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Restoration of endodontically treated teeth

A Project Submitted to The College of Dentistry, University of Baghdad, Department of Conservative in Partial Fulfillment for the Bachelor of Esthetic and Restorative Dentistry

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Certification of the Supervisor

I certify that this project entitled " **Restoration of endodontically treated teeth**" was prepared by the fifth-year student **Nabaa ali fadhel**

under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor's name : **Dr.samar abdulhameed**

Date

Dedication

I would like to dedicate my humble effort to:

My lovely family their affection, love, encouragement and prays of day and night make me able to get success and honor.

To my supervisor

To all people who supported me and help me.

ACKNOWLEDGEMENT

In the name of Allah, the Most Merciful, the Most Gracious. All praise is due to Allah; we praise Him, seek His help, and ask for His forgiveness. Thanks, or gratitude, means reciprocating kindness and giving praise to the one who has done good and kind things. The one who is most deserving of thanks and praise from people is Allah. May He be glorified and exalted. I am thankful to Allah, who supplied me with the courage, guidance, and love to complete this research. Also, I cannot forget the ideal man of the world and the most respectable personality for whom Allah created the whole universe, Prophet Mohammed (Peace Be Upon Him).

My deepest gratitude is to my supervisor, Dr.samar abdulhameed. we have been amazingly fortunate to have an advisor who gave us the freedom to explore on our own and, at the same time, the guidance to recover when our steps faltered. she taught us how to question thoughts and express ideas. Her patience and support helped us overcome many crises and complete this work. I hope that one day I will become as good an advisor to my students as Dr.samar abdulhameed has been to us. I am also thankful to her for encouraging the use of correct grammar and consistent notation in my writing and for carefully reading and commenting on countless revisions of this thesis. Also, for his help and encouragement throughout the whole course of our study. she had contributed many of the important ideas and suggestions for our research.

Abstract

The restoration of endodontically treated teeth has undergone significant changes in the last 20 years. Most of these changes are associated with the preservation of tooth structure, this has been achieved first of all with the increasing use of operative microscopes, nickel titanium instruments and more recently cone beam computed tomography; these instruments have allowed the clinicians to reduce significantly the amount of coronal and radicular hard tooth tissue removed in the process of cutting access cavities. The use of composites has also allowed the clinicians to restore with adhesive techniques teeth that would otherwise require extensive and destructive mechanical retentions. The use of partial crowns is becoming increasingly popular and this also helps prevent tooth structure loss. This article will focus on the choices available to restore both anterior and posterior teeth and will focus more on these contemporary adhesive techniques.

The aim of study :

The aim of studying is to learn about the various techniques, materials, and approaches used to restore teeth that have undergone root canal treatment. The goal of such restoration is to ensure that the tooth regains its function, appearance, and strength while minimizing the risk of further damage or infection.

Introduction

The restoration of endodontically treated teeth is one of the topics more studied and controversial in dentistry. Questions and contradictory opinions remain about clinical procedures and materials to be used to restore these teeth, once fractures are often related. Because of this, a search was performed in the MEDLINE/Pubmed database about the studies publicized in the last 10 years using the keywords nonvital teeth or endodontically treated teeth or pulpless teeth or devitalized teeth and dental restoration and dental pins or dental post and root canal preparation and post-and-core technique. A total of 207 studies were found and 43 were considered for this review article; considering the relevance of the articles related to fracture resistance of endodontically treated teeth restored following different principles and materials.

1. Endodontically treated tooth characteristics

Fractures are more common in pulpless teeth than teeth with vital pulps **(Assif D, Gorfil C. 1994)** although some authors have related a little difference at the fracture incidence between nonendodontically treated (41%) versus endodontically treated (58%) teeth in Chinese patients. However, the last study attributed the higher incidence of fractures in the nonendodontically treated teeth in Chinese people to their diet patterns or chewing habits such as the chewing of bones in meat **(Chan CP, Lin CP, Tseng SC, Jeng JH 1999)**. Factors such as sex, age and dental arch have been affected the incidence of fractures **(Rosenstiel SF, Land MF, Fujimoto J. 2002)**. As example, Chan et al. **(Chan CP, Lin CP, Tseng SC, Jeng JH 1999)**observed that the incidence of fractures was 1.4 times higher in male than in female patients and most fractures occurred in the 40-to-49-years age group in men and in the 50-to-59-years age group in women. In view of the afore

mentioned, researches were performed testing the reasons for fractures in endodontically treated teeth. In 1972, Helfer et al. **(Helfer AR, Meinick S, Schilder H. 1972)** argued that water loss (10%) in pulpless teeth could affect their properties. However, studies comparing some properties, such as microhardness, elastic modulus and tensile/compression strengths, in vital pulp and pulpless teeth related that these properties modified so few to affect fracture resistance of these teeth even though some change in humidity and in properties were noted **(Fusayama T, Maeda T 1969 , Lewinstein I, Grajower R. 1981)**. If the endodontically treated teeth were considered more brittle, in the past, due to structural change in the dentin, which lost water and collagen cross-linking after the endodontic treatment **(Pontius O, Hutter JH. 2002)**, actually it is known that loss of structural integrity associated with the access preparation results in increased cuspal deflection during function, which leads to a higher occurrence of fractures. Considering that in most endodontically treated teeth there are missing tooth structure caused by caries or existing restorations **(Assif D, Gorfil C. 1994, Larson TD, Douglas WH, Geistfeld RE.1981).**associated to endodontic access preparation, it is difficult to establish if higher occurrence of fractures is depending on the structural change in the dentin, missing of tooth structure or both. In addition, another issue related to the endodontically treated teeth is the coronal microleakage and bacterial contamination that occurs when they are not immediately restored, causing endodontic failure and requesting retreatment **(Swanson K, Madison S. 1987) .**So, the use of bonded restorations should be considered to avoid microleakage.

1. Effects of endodontic treatment on the tooth:

A tooth that requires endodontic treatment is commonly a tooth that has lost a large volume of tooth tissue and is heavily restored. These teeth are often more prone to fracture. The fracture of endodontically treated teeth may range from a simple cusp fracture all the way to catastrophic root fracture requiring extraction. The loss of marginal ridge/s has been shown to reduce cuspal stiffness. In the case of the MOD cavity, this was to an extent of 63% **(Chan CP, Lin CP, Tseng SC, Jeng JH 1999).** In a more recent study using micro-computed tomography a significant reduction in tooth stiffness was noted with an access cavity preparation and more so with a post preparation for a cast metal post. The preparation for a fibre-post proved more conservative and less tooth tissue needed to be removed. **(Rosenstiel SF, Land MF, Fujimoto J. 2002)**.

