclusion.

To prevent root canal system contamination within the period between endodontic treatment ending and the beginning of tooth's definitive restoration is a key factor for success. Therefore, the dentist should be concerned because bacterial contamination is considered an important cause of further problems in endodontically treated teeth.

Some recent studies have indicated that either coronal restoration or apical sealing microleakage negatively affects the endodontic treatment success. Coronal sealing importance has been increasingly recognized by literature. Currently, it has been suggested that apical microleakage may not be the most important factor for endodontic treatment failure and that coronal microleakage is the most likely cause and the key factor for endodontic and restorative treatment success or failure.

Temporary restoration after endodontic treatment

Tooth's restorative treatment after endodontic therapy should be initiated as soon as possible. However, because this is not possible in some cases, an adequate temporary restoration is extremely important to assure an efficient sealing and avoid contamination. To perform their function properly, temporary restorative materials should

present, among other features, high mechanical resistance, good marginal sealing, low solubility, thermal expansion coefficient close to tooth tissues, aesthetics, as well as easy handling, insertion and removal from the preparation.

When immediately restoration is not possible, a temporary restorative material should be used to prevent root canal system from saliva and microorganism contamination. Restorative materials showing any bonding mechanism to tooth structure, such as composite resins and glass ionomer cements (conventional or resin-modified) are good options. Nevertheless, the most common materials employed for this purpose are temporary restorative materials, such as zinc oxide eugenol cements (e.g., IRM) or plaster-based materials that are premixed and then cured when in contact with saliva (e.g., Cavit, Cimpat or Cotosol). It is important noting that temporary restoration, mainly placed into greater access cavities or into teeth presenting greater coronal destruction, does not adequately protect the tooth against fracture occurrence.

In some situations, to improve root canal system sealing, the dentist can use an intermediary procedure. In this case, root canal openings should be carefully cleaned with a round bur of compatible diameter and pulp chamber's floor cleaned from all gutta-percha and endodontic cement excess. Following, pulp chamber's floor should be sealed through bonding technique and composite resin or conventional/resin-modified glass ionomer cement. Next, temporary restoration is placed, with or without using a cotton pellet inside pulp chamber. Ideally, a thin layer of restorative material should be placed for sealing, allowing that root canal openings and gutta-percha be easily seen. This sealing type protects root canal system against contamination until the restorative phase is executed.

In some cases, it is possible that endodontic treatment access be executed through a full crown. Therefore, if the crown seems to be clinically acceptable, at endodontic treatment ending the caries presence must be checked and the temporary material should only be placed without any sign of this pathology. If caries is present, the crown and caries removal should be carried out to allow the temporary restoration placement. In some cases, however, crown's removal is not possible, consequently the most part of the carious tissue must be removed through endodontic access and a good temporary sealing should be executed. Accordingly, restorative treatment should be completed as soon as possible so that both the

carious tissue remnant and the crown be removed, diminishing root canal system and endodontic treatment contamination.

Thus, literature has suggested that the prognosis of endodontically treated teeth can be improved by a good root canal sealing and decreasing of bacteria and oral fluids' microleakage to periradicular areas. Moreover, literature has indicated that the tooth should be restored just after endodontic treatment ending because periapical tissues' health depends more on the temporary restoration than on endodontic treatment technical quality. It is important to highlight that endodontic retreatment should be considered in teeth which lost their coronal sealing or presented problems in their restorations, by any reason. Based on the penetration rate of bacteria and their endotoxins, accurately filled root canals of teeth which have lost their coronal sealing and have been exposed to oral environment for a period longer than two to three months need to be submitted to endodontic retreatment prior to definitive restoration placement.

Definitive restoration after endodontic treatment

Definitive restoration of endodontically treated teeth aims not only to promote coronal sealing and avoid microleakage/contamination, but also to replace the lost tooth structure and protect the remnant tooth structure, mainly against fractures. This restorative stage may involve the placement of one or more of the following elements: intraradicular post and core and coronal restoration itself. Notwithstanding, not all teeth undergoing endodontic treatment will necessitate the placement of intraradicular post and core/indirect restoration (e.g., full crown). The amount of coronal remnant is one of the main factors to be analysed during the restorative step of endodontically treated teeth. Therefore, a careful evaluation of each case should be executed to indicate the best restorative treatment option.

