

## Restoring Endodontically Treated Teeth: From Immediate Restorations to the “Reverse” Preparation Approach

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### Abstract

The restoration of the endodontically treated tooth comprises a challenge for the dental clinician. Given that a root canal treatment is not completed until a permanent restoration is delivered and the fact that there is an abundance of restorative choices, protocols and materials, the need for a correct approach, based on objective and clinical criteria is of utmost importance. In the present article a correlation between the remaining number of walls and the optimal restoration is attempted, resulting in a “restorative algorithm”. MEDLINE database was used as a search engine where articles from the last 30 years that relate to the topic, were searched. The conclusion to be drawn is that the preservation of healthy tooth substance along with the personalization of treatment plans are two crucial factors for a successful restoration, since there is not a universal approach that can be applied in every case.

**Keywords:** Restoration; Endodontically Treated Tooth; Dentinal Walls; Immediate Restoration; Post and Core; Endocrown

### Abbreviations

ETT: Endodontically Treated Tooth/Teeth; RCT: Root Canal Treatment

### Introduction

Even though root canal treatment (RCT) has reached high success rates [1] there is still a great percentage of endodontically treated teeth (ETT) that must be extracted due to poor coronal restorations. The clinicians should bear in mind that only 8,6% of the cases of endodontically treated teeth fail because of an inadequate RCT and 59,4% because of a poor coronal restoration [2]. According to Ray, *et al.* [3] an adequate coronal restoration has a stronger long term impact upon the RCT than the treatment itself.

However, not all teeth suffer the same losses after a RCT, as there are some with only one access cavity and others that have lost the majority of the coronal tooth substance, while it is important to remove all unsupported tooth substance before deciding for the final restoration [4].

An older belief which supported that the basic difference between ETT and vital teeth is the loss of water has been partially rejected, as there is a reduction regarding free and not bonded water [5]: Moreover, even if certain substances used in RCTs that deplete dentin from calcium ions [6], there are others, like eugenol, that have a positive impact upon tensile resistance [7].

What can be derived from the literature is that the most important factor regarding the biomechanical characteristics of ETT is the amount of the coronal tooth substance loss [5]. ETT with a small access cavity have lost only 5% of their structural integrity, while a mediobuccal occlusal cavity results in a reduction of 63% [8].

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The number of studies that attempt to correlate the remaining tooth substance with the restorative option is limited. What is attempted in this study is the creation of a “restorative algorithm” by combining the number of remaining coronal walls with some other factors as their width.

There are two reasons that explain why anterior teeth were not included in the present study. First of all there are hardly any relevant studies and secondly, this group presents some special features. Those are their anatomical characteristics and their position in the arch, so that they are subjected to forces that are unfavorable regarding both their direction-perpendicular rather than parallel to the tooth axis- and their type-tensile rather than compressive [11].

The abovementioned have been observed in studies where a bigger number of ETT of the anterior maxilla have failed [12,13], a fact that has raised concerns upon the restorative approach that involves a post placement in anterior teeth [14] as it is proven that stress concentration is 10 times bigger when non parallel forces are applied [15].

Regarding maxillary incisors the concentration of tensile stresses happens in the palatal side [16] makes the presence of adequate tooth substance there of utmost importance, even when it is missing from other sides [17].

**Restoration of endodontically treated posterior teeth**

As mentioned before, a tooth with a small access cavity is more resistant than a tooth with a mesiodistal occlusal cavity [18]. Loss of mesial and distal ridges is said to be one of the most important factors resulting in tooth weakening, together with the width and depth of the cavity [19] as the loss of tooth substance above the pulp chamber favors the deflection of cusps during function [20]. What remains to be answered is if the residual tooth substance can support a coronal restoration.

The categorization is made according to the number of residual dentinal walls [21] and taking into account previous relevant attempts [22].