The medicaments and irrigants used during root canal treatment can alter the physical properties of dentine and the prolonged use of calcium hydroxide renders the dentine more brittle and prone to fracture. **(Helfer AR, Meinick S, Schilder H. 1972, Fusayama T, Maeda T 1969 , Lewinstein I, Grajower R. 1981)** Additionally, non-vital teeth lose proprioception and are less adept at perceiving increased load**. (Huang TJ, Schilder H, Nathanson D 1991)**

Preservation of coronal tooth tissue without compromising endodontic access is desirable. Adhesive techniques allow the clinician to add to existing, residual tooth tissue and do not require creation of macromechanical retention; this permits preservation rather than removal of hard tooth structure.

2. **Timing of the restorative procedure:**

The factors to consider in terms of timing of the restorative phase of treatment are:

- Pre-existing endodontic status
- Quality of root canal filling
- Position of tooth in the mouth
- Type of restoration planned.

If root canal treatment has been completed to a technically satisfactory standard and the tooth is symptoms free then it is sensible to proceed with the final restoration straight away. This is particularly true when dealing with a previously vital, uninfected tooth. If the tooth was symptomatic that is, tender to biting and on lateral pressure, then delaying the final restoration for a few weeks while the tooth settles would be prudent. If the tooth fails to settle then root canal retreatment may well be required.If the tooth had a small pre-existing periapical radiolucency (less than 2 mm) then the tooth should be treated in the same manner as the vital tooth. If the tooth had a larger pre-operative periapical radiolucency and a good root filling has been completed then a short review period should be considered.There is conflicting evidence whether the pre-operative lesion size has an effect on endodontic success; some authors report it makes no difference,[7,8] while others suggest a larger lesion has a negative effect on outcome. **(Swanson K, Madison S. 1987, Larson TD, Douglas WH, Geistfeld RE.1981).** A larger lesion might

indicate the presence of a higher bacterial load within the root canal. In this scenario a more conservative review approach should be taken to ascertain whether the root canal treatment has been successful. A review period is sensible especially in a practice setting where patients will be financially investing in the final indirect restoration and are usually less accepting of failure. In those teeth where the prognosis is doubtful and a good root filling has been executed it may be advisable to allow for a longer review period until there is clinical evidence, and in some case, radiographic evidence, of healing. Should the clinician take this approach then the tooth must be adequately protected during this period to prevent unwanted, catastrophic tooth fracture. It is sensible to place a plastic restoration with cuspal protection or stabilise the tooth with a well-fitting, well-burnished thin copper band or an orthodontic band cemented with a glass-ionomer cement.

3. Treatment planning

Although endodontically treated teeth have been extensively studied, the treatment planning and materials to restore them is yet controversial. The difficulty to determine the treatment planning is shown in a study related by Tu¨rp et al. **(Tu¨rp JC, Heydecke G, Krastl G, Pontius O, Antes G, Zitzmann NU 2007)**, who asked four specialists about the better treatment for a fractured lateral incisor, and different treatment strategies were received based on the literature. Therefore, the question about the better way to restore these teeth remains among the clinicians: direct or indirect restorations, using or not posts, the better material and the principles used in the design prepares. Some criteria should be considered to select

the material and the technique used to restore endodontically treated teeth. Remaining coronal tooth structure and functional requirement are important factors to be observed to decide for a treatment planning.

4. **Functional requirement**

The tooth placement in the arch is an aspect to be considered when selecting materials and techniques to restore pulpless teeth because force is different in anterior and posterior regions. Some authors related that the incidence of fractures was more than 2 times higher in mandibular first molars than in maxillary first molars, maxillary first premolars, maxillary second premolars and mandibular second molars **(Chan CP, Lin CP, Tseng SC, Jeng JH 1999)** and attributed this fact to the heavier masticatory force and thin or flat roots in this region. Tamse et al. **(Tamse A, Zilburg I, Halpern J. 1998)** observed that longitudinal root fractures are more common in teeth or roots whose mesiodistal dimension is narrow, like upper premolars. According to Chan et al. **(Chan CP, Lin CP, Tseng SC, Jeng JH 1999)**, canines were the teeth least susceptible to fracture and incisors were susceptible after subjected to endodontic treatment. The force incidence in anterior and posterior teeth is different because posterior teeth are subject to vertical forces while the anterior must resist to lateral and shearing types of forces, increasing the post requirement to provide force distribution in the coronal and root parts of the teeth, avoiding fractures **(Chan CP, Lin CP, Tseng SC, Jeng JH 1999, Conceic¸a˜o EN, Brito RN 2002)**.

5. **Remaining tooth structure**

Depending on the remaining tooth structure, different treatment planning can be purposed. There are studies relating that loss of tooth structure greater than 50%

(Fig. 1) would determine the use of root posts to retain a core and to distribute stress. Although many professionals have believed equivocally, in the past, that posts could strengthen endodontically treated teeth, root posts are used only as a requirement to retain a core when coronal structure is missed (Fig. 1A). There is a direct relationship between remaining tooth structure and fracture resistance. According to Nagasiri and Chitmongkolsuk's study **(Nagasiri R, Chitmongkolsuk S 2005)**, greater remaining tooth structure means greater longevity for the teeth. One example is that molars with maximum tooth structure remaining after endodontic treatment had a survival rate of 78% at 5-year evaluation. This study is in agreement to Costa et al. **(Costa LCS, Pegoraro LF, Bonfante G. 1997)**, that relate cusp fractures of endodontically treated maxillary premolars to width of tooth preparation. The authors argued that greater width of MOD preparation decreased fracture resistance of these teeth, but an onlay preparation with cusp coverage increased fracture resistance. Steele and Johnson **(Steele A, Johnson BR.1999)** evaluated the fracture resistance of endodontically treated maxillary premolars presenting different design preparations and restorative materials in a laboratorial study, and noted that teeth with endo access only were more resistant to fracture than MOD preparations. In addition, the fact of restoring the teeth, using amalgam or composite resin improved the fracture resistance, independent of using bonding agents or not. A study performed by Cerutti et al. **(Cerutti A, Flocchini P, Madini L, Mangani F, Putignano A, Docchio F. 2004)** evaluated cuspal deflection in intact tooth and endodontically treated teeth restored with amalgam or composite resin. The results showed that teeth restored with amalgam recover cuspal deflection in a rate of 17% while a counterpart restored with composite resin, from 54 to 99% according to the composite resin used. Nevertheless, some teeth can