In some cases where the use of intraradicular post and core is necessary and it is installed immediately after endodontic procedure, definitive restoration should also be immediately executed, due to the difficulty of maintaining the temporary sealing. *In vitro* studies have demonstrated that provisionally restored teeth exhibiting an intraradicular post preparation present contamination similar to those not restored yet.

Teeth exhibiting little or no coronal remnant

Teeth exhibiting little or no coronal remnant require the use of intraradicular post and core to retain the coronal restoration.

Quite some time ago, it was believed that intraradicular post and core should be placed after endodontic therapy to reinforce tooth remnant. However, currently, studies have been unanimous in affirming that intraradicular post and core does not reinforce tooth remnant and it can even weaken the tooth due to the necessity of preparation and additional dentin removal for its placement, leading to higher root fracture susceptibility. These studies have already suggested that intraradicular post and core should be used only when there is insufficient coronal remnant to retain and support the final restoration.

Once intraradicular post and core does not reinforce an endodontically treated tooth and tooth preparation may increase the risk of root fracture and treatment failure, the decision of using an intraradicular post and core, at any clinical situation, should be carefully performed. In most cases, endodontic treatment is executed due to trauma, extensive caries, or restorative procedures. Accordingly, the evaluation on the decision of utilizing an intraradicular post and core is based on the amount of sound tooth remnant and on the capability of supporting a definitive restoration or filler core.

Intraradicular post and core employment is also dependent on the tooth type. Several endodontically treated molars do not require an intraradicular post and core because they show more coronal remnant and a larger pulp chamber to retain a filler core. Additionally, molars are more subject to vertical forces, due to their dental arch position and functional movements, which can lead to a lower necessity of intraradicular post and core. Notwithstanding, when it is required, intraradicular post and core should be placed at the largest and more straight root canal to avoid root weakening during preparation, as well as perforation of curved root canals. Lower molars' distal canal and upper molars' palatal canal generally are the most indicated for intraradicular post and core placement. When the retention, mainly in cast metal dowels, is still insufficient after the preparation of a single root canal or there is both a lack of locking and rotation of the coronal portion, additional locking measurements should be considered.

Generally, bicuspid exhibit less coronal remnant and smaller pulp chambers to retain intraradicular post and core after endodontic treatment than molars. Notwithstanding, they more frequently require this approach. Additionally to their root taper and curvature, several bicuspid roots are thin at mesiodistal direction, and some roots may present proximal invaginations. These factors show that the anatomical features of each tooth should be carefully considered during intraradicular post and core preparation to avoid interurrences and iatrogeny, such as root perforations.

Some studies indicate that intraradicular post and core may not be required in endodontically treated anterior teeth exhibiting little coronal structure loss, indicating that these teeth could be restored directly through bonding technique and composite resin. However, if there is a need of a full crown placement after endodontic therapy due to significant loss of coronal remnant, intraradicular post and core will be required. Once more, attention should be given to the anatomical features of each tooth type. Lower incisors, for example, show thin tooth roots at mesiodistal direction, which can make its intraradicular preparation more difficult. Generally, anterior teeth should resist to lateral and shear forces, and, their pulp chambers are small to retain adequately a final indirect restoration without a post and core. Nevertheless, it is highlighted that the amount of coronal remnant and tooth's functional requirement determines if an anterior tooth will or will not demand the use of intraradicular post and core.

Intraradicular posts

The main goal of intraradicular posts is to retain and support the final restorations of tooth presenting extensive loss of coronal structure. Cases in which they are correctly indicated, caution should be taken during intraradicular preparation because, although relatively uncommon, interurrences may occur, such as: perforation at root's apical portion or at flattened areas of some roots' medium third. Intraradicular post installation may also increase the chances of root fracture and restorative treatment failure, especially if an excessive radicular dentin wear during preparation is executed. Thus, intraradicular post installation is recommended only when other options to retain a core or final restoration cannot be used.

Intraradicular posts can be classified in several manners. In a didactic and simple way, they can be divided into two large groups: customized or anatomical and pre-fabricated. Among the customized posts, cast posts are the most known and used in daily clinics, mainly in cases with little or no coronal remnant. Currently, due to aesthetics requirements, customized glass fiber posts and composite resin filler core have also been used in anterior teeth, at daily practice.

