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ScienceDirect
Journal of Prosthodontic Research 55 (2011) 69–74
Journal of Prosthodontic Research
www.elsevier.com/locate/jpor

Review

Endodontically treated teeth: Characteristics and considerations to restore them

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Received 30 June 2009; received in revised form 20 May 2010; accepted 13 July 2010
Available online 14 August 2010

Abstract

The restoration of endodontically treated teeth is a topic that is extensively studied and yet remains controversial. This article emphasizes the characteristics of endodontically treated teeth and some principles to be observed when restorations of these teeth are planned. It was concluded that the amount of remaining coronal tooth structure and functional requirements determine the best way to restore these teeth, indicating the material to be used, direct or indirect restorations, associated or not to posts.

Keywords: Endodontically treated teeth; Dental posts; Dental restoration

Contents

1. 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

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1883-1958/$ – see front matter
doi:10.1016/j.jpor.2010.07.003

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.

1.1. Endodontically treated tooth characteristics

Fractures are more common in pulpless teeth than teeth with vital pulps [1] 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 [2]. Factors such as sex, age and dental arch have been affected the incidence of fractures [3]. As example, Chan et al. [2] 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. [4] 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 [5–7].

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 [8], 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 [1,9] 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 [10]. So, the use of bonded restorations should be considered to avoid microleakage.

1.2. 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 Türp et al. [11], 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.

1.3. 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 [2] and attributed this fact to the heavier masticatory force and thin or flat roots in this region. Tamse et al. [12] 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. [2], 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 [2,13].

1.4. 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 [14], 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. [15], 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 [16] 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

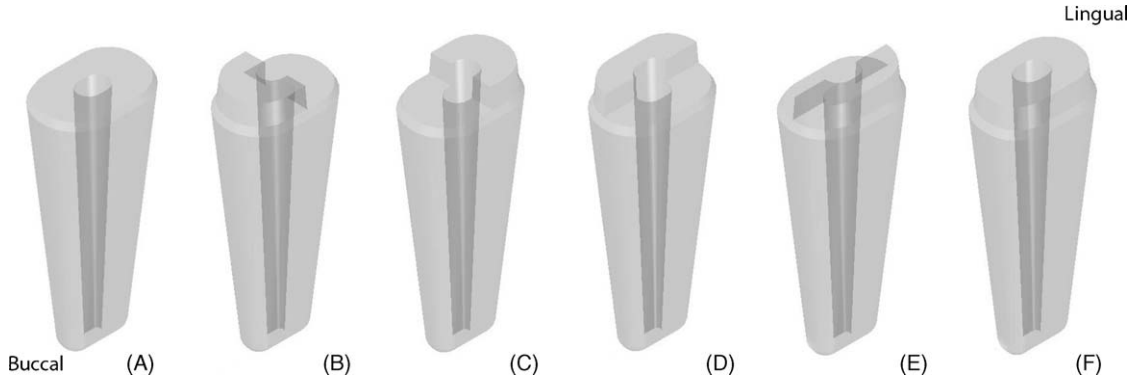

Fig. 1. Tooth designs of endodontically treated teeth when coronal structure is missed. (A) All coronal tooth structure was removed to the level of the preparation shoulder. (B) Part of the labial wall was preserved. (C) Part of the palatal wall was preserved. (D and E) Part of the proximal walls were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

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. [17] 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. [18] 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. The authors concluded it based on the fact that the median load necessary to cause failures were 607 N, 782 N, 358 N, 375 N, and 172 N for the complete (Fig. 1F), palatal (Fig. 1C), labial (Fig. 1B), proximal (Fig. 1D and E), and no retained coronal tooth structure incisal to the finish line (Fig. 1A), respectively [19].

1.5. 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 [20]. 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 [21]. 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 [22].

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.

1.6. Use of posts

Although some researchers believed in the past that posts could improve the fracture resistance in endodontically treated tooth, nowadays it is known that preparation of a post space may increase the chances of root fracture [23], so that posts should only be used when other options were not available to retain a core [1]. Some authors argued that the decision for using root posts depends of the amount of remaining coronal tooth structure and the functional requirements [8,24]. Studies were performed comparing the fracture resistance of endodontically treated teeth when they were restored with or without posts. Nevertheless, there are metal and fiber post available in the market and the indication of these materials is different. According to Grandini et al. [25], fiber posts associated to direct resin restorations is a faster therapeutic option that conserves

remaining tooth structure. These authors evaluated fiber post/direct resin restoration longevity by 6, 12, 24 and 30-month recall and satisfactory results were found although any comparison with teeth without posts had been made. Besides, a study that compared longevity of endodontically treated teeth restored with amalgam or fiber posts and composite resin concluded that restorations with fiber posts were more effective than amalgam in preventing root fractures but less effective in preventing secondary caries [26].