present loss of tooth structure beyond MOD or endodontic access preparation (Fig. 1B–F). Thus, in the situations that greater coronal tooth structure is lost and a post is necessary to retain a core (Fig. 1A), the presence of vertical tooth structure (Fig. 1F) will provide a ferrule effect that is important to long-term success, contributing to load distribution, improving stability and rotation resistance. A study related by Tan et al. **(Tan PLB, Aquilino SA, Gratton DG, Stanford CM, Tan SC, Johnson WT 2005)** demonstrated that teeth restored with post/core using 2-mm uniform ferrule presented fracture resistance similar to endodontically treated tooth restored without posts. In addition, this study related that fracture resistance increases proportionally to quantity of remaining coronal tooth structure once 2-mm ferrule group (Fig. 1F) and nonuniform ferrule groups (Fig. 1B–E) were more fracture resistant than the group that lacked a ferrule (Fig. 1A). Another study that evaluated the effect of remaining coronal tooth structure location on the fracture resistance of endodontically treated tooth demonstrated that palatal walls (Fig. 1C) were more resistant to fractures than labial (Fig. 1B) because avoid arc of crown displacement in the vestibular direction.

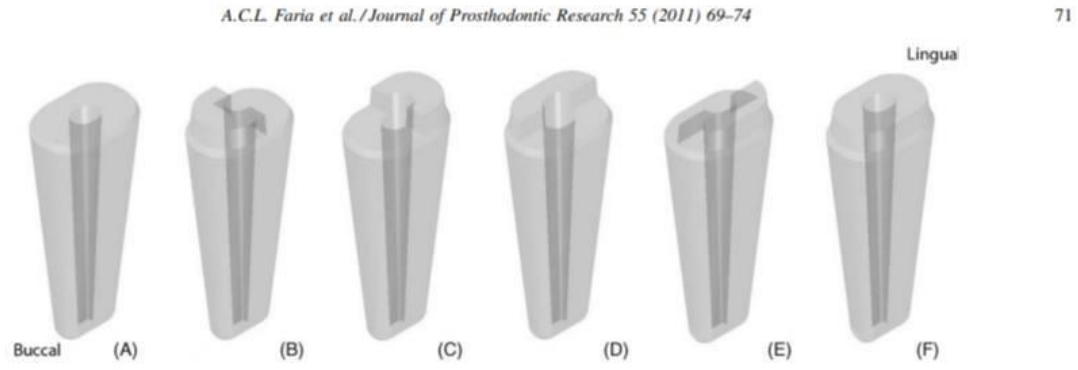


Fig. 1. Tooth designs of endodontically treated teeth when coronal structure is missed. (A) All coronal tooth structure was removed to the level of the preparation shoulder. (B) Part of the labial wall was preserved. (C) Part of the palatal wall was preserved. (D and E) Part of the proximal walls were preserved. (F) Part of axial walls were preserved in all tooth faces.

6. Cuspal coverage

A study that compared the fracture resistance in tooth restored or not with crowns, presented a six times greater rate of success in crowned tooth when tooth type and presence of caries at access were controlled. According to the authors, even though other forms of coronal coverage, such as gold, ceramic or composite resin onlays could provide protection against fractures, there are not reports in the literature to support the use of these onlays to restore posterior teeth **(Aquilino SA, Caplan DJ.2002)**. Considerations about the use of crowns in endodontically treated teeth restored with fiber posts and composites were performed by some authors that related no advantages in using metal-ceramic crowns. The authors argued that clinical success rates of endodontically treated premolars, with class II carious lesions and cuspal preservation restored with fiber posts and direct composite restorations, were equivalent to a similar treatment of full coverage with metal-ceramic crowns after 3 years of service **(Mannocci F, Bertelli E, Sherriff M, Watson TF, Ford TRP.2002)**. Another study that compared the type of material used in crowns argued that the success rate of the restorations is affected by material, once survival rate was 91.7% in cast restorations, 86.5% in amalgam restorations and 83% in composite restorations **(Lynch CD, Burke FM, Nı´ Rı´orda´in R, Hannigan A. 2004)**. Thus, the decision on use of a crown is depending on functional requirement and remaining tooth structure because teeth that had their cusps preserved did not necessarily present low fracture resistance.

7. Post

A dental post is a small metal or ceramic rod, typically made of titanium or zirconia, that is placed into the root canal of a tooth that has been extensively damaged or had root canal therapy. **(Go¨hring TN, Peters OA.2003)** The post provides additional support and retention for a dental crown or bridge that will be placed on top of the remaining tooth structure. Dental posts are typically used in cases where there is insufficient natural tooth structure to support the restoration or where there is a risk of the tooth fracturing under normal biting forces. The decision to use a dental post is based on a thorough clinical and radiographic evaluation by a dentist, taking into consideration the remaining tooth structure, the condition of the surrounding bone and gums, and the patient's overall dental health. The use of dental posts is generally considered safe and effective, but there are certain situations where they may not be indicated, such as when there is inadequate tooth structure to support the post, when the root canal is compromised, or when the patient has a known allergy to the materials used in the post. **(Go¨hring TN, Peters OA.2003, Schwartz RS, Robbins JW.2004, Grandini S, Goracci C, Tay Fr, Grandini R, Ferrari M.2005)**

7.1.Indications of post: (Fredriksson M, Astba¨ck J, Pamenius M, Arvidson K.1998)

• A tooth that has undergone root canal therapy and requires additional support for a restoration

• A tooth that has been severely damaged or broken and does not have enough remaining tooth structure to support a restoration

• A tooth that has been weakened due to multiple fillings or restorations

• A tooth that has been previously treated with a post and needs a replacement restoration

7.2.Contraindications: (Fredriksson M, Astba¨ck J, Pamenius M, Arvidson K.1998)

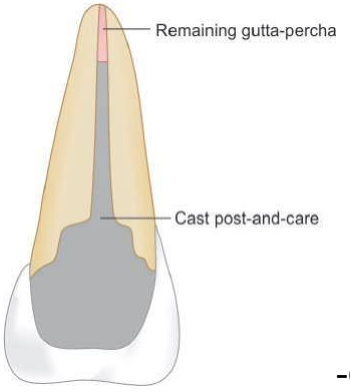
• A tooth that has a poor prognosis and should be extracted instead of restored

• A tooth that has insufficient remaining tooth structure to support a post and restoration

• A tooth that has a fracture or crack that extends below the gumline

• A tooth that has an infection or active periodontal disease

• A patient who has a high risk of root fracture or postsurgical complications.