Cast metal dowels present a great versatility, because they can be obtained through several metal alloys. Additionally, since they are customized, they allow the use of a thin layer of luting cement and show high resistance, as well as clinical longevity proved by scientific evidence. However, they exhibit some features unfavorable to tooth remnant preservation, such as irregular stress dissipation and stress concentration at apical area favoring the wedge effect, the possibility of oxidation and corrosion, facilitating microleakage and tooth structure pigmentation. Currently, aesthetics is also one of the main disadvantages of cast metal dowel use, mainly in anterior teeth receiving all-ceramic crowns with high translucency.

It is important highlighting that cast metal dowels demand at least two appointments (one comprising the preparation, and dowel's impression or modeling; other comprising dowel's proof, adjustment, and cementation), which result in longer chairtime, as well as laboratorial procedures and costs. Between the appointments, it is necessary to place a temporary crown and post, which can increase the possibility of root canal systems contamination. Ideally, it would be interesting that intraradicular dowels be installed at one appointment, as prefabricated posts. However, despite their disadvantages, countless long-term studies have reported high success rates for cast dowels, if they are well indicated and well constructed.

The increasing demand for aesthetic intraradicular posts resulted in the appearance of prefabricated ceramic posts, in 1990. Generally, they are fabricated in zirconium oxide and present physicochemical characteristics such as modulus of elasticity and flexural strength close to metals (i.e., Cosmopost and Cerapost systems). Despite of the good mechanical properties, the high modulus of elasticity (which indicates the material's rigidity, so that, the greater the modulus of elasticity, the greater its rigidity) of both metals and ceramics (ranging from 80 and 200 GPa, depending on the metal alloy and on the ceramic) may be related

to the relatively high root fracture rate when this type of post is used. Because ceramic posts' modulus of elasticity can reach up to 10 times greater than dentin's modulus of elasticity (about 20 GPa), stress distribution and transference to root during masticatory efforts may negatively influence on the results.

Other important factor to be considered regarding to the use of metallic and ceramic intraradicular posts is their removal, for example, due to their fracture or endodontic retreatment. Metallic (cast dowels) and ceramic posts removal is a very difficult procedure involving risks, because these materials present high rigidity and hardness, making difficult their wear by rotary instruments, ultrasound or burs. When performing the wear of posts at their intraradicular portion, attention should be given to assure that only the post is worn, avoiding deviations and even perforations.

In an attempt to decrease the problems found by the use of intraradicular posts with physicochemical properties very different from those exhibited by dentin, new materials have been introduced into dental market, for this purpose. Carbon fiber posts gained popularity in the 1990s. Their main advantage would be higher flexibility and modulus of elasticity close to dentin. Besides that, because carbon fiber posts can be adhesively cemented to root dentin, it was believed that stresses would be more uniformly distributed on root, resulting in less root fractures.

However, carbon fiber posts exhibit a dark color. This would be a problem concerning to the restoration's aesthetic aspect, as previously discussed. Additionally to carbon fiber posts, other fiber posts are also available in dental market, including quartz and glass fiber posts, which have mechanical properties similar to those of carbon fiber posts, but with better aesthetics. Glass fiber posts are composed of about 40% of silica-based glass fibers (50 to 60% of SiO_2), with about 12 to 18 μm , 30% of resin material (BIS-GMA or epoxy resin) and 30% of inorganic fillers. It is precisely because of its composition that this type of post provides light refraction and transmission through tooth structure, ceramics or resin, without the need of opacifying or modifying agents. In comparison with ceramics or metallic posts, fiber posts are relatively ease to remove through rotary instruments or ultrasound, because the fibers orientation helps to maintain the instrument at the correct aligning, avoiding deviations.

Concerning to shape, prefabricated posts can be parallel or conical. Generally, conical posts

are easier to be installed because of their shape similar to both the root and then prepared and filled root canal. Additionally, the conical shape helps in the maintenance of dentin preservation at apical region during preparation, avoiding an additional weakening of the tooth structure to be restored. Also, it is interesting to emphasize that conical posts are less retentive than parallel posts. Notwithstanding, clinical studies have shown that, despite of the smallest retention when compared with parallel posts, conical posts can be very retentive if they have an adequate length. Concerning to stress distributions, conical posts generate greater stress around all root, while parallel posts generate stress at root apex.