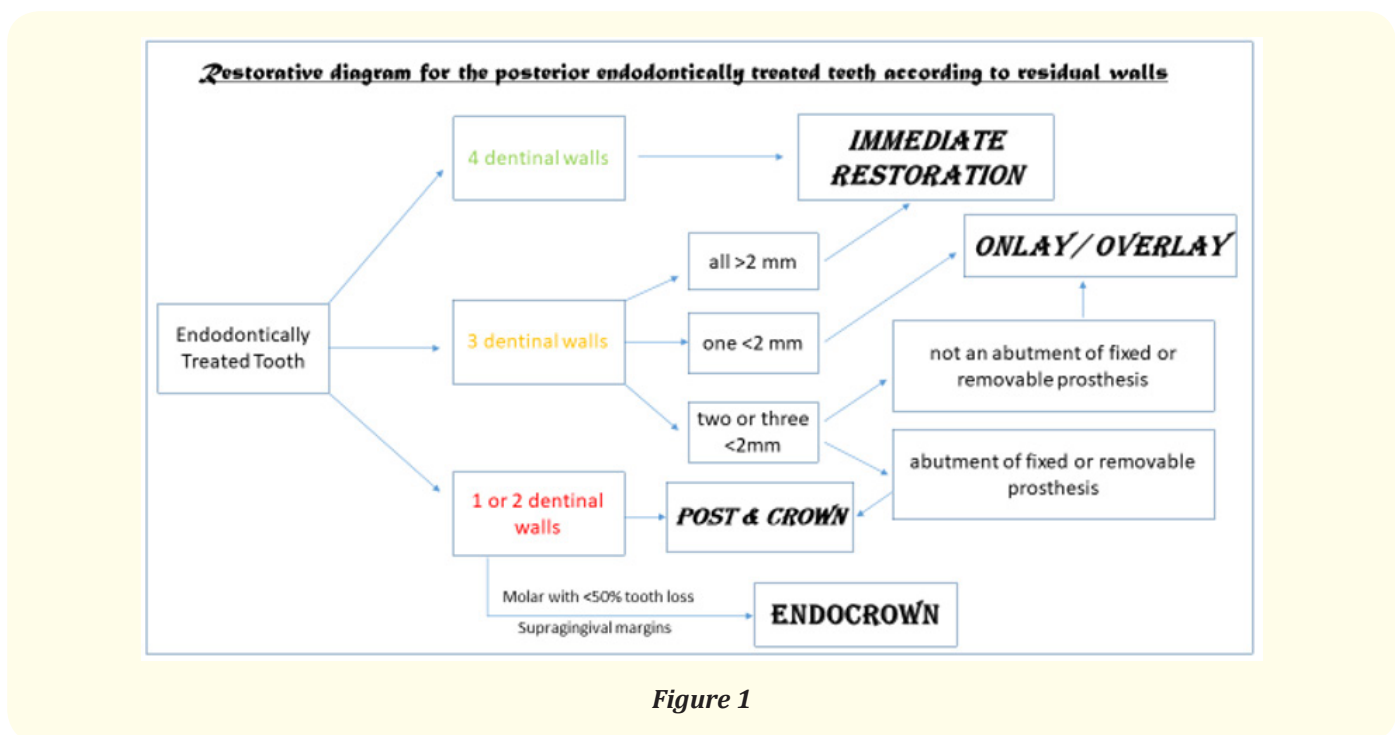


Figure 1

### 4 dentinal walls

According to a study carried out in Germany, dentists place posts in more than half (52%) of ETT [23]. This fact may be derived from the false belief that a post reinforces the tooth, while it only supports a coronal restoration [24]. According to literature, in a tooth with 4 or 3 dentinal residual walls with an adequate width, placing a post provides nothing regarding the restoration [25]. In fact, according to Bitter, *et al.* [26] and Neumann, *et al.* [27], placing a post in a tooth with the abovementioned characteristics could be described as an overtreatment.

In the case where none of the dentinal walls is lost an immediate restoration is the most appropriate choice [28]. Due to the improvement of bonding systems the micromechanical retention achieved is said to reduce cuspal deflection during function, restoring in some extent the integrity of the ETT [29]. In these cases, horizontal stratification of the material has been proven to provide the best results by diminishing polymerization shrinkage (c-factor) [30].

### 3 dentinal walls

This is a quite controversial category as more than 50% of the tooth substance is present which has been characterized as the critical amount for the restorative choice [31], but one of the crucial marginal ridges, either the mesial or distal, is usually lost [5]. Dammaschke, *et al.* [32] have mentioned that teeth with one or two restored surfaces present less fractures than teeth with three or four restored surfaces.

What will determine clinician's choice is the width of the remaining dentinal walls. Scotti, *et al.* [33] have characterized this parameter as simple and efficient: when a width of 2 mm is present, an immediate restoration can be delivered, while an indirect restoration should be delivered in the presence of thinner dentinal walls.

#### 3 dentinal walls, all > 2 mm

In this case all walls have sufficient thickness and the remaining marginal ridge is thick enough so that an immediate restoration can be delivered [28] by taking advantage of the ability of composite resins to bond to the tooth substance and thereby offering a smooth stress transmission, thus reinforcing the remaining tooth substance [34].