-Cast post-and-core system

7.3.types of post:

7.3.1Metallic Posts

The custom cast post has been used for many years and can provide excellent clinical service, however, a recent major systematic review of the available literature (6 in vivo and 10 in vitro studies) was unable to demonstrateany superiority of cast posts over direct post-core restorations. With evidence of relatively equal performance, direct post and core restorations can reduce both cost and time factors for the patient. A further advantage is the lack of necessity to remove additional dentine in order to remove undercuts, which further weakens the tooth. Clinical studies support the effectiveness of prefabricated posts.

Greater tooth structure is removed for cast posts, two appointments are necessary and the cost is high. Even clinical situations with considerable loss of internal dentine ,traditionally restored with a custom cast post and core ,have been shown more successful in vitro when restored with bonded resin composite reinforced by a central metal post.

Prefabricated metal posts of many different designs are available in stainless steel and titanium alloy. There is no consensus on superiority of one over another. Post retention and core retention are similar between the two materials. However, a commonly used parallel titanium post was found to be significantly less rigid than an equivalent stainless steel post and was not recommended for clinical application where heavy loads are anticipated.

The majority of metal posts involve tapered or parallel design of which parallel provides greatest retention, particularly if the surface is grooved or roughened. Although tapered post shape requires less dentine removal and is more consistent

with root anatomy, a growing body of evidence suggests that tapered, unbonded posts exert a wedge effect that puts the root at risk of fracture and predisposes to loss of retention.(Figures 7a and b)Optimal ferrule and residual root strength are essential to prevent vertical root fracture caused by concentration of occlusal stresses down a tapered post. Passive postplacement for any post design provides least amount of stress on the root.

Figure 7a

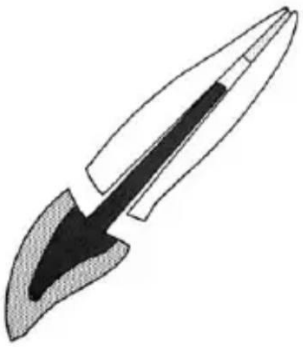


Figure 7b

7.3.2Non-Metallic Posts

The addition of non-metallic posts composed of various different fibre-reinforced polymer or composite materials from many different manufacturers, with differing designs, sizes and composition has introduced considerable variability and debate into the subject of post-core restorations. Newer concepts, including possible advantages from use of less rigid posts and the potential for adhesive luting cements, are some what controversial and comparisons and conclusions from the limited available research are difficult to make at this time.

(1) CARBON FIBRE POSTS

The carbon fibre prefabricated post, introduced in the early 1990s, is comprised of longitudinally aligned carbon fibres embedded in an epoxy resin matrix (approx 36%). This type of post has no radiopacity and is black in colour – both significant clinical disadvantages. Although it has been claimed that the carbon fibre posthas a modulus of elasticity close to that of dentine, there have been several studies refuting this.The carbon fibre post is "quite stiff and strong, to a degree comparable to several posts made of metal" and to have a modulusabout ten times higher than dentine .Water immersion has been found to reduce the strength and stiffness considerably, due to epoxy degradation. Clinical success with carbon fibre posts cannot therefore be used as evidence for the desirability of more flexible posts and may well be associated with the use of tougher resinluting cements used to retain the post within the root canal. Effective bonding between the industrially processed and highly polymerized epoxy resin post andcomposite cores can be problematic. Retention of composite core to carbon-fibre posts is lower than that to metal posts and retentive failure at the post-cementinter face has been documented.

Clinical results are few and somewhat variable. In a Cochrane systematic review

designed to compare the clinical failure rates of metal versus non-metal posts ,only one study comparing Composi post carbon fibre posts with cast posts

met the review objectives. There were fewer failures (0/97) associated with the carbon fibre post than with the conventional cast posts (9/98)after 4 years of clinical service.

(2) TOOTH-COLOURED POSTS

With the development of all-ceramic crowns and the high interest in esthetic restorations, many different esthetic white or translucent prefabricated posts have been introduced. These include zirconium-coated carbon fibre, glass fibre-reinforced epoxy, fibre-reinforced composite and zirconia posts. The multiplicity of designs and materials makes comparison sand recommendations difficult, particularly given the paucity of clinical studies.

(i) Zirconia Ceramic Posts

Zirconia ceramic posts are white, radiopaque, strong and very rigid. They have a modulus of elasticity higher than stainless steel and any modification to the post may affect the strength and must be carried out with a diamond disc. The high rigidity of zirconia ceramic posts produces higher stresses at the entrance to the canal when minimal tooth structure remains and more catastrophic root fractures in vitro compared to metal and carbon fibre posts.Bonding of composite resincores to the post has proved unpredictable and has been shown to be problematic for composite core integrity. Use of zirconia posts with heat-pressed ceramic core shas provided good results in vitro and in a small pilotclinical study over 29 months.

However, poorer result shave been seen in vivo over 4 years. This indirect technique also involves added expense and a second appointment. It is probable that zirconia posts with heat-pressed ceramic core essentially provide an esthetic

version of the cast post core. In a relatively recent review ,Morgano has stated that "little is known about the long-term survival of these all-ceramic posts and they seem to have limited applicability.

(ii) Fibre-reinforced and Composite Posts

Introduced in recent years, many different types of reinforced polymeric posts are available in a variety of shapes and sizes from different manufacturers. Largely used for highly esthetic restorations, these posts typically are bonded with resin luting cements and utilize composite cores. In vitro studies have indicated that these posts are not as strong as conventional posts and manufacturers caution that they should not be used where remaining tooth structure is less than ideal or where high occlusal forces are present. The instructions for one state the post should not be used if there is less than 2-3 mm of supra-gingival tooth structure present, if there is parafunction or a deep overbite. The mechanical and physical properties of these commercial posts vary considerably and caution is advised in using research results for a particular product as a generalization for all fibre-reinforced posts. Several in vitro studies have determined the resistance to fracture of teeth with

post-core restorations under static loading and the conflicting results demonstrate the difficulties involved in standardizing this type of experiment.