Currently, double-tapered posts have been seen frequently at dental market. These posts are more advantageous than the last two because, at most part of their length, they exhibit a low taper, almost being considered as parallel. However, at apical portion, they show a higher taper. Due to this shape, they present a higher retention and promote a higher preservation of tooth structure at apical third; additionally they provide a better stress distribution.

Preparation of intraradicular posts

Regardless of the post type to be used, whenever possible, root dentin structure should be preserved at most because the greater the increase of its removal and preparation, the greater the root weakening and fracture possibility. Besides that, prior to root canal desobturation and preparation, the dentist should keep in mind that root diameter may different at buccal-lingual and mesiodistal directions. To determine the adequate length and diameter of intraradicular posts, as well as to prevent the occurrence of root perforations and other interurrences, it is necessary to consider the following conditions, during preparation: root taper, proximal invaginations, root curvatures and crown/root angle. In most cases, the endodontist performing then endodontic treatment is the specialist who should execute the intraradicular post space preparation, because this professional knows better the root canal system morphology.

Root canal desobturation and preparation should always be performed under absolute isolation, to maintain the aseptic chain and avoid some possible root canal contamination. Gutta-percha can be initially removed with the aid of a heated instrument or chemical substances. Also, Gates-Glidden and rotary instruments can be used.

During intraradicular preparation, apical sealing should be kept by maintaining 3 to 6 mm of gutta-percha at apical area, because it is important to assure a good barrier against a possible region reinfection. This minimum amount of gutta-percha, in some cases, may limit the post length. Nevertheless, when this occurs, apical sealing is the factor that should prevail. Additionally, once the intraradicular preparation is completed, the post should be cemented as soon as possible, avoiding the possibility of contamination.

Concerning to length, it can be considered that the greater the length the greater the post's retention, although root's amount and shape are also important factors for determining the post length. Anatomical limitations do not even allow that the greatest post length be achieved in relation to root length. Therefore, in curved or short root canals, an additional retention can be executed through either the luting cement agent or more parallel post designs. As a general rule to determine the ideal intraradicular post length, we can cite: the post length should be at least equal to the clinical crown length; the post length should be equal to at least half or two thirds of the root remnant length; and post's root portion should be inserted into at least half of the root supported by alveolar bone. The first two statements are important to achieve a maximum retention with good stress distribution. The last statement, on the other hand, is important to diminish root fracture possibility because fracture risk increases when this condition is not followed.

Literature has supported the aforementioned statements, since clinical studies indicate that longer posts were associated to higher success rates. For example, one study reported failure rates of about 2.5% when the post length had been equal to the clinical crown length. Cases in which the post length was equal to one quarter of its respective clinical crown, the failure rates were 10 times greater, reaching 25%. Other interesting study on vertical fractures in endodontically treated teeth revealed that two thirds of the cases had been associated to extremely short posts, only retained within the roots' cervical third.

It is largely accepted that the post diameter has little influence on its retention. However, larger preparations, evidencing a higher radicular dentin wear, may increase root fracture risk. Generally, post width (as well as preparation) should not exceed one third of the smallest root width, with a minimum of 1 to 1.5 mm of root wall around all preparation, respectively for apical and cervical portions.

Cementation of intraradicular posts

As aforementioned cited the cementation of intraradicular posts should be executed as soon as possible, after root preparation ending. The main factors influencing on post bonding to radicular dentin include properties, such as: high tensile and bond strength, and low potential for plastic deformation occurrences, microleakage and water absorption. Additionally, luting cement agent's handling features during post cementation and degree of polymerization may also play an important role in increasing clinical longevity.

The most used luting cement agents for this purpose are zinc phosphate cement, glass ionomer cement (conventional or resin-modified), and resin cements. From these, zinc phosphate is still one of the most commonly used for metallic posts, because it has advantages such as: longer working time and compatibility with zinc oxide and eugenol, present in a great number of endodontic cements. Notwithstanding, the main disadvantages of this cement are high solubility, especially in the presence of acids, and lack of adhesion to dentin. Conventional glass ionomer cements are also well indicated for metallic post cementation, however, despite of adhesion to dentin and fluoride release, these materials are also soluble and tend to present higher microleakage levels, as well as modulus of elasticity smaller than zinc phosphate cement and dentin. Currently, resin cements have been very used, although literature has reported conflicting results that may be explained by polymerization inhibition by eugenol (as already mentioned, it is present in some endodontic cements) and by the adhesive technique itself. However, despite of the disadvantages, literature has indicated a recent tendency towards to the use of resin cements, because they may improve the retention, tending to present a smaller possibility of marginal leakage. Also, they provide at least at short time, root remnant reinforcement.