The reduction of polymerization shrinkage (c-factor) is of utmost importance, so the placement of the restorative material should be done in stages. In this was the polymerization stresses will not cause any cracks regarding the tooth substance [35] which are the cause of many cases of tooth hypersensitivity, as the tooth-composite resin bond has been compromised [30].

#### 3 dentinal walls, one of them < 2 mm

If the thin wall contains a functional cusp, an indirect restoration such as an onlay would be the most appropriate choice [36], given that their 12 year survival rates range from 74 to 100% [37]. Onlays are preferred instead of inlays because they protect the weakened dentinal wall and stresses are not directly transmitted to the tooth substance but are partly absorbed from the restoration [38]. Regarding the materials to be used, composite resins have almost the same elastic modulus as dentin, thus absorbing stresses [39], but the fact that they present discoloration, wear and weaker bond strength with tooth substance, may sometimes make ceramics a more appropriate choice [40].

#### 3 dentinal walls, two or three of them < 2 mm

The restorative dilemma here is among an onlay-overlay and a full contour crown combined with a post [28]. It is well known that an indirect restoration provides better interproximal contacts, occlusal stability and reduces bacterial microleakage [41]. It should also be mentioned that loss of tooth substance favors cuspal deflection during function [42].

Restorations such as onlays-overlays present the following advantages [43]: they preserve tooth substance, provide the opportunity for better oral hygiene thus preserving periodontal health, enable adhesive luting without hydrolytic behavior, preserve the anatomic tooth shape and allow better visual margin control.

In some researches, teeth restored with onlays were almost as durable as intact teeth [29] Premolars restored in this way corresponded better to cyclic load [44], with very few fractures even when less than 2 mm of tooth substance was present [33]. Maxillary premolars compose a high risk category as their anatomy favors cuspal deflection during function and consequently, fractures [45].

In general, onlays-overlays increase fracture resistance by providing homogeneous distribution and cuspal deflection prevention [46], with excellent results, even in extensively damaged teeth [47].

The choice between the one or the other option should be made after careful assessment of the patient’s medical and dental history, their needs and should keep up with the overall treatment plan. In a case where a tooth will be used as an abutment for a fixed or removable prosthesis [48], a post might be recommended in order to support a core [49]. ETT present higher failure rates than vital teeth [50], so special care in order to protect them should be taken. It is mentioned that when the width of remaining tooth substance in an ETT reaches 1,5 mm, the presence of a post provides favorable results [51]. Another important factor that should be mentioned regarding ETT is that their proprioceptive ability is 2,5 times lower than that of a vital tooth [52].

### 1 or 2 dentinal walls

According to the available literature the choice in this category is quite clear [48]. It is mentioned that when 2 or 3 dentinal walls must be replaced, a conservative approach should not be applied [53] and a post and core approach along with a crown is the best choice. A post can diminish oblique stresses by 21 - 25% [15]. Besides, it is in large mesial-distal occlusal cavities where polymerization shrinkage induces most of the stresses [54], so immediate restorations should be avoided.

What should be stated is that when 1 or 2 dentinal walls are present, placing a post not only raises fracture resistance, but also turns a large number of unfavorable failures into favorable [4]. In a research where premolars with or without posts were compared, the result was that in teeth with 2 or less dentinal walls and no post, fracture resistance dramatically decreased [9] and the majority of the literature supports this condition [55,56].

Given that a post is among the restorative plan, there are certain rules that should be respected: preservation of as much healthy tooth substance as possible, ferrule effect [10,57-61], post length equal to 2/3 of root length, width equal to 1/3 of root width with at least 1 mm of surrounding dentin [62], careful occlusal adjustment in order to avoid oblique forces [63].

### Endocrowns

Pissis [64] was the forerunner of the endocrown technique, describing it as the “mono-block porcelain technique.” The term “endocrown” was described for the first time by Bindl and Mörmann [65] in 1999 as adhesive endodontic crowns, and was characterized as total porcelain crowns fixed to depulped posterior teeth.

Endocrowns are anchored to the internal portion of the pulp chamber and on the cavity margins, thus obtaining macromechanical retention provided by the axial opposing pulpal walls and micro-retention/chemical bonding attained with the use of adhesive cementation [66].