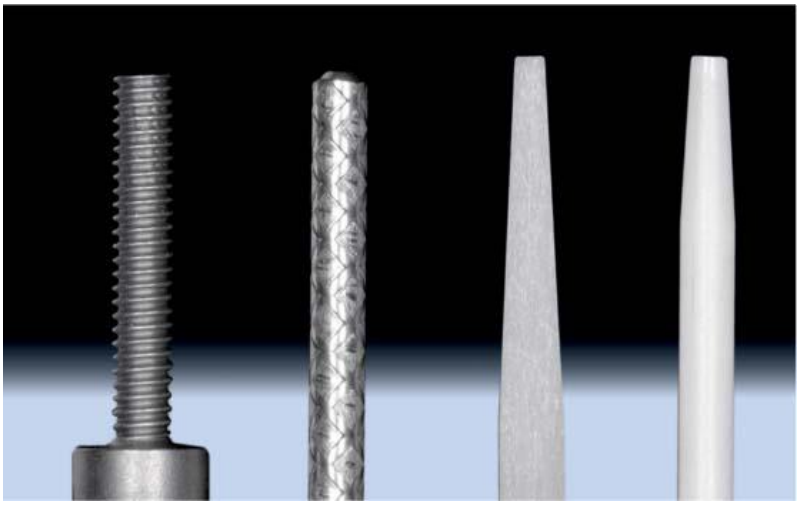
Glass-fibre reinforced posts have less stiff fibres than carbon fibre posts. They are therefore more flexible than both metal and carbon-fibre posts and this has been both cited as an advantage in some reports and a disadvantage in others. The two sides of the current debate pit the possibility of flexure producing micro-movement of the core, cement breakdown, leakage and failure versus the possibility of reduced catastrophic rootfracture.

Much of the laboratory research utilizes post-restored teeth that are loaded directly on the core or crown without the presence of any ferrule. In these situations it is customary to find that the load to failure is significantly higher for the stronger metallic posts than any of the fibre-reinforced posts, but results in more significant root fracture .In other words, the failure occurs at lower loads, but is less catastrophic with fibre-reinforced posts. It is frequently stated that such teeth remain re-restorable as fibre posts will be more readily retrievable from the canal.

How useful this would bein the clinical situation is unclear. In the absence of an adequate ferrule, failure will occur and the debate centres on whether it is better to have re-restorable failures in the short term or unrestorable failures after along time in function or at high stress levels.

An unacceptably high 12.8% clinical failure rate has been documented over 2 years for glass-fibre posts and no difference was noted between parallel or tapered design.The main type of failure was post fracture and this high failure rate was linked to lack of remaining vertical tooth structure. With the presence of an optimal ferrule and normal function for a single anterior esthetic crown, glass-fibre posts

may provide adequate results. However, clinical studies are currently unavailable and in-vitro results are equivocal, suggesting caution in more universal application



8. Core

A dental core, also known as a core buildup, is a dental restoration that is used to rebuild the bulk of a severely damaged or decayed tooth before a crown is placed. The core material is typically made of a composite resin or amalgam, and is bonded to the remaining tooth structure to provide a strong, stable foundation for the crown. **(Smith CT, 1998)**

8.1.Procedure:

The core build-up procedure is typically performed in two appointments. During the first appointment, the dentist will assess the tooth and determine if a core build-up is necessary. The remaining tooth structure is then prepared by removing any decay or damaged tooth structure. The dentist may also shape the tooth to provide an optimal foundation for the core build-up material.

8.2.Materials:

There are several materials used for core build-ups in dentistry, including composite resin, amalgam, and glass ionomer cement.

Composite resin is a tooth-colored material that is often used in aesthetic cases because it can be matched to the color of the surrounding teeth. Composite resin is bonded to the tooth, providing an esthetic and natural-looking restoration. It is also a more conservative option as less tooth structure needs to be removed compared to amalgam.

Amalgam is a silver-colored material that has been used in dentistry for over a century. It is known for its durability and strength and is a good option for posterior teeth where esthetics are not a concern. Amalgam is also less technique-sensitive than composite resin, making it easier to place.

Glass ionomer cement is a tooth-colored material that is often used in cases where the tooth has been treated with root canal therapy. Glass ionomer cement contains fluoride, which can help to prevent further decay, making it a good option for patients who are at high risk for developing caries.

The choice of material used for the core build-up will depend on several factors, including the location of the tooth, the extent of the damage, and the esthetic concerns of the patient.

8.3.Indications for a dental core include: .(Smith CT, 1998)

- ❖ Extensive tooth decay or damage that has weakened the tooth structure
- ❖ Fractured or broken teeth

- ❖ Teeth that have undergone root canal therapy
- ❖ Teeth with large fillings that have failed
- ❖ Teeth that have been worn down due to bruxism (grinding of teeth) or other factors.

8.4.Contraindications for a dental core include: .(Smith CT, 1998)

- ❖ Insufficient remaining tooth structure to support the core
- ❖ Presence of active gum disease or periodontal disease
- ❖ Large, deep decay that extends beyond the crown of the tooth
- ❖ Allergic reactions to the materials used to make the core.

It is important to consult with a dentist to determine if a dental core is necessary and appropriate for your specific dental needs. The dentist will evaluate the extent of damage or decay, the amount of remaining tooth structure, and other factors to determine if a core is necessary, and if so, what type of material is best suited for the restoration. **.(Smith CT, 1998 , Roberts DH.1970)**

9. Inlay , onlay and overlay

Inlays , onlays, and overlays are three types of restorations that are used to repair teeth that are damaged by decay, trauma or wear. These restorations are often made of dental materials such as porcelain or composite resin, and are used to replace missing tooth structure while preserving as much of the natural tooth as possible. The purpose of this report is to provide an overview of inlays, onlays, and overlays, their indications and contraindications, and the materials used to create them.**(Lynch CD 2007)**

9.1. Inlay:

An inlay is a type of dental restoration that is used to repair a tooth that has a cavity or other damage that is too large to be treated with a filling, but not large enough to require a crown. Inlays are custom-made to fit the specific shape and size of the damaged area of the tooth. They are typically made of porcelain or composite resin, and are cemented into place with dental adhesive. Inlays are an excellent option for restoring the natural appearance and function of a tooth, while minimizing the amount of tooth structure that needs to be removed. **.(Lynch CD 2007 , Pameijer CH, Garcia-Godoy F 2002)**

When the tooth decay area is too bigger for a general dental filling, an inlay will be considered an alternative method. Inlays usually cover the central part of the tooth or the area between the cusps and are positioned within the hard tissues of the tooth. They do not cover the cusps. For this reason, they are shaped to fit perfectly on your teeth, so can prevent leftovers from entering underneath tooth decay areas, creating further decay. The material used for inlays usually is porcelain like other

dental crowns, so it will be stronger and more durable compares with other composite fillings.