Literature has reported that cast metallic dowels cementation with conventional cements, such as zinc phosphate and glass ionomer, do not provide root reinforcement. On the other hand, adhesively-cemented intraradicular posts may initially strengthen the root, but this strengthening is likely lost as time goes by, when the tooth is submitted to functional tension and through adhesive interface degradation.

Among all aforementioned luting cement agents, resin cements are those necessitating more attention regarding to its technique. Cautions initiate soon after the intraradicular preparation

ending, since any residue of gutta-percha and endodontic cement coming from root canal desobturation should be removed from dentinal walls to assure an adequate bonding procedure. After desobturation and preparation, canal walls should be cleaned with a Peeso drill and washed through dental triple syringe and irrigant syringe. Root dentin walls cleaning and washing are extremely important to assure a good adhesion, because bonding failures occur mainly due to impurities present within root canal. In cases employing a zinc oxide and eugenol-based endodontic cement, literature has reported that a good canal cleaning after preparation decrease or even eliminate the possibility and occurrence of problems in resin cements' polymerization by interacting with eugenol.

After cleaning and washing procedures, the removal of the demineralized collagen layer is performed through using a proteolytic agent, such as sodium hypochlorite, aiming to improve resin bonding to root canal walls due to greater penetration of resin tags into dentinal tubules. The bonding protocol itself is then initiated by applying a total-etching or a self-etching adhesive system, always according to the manufacturer's instructions. After the adhesive protocol, the chemical-cured or double-activated resin cement should be handled, carefully inserted into root canal, followed by post insertion. When glass fiber posts are used, prior to cementation and after proof, they should be cleaned with 70% alcohol and undergo silanization.

Filler core

The filler core construction is necessary in cases presenting little or no coronal remnant, allowing thus that the definitive restoration be placed and retained. Several materials can be used for constructing a filler core. Ideally, they should have properties, such as: high tensile and bond strength, biocompatibility, easy handling, bond to the remaining tooth structure, thermal expansion coefficient, shrinkage similar to tooth structure and dimensional stability. Unfortunately, similarly to most of dental restorative materials, none can achieve all these features. Amalgam, composite resin, and glass ionomer cement are currently the most used materials for constructing filler cores.

Despite of the great aesthetic appealing of the current days, amalgam has been successfully used for many years. Notwithstanding, this material presents as disadvantages a long setting time, which

make impracticable its immediate preparation after its condensation and initial crystallization. Additionally, the clinician must be well trained to use amalgam in extensive or complex restorations, as well as in cases with little thickness, due to fracture risk. Concerning to aesthetics, amalgam would not be a good filler core for metallic or metallic-ceramic crowns. However, currently, with the increase of the number of ceramic systems developed and employed, amalgam has not been used as filler core material, routinely. On the other hand, composite resin and glass ionomer cements have offered more satisfactory aesthetics, mainly in anterior teeth and teeth receiving ceramic crowns or indirect restorations. Among these, composite resins should be the material of choice for constructing filler cores in many clinical situations, instead of glass ionomer cements, because these latter exhibit a low modulus of elasticity, smaller adhesion to dental tissues, relatively difficulty of insertion into cavity without the use of a Centrix syringe, and high solubility.

Coronal restoration

In teeth with little or no coronal remnant, coronal restorations generally involve full crowns, such as metallic, metal-ceramic, or all-ceramic crowns. Cases in which some coronal remnant (e.g., one wall) is present and can be preserved, onlay restorations with cusps coverage may be used in endodontically treated teeth. However, these types of indirect restorations demand the execution of an extensive preparation and exhibit a higher cost to patient.

Concerning to cusps coverage, literature has indicated that each clinical situation should be carefully evaluated to determine whether this coverage type would be important for the restoration's longevity and clinical success. Even in cases exhibiting little tooth remnant, it is recommended that cusps coverage be performed after endodontic therapy, because most of teeth requiring endodontic treatment generally undergo severe damages as a result of extensive carious lesions and/or fracture.