From a biomimetic perspective, the preservation and conservation of tooth structure is paramount in maintaining the balance between biological, mechanical, adhesive, functional, and esthetic parameters [67]. The main advantage of endocrowns is related to the fact that they do not require root dentin removal for the retainer installation, in addition to preventing the risk of recontamination during

disobturation [67]. Additionally, during an endodontic failure, reinterventions can be performed more easily [68]. The supragingival margins facilitate plaque control, clinical inspection and preserving the periodontium with minimal involvement of the biological width [69].

Initial reports have demonstrated the favorable clinical performance of endocrown restorations [70-72], while Bindl and Mormann [65] observed that only one out of 19 endocrowns in 13 patients (95,5% survival) after 28 months failed because of recurrent caries and recent results of a 7 and 10 year clinical studies are the first long term reports that further suggest the viability of the endocrown method, with the success rate being much higher for endocrowns than that obtained for peripheral crowns (99,78% vs 98,66%) [73,74]. Cohesive failure of bonding is the main reason for failure in premolars restored with endocrowns, while more treatment failures occurred in premolars than in molars (75%/90.5%) during 12 years [75].

### Discussion

Apart from the condition of each tooth the clinician should also take into account patient’s medical and dental history. For instance, a parafunctional patient produces oblique forces of high magnitude [72], while continuous loading favors fractures [73]. In such a patient a careful treatment plan should be made.

Regarding tooth related parameters, it is important to distinguish whether a tooth is about to support only itself or it is going to be a part of a fixed or removable partial denture [73]. Presence of proximal contacts is also an important factor as adjacent teeth tend to distribute occlusal stresses [74].

The present article attempts to categorize restorative choices by combining the number of residual dentinal walls with some other factors, such as their width [21,33,55]. It should be taken into account that RCT is not completed until a permanent restoration is delivered [2]. More than half of extractions could have been avoided if an adequate restoration was placed [32].

Nowadays, an abundance of restorative choices is available in order to deliver restorations that shall not endanger the survival of the tooth. Apart from the traditional concepts which take advantage of the macromechanical retention, restorations that are either completely or partially based on micromechanical retention have recently arisen [66].

Endocrowns are such restorations that present the advantage of the construction of both the crown and core as a single unit which obtains more stability and retention. The interfaces of materials with different moduli of elasticity represent the weak point of a restorative system, as the toughness/ stiffness mismatch influences the stress distribution [76]. In addition, the endocrown also presents the advantage of reducing the multiple interfaces effect in the restorative system with a thicker ceramic occlusal portion compared with the classic crown. These reasons give the endocrown restoration the lowest stress values on the dentin and luting cement [77].

When up to one half of the coronal tooth structure is missing, complete occlusal coverage is achieved conservatively using endocrown [78]. The endocrown is indicated when there is excessive loss of coronal dental structure and limited freeway space, which makes it impossible to obtain sufficient ceramic thickness to cover the metal or composite resin core [79]. Endocrowns are especially indicated in cases of inadequate clinical crown length and extensive loss of dental tissues that do not allow the use of an adequate ferrule [65] and they are convenient for all molars, particularly those with clinically low crowns, calcified root canals, or narrow canals [80].

Besides, many classical indications for a crown restoration are nowadays questioned [81]. Ferrule, which is typically found in conventional crowns and can be described as a ‘bracing mechanism’ of the restoration around the cervical tooth structure [58] may cause the loss of sound enamel and dentin tissues that would be important for proper bonding of the restoration [82], while endocrowns are usually prepared without ferrule.

Regardless of the type of restoration, it is critical that all restorative protocols to be applied only if knowledge regarding biomechanics is acquired and every action and preparation should respect healthy tooth substance [83-87]. This is in accordance with Zicari, *et al.* [88] who mentioned that healthy tooth substance preservation as an alternative to post placement is shown to protect teeth against catastrophic failures.

### Conclusions

1. Delivery of an adequate restoration protects what was achieved during root canal treatment.
2. All decisions and actions should respect biomechanics and preserve healthy tooth substance. The material should serve the needs of the tooth and not the opposite.
3. When 4 dentinal walls are present an immediate restoration is the best choice.
4. Width of remaining tooth substance is the critical factor in teeth with 3 walls.
5. A post and core approach combined with a crown is the most appropriate choice for teeth with 1 or 2 residual walls.
6. Endocrowns constitute the latest and more conservative approach that takes advantage of the micromechanical along with macromechanical retention and they are recommended in molars that have lost up to 50% of tooth substance and where peripheral supragingival enamel margins are present.
7. Each case should be carefully examined and every decision should be made after careful medical and dental history assessment.

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