9.2.Onlay:

An onlay is similar to an inlay, but it covers a larger area of the tooth. Onlays are used to repair teeth that have more extensive damage, such as a large cavity or a crack that extends into the chewing surface of the tooth. Onlays are also custom-made to fit the specific shape and size of the damaged area of the tooth. They are typically made of porcelain or composite resin, and are cemented into place with dental adhesive. Onlays are a good option for restoring the natural appearance and function of a tooth, while preserving as much of the natural tooth as possible. **(Christensen GJ. 1998)**

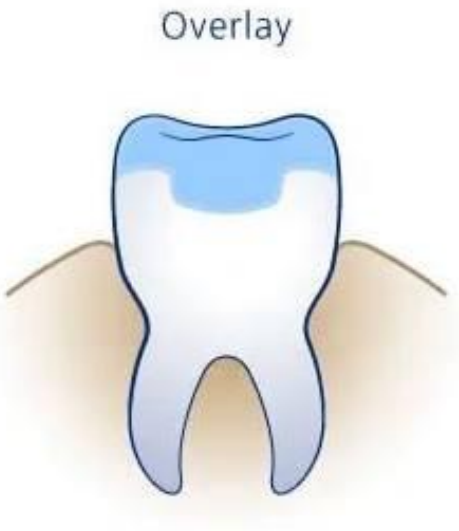
When a patient gets a decay of the middle and side of the tooth, an Onlay can be considered a treating method as it may cover one or more cusps of your tooth. Compared with inlay, Onlay covers more areas, they are positioned inside the deep

tissues of the tooth as well as covers part of the biting surface of the tooth. This helps to protect the damaged tooth from a direct chewing load.

9.3.Overlay:

An overlay is a type of dental restoration that is similar to a crown, but covers only the chewing surface of the tooth. Overlays are used to repair teeth that have extensive damage to the chewing surface, such as large cavities or fractures. They are typically made of porcelain or composite resin, and are cemented into place with dental adhesive. Overlays are a good option for restoring the natural appearance and function of a tooth, while preserving as much of the natural tooth as possible. **(Christensen GJ. 1998)**

Overlays cover a much larger portion of the occlusal or biting surface. Though they are often compared to partial crowns, overlays are very different from crowns. The main difference is overlays keep more of the natural tooth structure intact.



9.4.Indications and Contraindications:

The indications for inlays, onlays, and overlays are similar. These restorations are typically used to repair teeth that have moderate to severe damage, but still have enough healthy tooth structure to support the restoration. They are also a good option for restoring the natural appearance and function of a tooth, while preserving as much of the natural tooth as possible. The contraindications for inlays, onlays, and overlays include teeth that have extensive damage that cannot be repaired with these restorations, teeth that have insufficient tooth structure to support the restoration, and teeth that are not able to be adequately cleaned and maintained**.(Land MF, Chaffee BW 2012)**

9.5.Materials:

The materials used to create inlays, onlays, and overlays vary depending on the specific needs of the patient. Porcelain and composite resin are two common

materials used for these restorations. Porcelain is a durable and aesthetically pleasing material that can be custom-colored to match the patient's natural teeth. Composite resin is a less expensive option that can also be custom-colored to match the patient's natural teeth. Both materials have their advantages and disadvantages, and the choice of material will depend on the specific needs of the patient. **.(Lynch CD 2007)**

9.6.Prepration:

Preparing and placing inlays and Onlays is a multistep process, it involves:

i. Preparing the tooth (e.g. removing the decay).
ii. Taking an impression of the area to receive the restorations.
iii. Preparing the inlay or Onlay in a dental laboratory or with special equipment (CAD/CAM).
iv. Cementing or bonding the restoration of the tooth.

If a dentist has the appropriate equipment (CAD/CAM), this can be done in a single visit to the dentist. A temporary inlay or Onlay is placed on the prepared tooth while a patient waits for the finished restoration to return from a dental laboratory. Materials such as gold, composite resin or ceramics may be used to create inlays or Onlays. Which material is chosen may be influenced by aesthetic appeal, strength, durability and cost. The material used plays a major role in determine how long those restorations will last, as some substances are tougher and better tolerated than others. Other factors that influence the longevity of an inlay/Onlay include the strength of the tooth that is treated, the amount of chewing that occurs on the restorations and a patient’s willingness to maintain oral hygiene and to have regular examinations. As I previously

referred, the clinical applications of inlays and Onlays are really impressive because with a minimal invasive restoration, we succeed a perfect bio-esthetical result.

In cases which the preparation of the teeth gives the appropriate support or a sufficient amount of enamel for a successful bonding, the construction of an Onlay in cases we have excessive loss of tooth tissues is possible. The presence of enamel is important because the durability of the adhesive interface with enamel is very predictable.

The main contradictions are:

I. Patients with huge amounts of decay.
II. Patients with periodontal disease and poor levels of oral hygiene.
III. Patients with dental erosion.
IV. Patients with excessive loss of tooth tissue, which makes the tooth inadequate for bonding.
V. In teeth where the remaining tissue are very discoloured and as a result we have a negative aesthetic result.
VI. Patients with Para functional habits.

10.endocrown

is a type of dental restoration that is used to restore and strengthen a tooth that has undergone root canal therapy. It is a single-unit restoration that combines the features of a crown and a core buildup into one structure, and is cemented directly onto the remaining tooth structure. The endocrown is typically made of a strong ceramic material, such as zirconia, which provides excellent esthetics, durability, and biocompatibility.

The endocrown is indicated in situations where a tooth has undergone significant damage or decay, requiring root canal therapy to remove the infected pulp and nerves from the tooth. After the root canal procedure, the tooth structure is often weakened and may require additional support to prevent further damage or fracture. The endocrown is used to restore the tooth to its original shape and function, while providing stability and strength to the remaining tooth structure.

10.1.Advantages

- Preservation of healthy tooth structure: Since the endocrown is cemented directly onto the remaining tooth structure, it eliminates the need for a separate core buildup restoration, which can remove healthy tooth structure.

- Increased strength and durability: The endocrown is made of a strong ceramic material, which provides excellent strength and durability, and reduces the risk of fracture or damage to the tooth.
- Better esthetics: The ceramic material used in the endocrown is highly esthetic and can be color-matched to the surrounding teeth, providing a natural-looking restoration.

10.2.Contraindications for an endocrown include insufficient remaining tooth structure to support the restoration, active gum disease or periodontal disease, and the presence of large, deep decay that extends beyond the crown of the tooth.

10.3.Preparation

The main purpose for the use of Endocrowns is to attain an all-ceramic bonded restoration that is minimally invasive of root canals. Therefore, the Endocrown preparation is different from the conventional full coverage crowns **(Debbabi I, Nouira Z, Saafi J, Harzallah B, Cherif M. Endocrown)**. Several studies described the endocrown preparation following Bindl and Mormann technique. While few studies described some modifications to the original preparation.

Rational:

Endocrown is a monolithic ceramic bonded restoration with a supragingival butt joint keeping as much as possible enamel for improved adhesion. The endocrown will invade the pulp chamber only. The pulpal chamber shape and cavity warrants stability and retention. No need for further preparation. Furthermore, the pulpal

floor saddle form enhances stability. **(Debbabi I, Nouira Z, Saafi J, Harzallah B, Cherif M. Endocrown)** .