Teeth with intermediary coronal remnant

Clinical situations in which the coronal remnants exhibit approximately half of its original volume, their restorations just after endodontic treatment may involve the installation of a prefabricated glass fiber post followed by direct composite resin restoration.

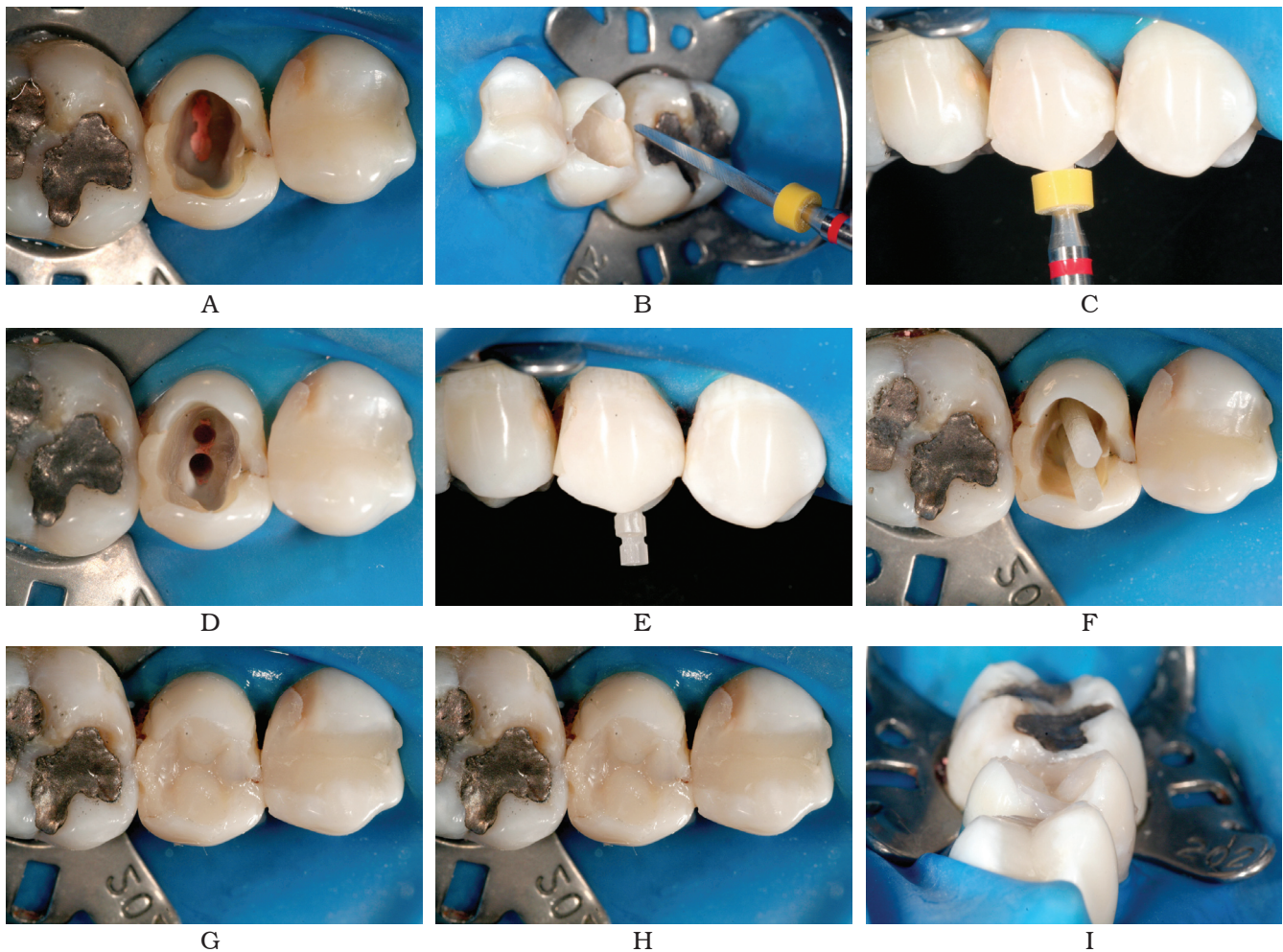


Figure 1 – Placement of two esthetic prefabricated posts on a bicuspid and construction of filler core: (a) occlusal view after temporary restoration removal and access to root canal openings; (b) beginning of root canal desobturation; (c) bur inserted into one root canal indicating the desired measurement of desobturation; (d) final preparation to install the esthetic posts; (e) and (f) vestibular and occlusal views of the posts' prove prior to cementation; (g), (h) and (i) final aspect after posts' cementation and direct composite resin restoration to filler core construction