10.3.1.Occlusal preparation

A minimum of 2 mm occlusal height reduction in the axial direction should be attained. The ceramic occlusal thickness is usually 3-7 mm. Studies indicated that the fracture resistance of all-ceramic restorations rises with the increase of occlusal thickness, and that endocrowns with 5.5 mm thickness fracture resistance is twice as much as ceramic crowns with 1.5 mm occlusal thickness **(Zogheib LV, Saavedra Gde S, Cardoso PE, Valera MC, Araújo MA 2011)**The reduction can be done by making 2mm depth orientation grooves, then with a coarse grit wheel diamond occlusal surface reduction is done. The diamond is directed along the long axis of the tooth, parallel to the occlusal plane. The diamond shape ensures the proper reduction alignment and the desired flat surface, wherein the cervical margin or cervical sidewalk is determined. Ideally, the margins should be kept supragingival allover In areas where the esthetic requirements or clinical factors requires a difference in level, a slope of no more than 60° should be between the different cervical levels. Any undermined enamel with less than 2 mm thickness should be eliminated **(Debbabi I, Nouira Z, Saafi J, Harzallah B, Cherif M. Endocrown) (Zogheib LV, Saavedra Gde S, Cardoso PE, Valera MC, Araújo MA 2011)**. The cervical sidewalk is the foundation of the restoration, the objective is to accomplish a wide, uniform, steady surface resistant to compressive stress **(Gaintantzopoulou MD, El-Damanhoury HM. 2016)** . The prepararation should be parallel to the occlusal surface to confirm stress resistance along the long axis of the tooth.

Figure 2: Making the guide grooves in an isolated tooth and in situ.

Figure 3: Preparation of the cervical margin or "cervical sidewalk" using a wheel bur held parallel to the occlusal plane.

10.3.2.Axial Preparation

At this step, undercuts in the access cavity should be eliminated. A cylindrical-conical course grit diamond with an occlusal taper of 7 degrees is utilized to make the pulp chamber and endodontic access cavity continuous. Diamond should be held parallel to the long access of the tooth, excessive pressure is avoided and the pulpal floor is kept untouched. Reducing a lot from the walls of the pulp chamber will result in the reduction of their thickness and the enamel strip width. The cavity depth must be at minimum 3 mm. **(Debbabi I, Nouira Z, Saafi J, Harzallah B, Cherif M. Endocrown) (Zogheib LV, Saavedra Gde S, Cardoso PE, Valera MC, Araújo MA 2011)** The greater the extent of the pulp chamber the better the mechanical properties **(Gulec L, Ulusoy N. 2017)** . The recommended endocrown measurements are a 3 mm diameter cylindrical pivot and a 5 mm depth for the first

upper premolars and a 5 mm diameter and a 5 mm depth for molars . Bindl and Mörmann evaluated the performance of premolars and molars Endocrowns and perceived that the premolars showed more failures than the molars, that was due to the adhesion failure on them . Adhesion failure in premolar endocrowns might be because of the diminished surface of adhesive bonding in comparison to molars, and the increased proportion of the prepared tooth structure to the overall crown causing higher leverage for premolars than molars . Premolars having deep occlusal fissures have higher flexibility than ones that are shallow or fissuerless. Thus, premolars endocrowns must have a flatter occlusal table to minimize the crown height and the cuspal slopes resulting in shallower fissures to decrease cuspal bend and the threat of fracture during grinding **(Forberger N, G¨ohring TN.2008)** . In an attempt to improve the success of premolars endocrowns, the need for further intraradicular extensions might be a prerequisite **(Pereira JR, de Ornelas F 2006)** . Gulec and Ulusoy compared two designs with and without intraradicular extension; they found that the modified endocrown design with intraradicular extensions protected the remaining tooth structures better than the unmodified endocrown design. Regarding the stresses that occurred in enamel, modified endocrown restoration design transmitted less stress highlighting that it is a more toothfriendly design. However, the stresses that occurred in restorative materials, maximum principle stress values were higher for the modified endocrown restoration design. They concluded that when the material volume used for the restoration increases, the material itself is adversely affected but the stress transmitted to the dental tissues is reduced

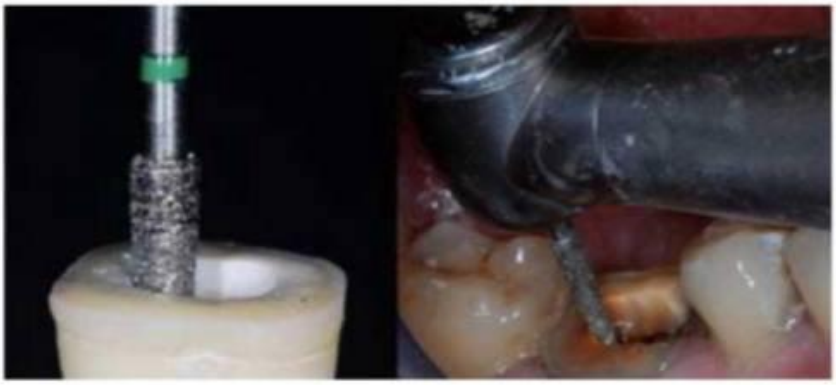


Figure 22: Axial preparation using a cylindro-conical drill to make the coronal pulp chamber continuous with the access cavity.

10.3.3Ferrule

The presence of ferrule in full coverages crowns supported by post and core was thoroughly investigated and well acknowledged to increase fractures resistance and fatigue cycles to failure **(Lima AF 2010)** . Einhorn et al. **(Einhorn M, DuVall N, Wajdowicz M, Brewster J, Roberts H.)** investigated the consequence of the ferrule features incorporation, on molar endocrown failure resistance. Their results showed that adding ferrule to preparations increased the dentin surface available for bonding. However, there were milling limitations in reproducing the endocrowns inner surface. Hence, it was reported that the more complex the preparation design became because of the addition of ferrule, the resultant endocrown inner surface adaptation to the preparation seemed to reduce. (Figure 1) They concluded that ferrule-containing endocrown preparations revealed significantly superior failure loads than regular endocrown restorations; yet, there was no difference among the groups in the calculated failure stress based on existing surface area for adhesive bonding. Moreover, less occurrences of disastrous failure were detected with the Endocrown preparations containing 1 mm of preparation ferrule design.