In some cases when tooth-reinforcing structures, such as marginal ridges, are still present and the tooth displays a deep pulp chamber, we can choose a definitive composite resin restoration only, without the need of an intraradicular post.

Thus, the dentist should evaluate all situations, carefully, to opt by the best restorative treatment for endodontically treated teeth, assuring a good prognosis and higher clinical longevity.

Teeth with great coronal remnant

In some situations, the endodontically treated tooth does not undergo a great coronal structure loss, despite of small preexisting restoration

and access surgery. In these cases, which the tooth shows a great conservation of the coronal structure remnant, the risk of fracture is low and the restorative treatment includes only the execution of direct composite resin or amalgam restorations to close the endodontic access, with very good prognosis.

Immediate dentin sealing

Although this text addresses the restoration of endodontically treated teeth, the repercussion of indirect restoration preparation in vital teeth should be commented, mainly about immediate dentin sealing, issue that has been increasingly discussed on current literature.

Prosthetic preparation of pulped teeth invariably leads to a considerable loss of tooth structure, with exposure of dentin tissue. This dentinal surface itself deserves special attention in the sense of preventing bacterial penetration into dentinal tubules, pulp pathologies and sensibility.

A relatively frequent occurrence in dental offices is post cementation sensitivity after bonding systems use. This sensitivity is explained by the hydrodynamic theory, in which fluids movimentation through dentinal tubules internal space would be capable of sensitizing the nervous fibrils, provoking pain. An approach that has been gaining very

prominence is the immediate dentinal sealing technique, which consists in dentin hybridization immediately after the tooth preparation, even prior to the impression procedure. This hybridization acts as a waterproofing membrane on the freshly-cut tissue, preventing the occurrence of the aforementioned problems. The dentist can easily use this technique with the resources already present in dental office.

The technique consists in employing a bonding system on tooth structure following the same bonding protocol used for constructing direct composite resin restorations.

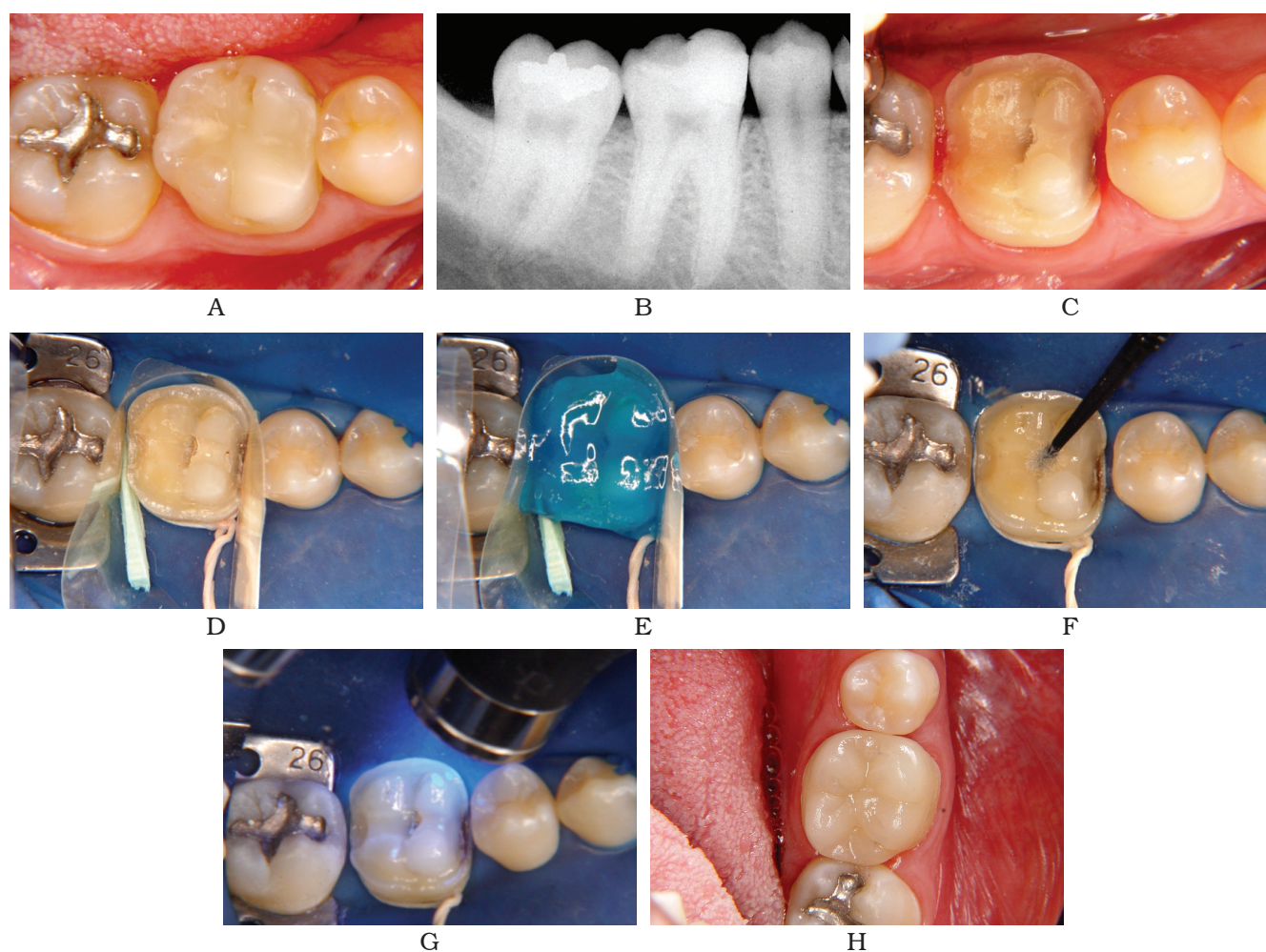


Figure 2 - Immediate dentin sealing: (a) and (b) clinical and radiographic initial aspect of the lower first molar to be prepared; (c) preparation finished; (d) absolute isolation; (e) acid etching; (f) adhesive application; (g) light-curing; (h) final aspect after definitive restoration cementation. In this case, after light-curing, the most superficial uncured layer of the adhesive was removed by Robinson bristle brush with pumice, followed by impression and construction of the temporary restoration

At this point, we should highlight some important factors: it is recommended the use of a multipurpose adhesive system, i.e., presenting separate primer and bond (hydrophobic bonding) agents. This system may be a total etching (acid + primer + bond) or self-etching (acid primer + bond) type. The great advantage of self-etching systems is that, because dentin etching with phosphoric acid is not necessary, dentin permeability is not increased (because the smear layer is not removed). By this mechanism of action, self-etching systems are less prone to exhibit post-operative sensitivity.

The clinical protocol initiates with the application of the bonding system following the manufacturer's instruction. After the final light-curing of the adhesive system, its most superficial layer should be removed by Robinson bristle brush with pumice. The following steps comprise the construction of the temporary restoration and impression procedure. Special caution should be taken during the removal of the superficial bonding layer, because otherwise, temporary restoration will firmly bond to the tooth.

More recently, some authors have indicated the insertion of a composite layer after the application of the adhesive system not only on dentin, but also on cervical enamel. In cases displaying subgingival preparation, cervical wall should be repositioned supragingivally by using the material, always under absolute isolation. To execute this technique, we should choose a micro-hybrid composite resin of regular consistency (normal), avoiding high flow, low viscosity (flowable) resins. This choice is because regular consistency resins present more adequate modulus of elasticity for this clinical situation.

One question that can be raised regarding to the cementation step is whether this layer could interfere on the bond strength of the resin cement. Several studies have demonstrated that, once well prepared, this surface becomes highly receptive to the resin cement and shows bond strength values higher than those demonstrated by cementations directly on non-sealed dentin.

At the moment of cementation, the previously sealed dentin should be sandblasted with aluminum oxide particles. This procedure will increase this sealing layer's surface energy, however, without completely removing it. The bonding potential on this surface is very good, and the professional should normally follow the cementation protocol proposed by the cement agent's manufacturer.

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