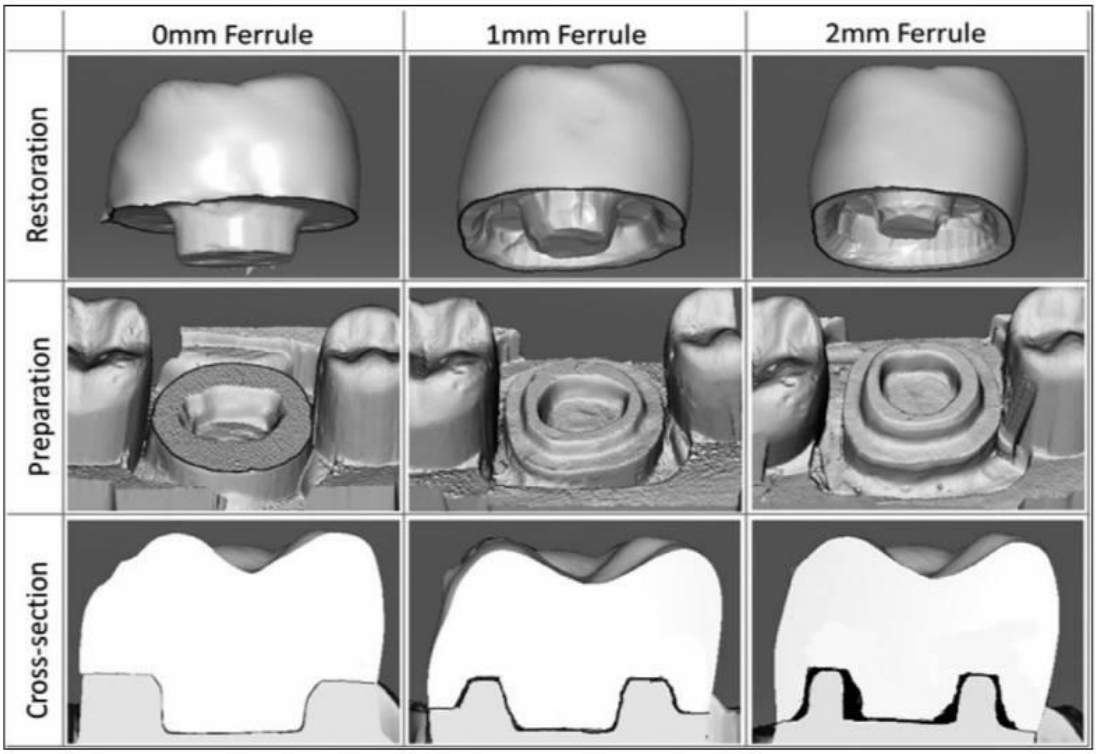


Fig 1: Three preparation design with no ferrule, 1 mm ferrule, 2 mm ferrule. Reproduced with permission from *Einhorn M, DuVall N,* Wajdowicz M, Brewster J, Roberts H. Preparation Ferrule Design Effect on Endocrown Failure Resistance. Journal of Prosthodontics. 2019; 28(1):e237-42. (John Wiley and Sons Publication)

11. Cementation

To date, resin cements composed of Bis-GMA or UDMA resin matrix and inorganic filler particules are the most popular types of cements. When compared to conventional cements, with superior mechanical and aesthetic properties, resin cements have an increasing use in cementation of ceramic, metal and composite indirect restorations **(. McCabe JF, Walls AW 1998).** Usually eugenol-containing root canal sealers are believed to inhibit the polymerization of resin cements. This problem may be overcome by cleaning of the root canal walls and acid etching. Cleaning all of the gutta percha and eugenol-containing root canal sealer in the canal is difficult without removing dental tissue. Debris on the rough surfaces of

the root canal prevents the adequate roughen of dentin and polymerization of resin cement. Results indicated that the stress values on the enamel, dentin and luting cement for endocrown restorations were the lowest ones among the values for inlay and conventional crown restorations. For normal biting, Weibull analysis showed that failure probability was 95%, 2% and 2% for the inlay, endocrown and conventional crown restorations, respectively. Both light- and dual-polymerizable luting resins can be adequately polymerized when they are used for luting thick indirect endocrown restorations **(Gregor L, Bouillaguet S, Onisor I, Ardu S, Krejci I, Rocca GT. 2014).**

Steps of cementation :

1. the internal surface of the restoration is etched with hydrofluoric acid for the time recommended by the manufacturer of the ceramic system then rinse and dry.

- Holding the restoration with an adhesive device will help you get through the procedures very easily, eg. Optrastick " Ivoclar vivadent ".

2. apply several layers of a silane agent to the etched surface. " almost for 60 seconds "

3. the preparation surface is etched with phosphoric acid for approximately 15 seconds after protecting the neighboring teeth with celluloid bands. Then rinse and remove the excess moisture.

4. multiple layers of a light cured adhesive system are applied to the tooth preparation surface.

-Be careful to remove excesses that tend to accumulate in the internal angles of the preparation. Then the adhesive is light cured.

5. a thin layer of the adhesive should also be applied to the ceramic surface previously silanized.

- An interesting tip :

Use two wooden wedges, one on each proximal surface, before the cementation itself. The point is the inversion of the wedges in order not to hinder the insertion of the restoration. In this position, the wedges will prevent excess cement from flowing towards the interproximal spaces, facilitating the finishing procedures and the removal of the marginal excesses.

6. a dual cued resin cement is then applied to the internal surface of the restoration, which is placed into position and seated with gentle finger pressure.

- After being fully seated , a spatula for composites is used to maintain slight pressure on the restoration while the adhesive device is pulled and removed.

Then , still maintaining gentle pressure on the restoration the gross excess cement along the entire margins is removed with disposable brushes, spatulas or with an explorer.

7. a tack cure is performed for about 5 seconds to keep the restoration in position allowing for the through removal of the excess cement and adhesive. The wedges are removed and all excesses are then removed using dental floss and abrasive strips. The final light curing is applied to the whole surfaces , 60 seconds per surface is recommended.

8. remove the rubber dam , check the occlusal contacts and adjust any premature contacts using fine and extra fine diamond points until obtaining an acceptable occlusal standard.

- All sites adjusted with diamond points should be polished with special abrasive rubbers for the intraoral polishing of ceramics.

Conclusion :

In conclusion, studying the restoration of endodontically treated teeth is crucial for dental professionals to provide effective treatment and care for their patients. It involves a comprehensive approach that includes selecting appropriate materials, determining the best retention method, providing adequate protection against occlusal forces, and achieving esthetically pleasing results. By understanding the various techniques and approaches to restoration, dental professionals can improve the success rates of endodontic treatment and ensure that their patients maintain good oral health and function for the long term.

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