If a post will be used to restore teeth, it is necessary to determine the better post to be used because there are metallic and ceramic custom posts and prefabricated posts made of metals, glass fiber or carbon fiber. The remaining tooth structure and functional demands are determining factors to choose a post. Minimal radicular tooth structure will require carbon or glass fiber posts because they present approximately the same modulus of elasticity as dentin and forces would be distributed more evenly in the root, resulting in fewer root fractures. In 1998, when Fredriksson et al. [27] evaluated the use of carbon fiber posts in patients, they found results similar to control teeth, once no dislodgement of root or post fractures were observed clinically or on radiographs. These results indicated that this system can be a viable alternative to conventional post systems.

Because carbon fiber posts were aesthetically unsatisfactory, some posts were coated with minerals to improve the aesthetics, once situations that esthetic necessity is greater will require ceramic and glass fiber posts. A case presentation demonstrates the importance of using this type of post to restore anterior teeth whose esthetics is determining [28]. Martelli [29] presented carbon-based and glass fiber posts with translucencies and moduli of elasticity closely approximating that of the dentin for the restoration of pulpless teeth. In 2003, Malferrari et al. [30], in a prospective clinical follow-up study, evaluated the acceptability in patients who had their teeth restored with quartz fiber-reinforced epoxy posts (Aesthetic post) over a 30-month period and found a failure percentage of only 1.7%; however, in all failed cases it was possible successfully replace the restoration once no root fracture was recorded. Among the failures, one was a cohesive fracture at the edge of the composite resin of the core, and the other two were adhesive fractures involving the cement-post-core detaching from the dentinal walls of the root canal. Thus, fiber post failures are more associated to displacement or detachment of the post and crown or prosthesis decementation than root fractures, a common failure related to conventional metal cast posts. Because metal cast posts present high rigidity, they appear to vibrate at high frequencies when loaded with lateral forces, which achieving critical points, may determine longitudinal fractures of the root [30]. However, fiber post presents moduli of elasticity close to the teeth and adhesive failures can be caused by a technical error at the cementation procedure. In addition, prefabricated fiber posts require a thicker layer of cement than metal cast posts. Because of this problem, Boudrias et al. [31] presented a double taper post system developed to conform more precisely to the shape of endodontically treated canals with benefits of minimal tooth structure removal, greater post-to-canal adaptation in the apical and coronal half of the canal, and good post retention.

An article describes the treatment of one patient using a bondable polyethylene ribbon as an alternative to use as a post-and-core build-up material due to esthetic qualities, mechanical properties and the neutral color of the reinforcing material, with minimal enlargement of the canal, decreasing risk of perforation in the apical or lateral areas of the root [32]. Among the advantages of these prefabricated posts, there is the possibility of restoring endodontically treated teeth presenting minimal remaining coronal tooth structure in a single-appointment, simplifying treatment planning and resulting in esthetically acceptable restorations [33,34].

Comparison between custom and prefabricated posts has been issue of the researches. Fokkinga et al. [35] evaluated the fracture resistance when prefabricated metallic or glass fiber posts or custom glass fiber posts were compared to endodontically treated teeth without posts, and the authors did not find significant difference in failure loads and failure modes. Similar results were found in other studies [36,37] that compared the fracture resistance of endodontically treated teeth restored with custom or prefabricated posts using several designs, planning fixed prostheses for them. However, when Hayashi et al. [38] studied the mode of fractures when tooth restored with fiber post, prefabricated metallic post and cast metallic post-core were subjected to oblique and vertical load, they concluded that greater loads are necessary to fracture tooth restored with cast metallic post-core when subjected to vertical loads, but at the case of the oblique loads, prefabricated metallic posts required smaller loads. Considering the mode of fractures, vertical loadings caused cracks propagated in the middle and apical portion of the roots while at the situation which oblique loads were applied, most of the fractures occurred in the cervical part of the root when fiber posts were used, and in the middle part, when prefabricated metallic or cast metallic post-core were used. Although metal cast post presents higher fracture resistance, when fractures happen, tooth are lost because of the position of the fracture while cervical root fractures of teeth restored with fiber posts did not necessarily represents lost of the teeth.

Glazer [39] studied, in a 5-year period, patients submitted to endodontic treatment whose remaining coronal structure was inferior to 50% and carbon fiber posts and metalloceramic crowns were used to restore teeth. The overall failure rate was 7.7% and the cumulative survival rate was 89.6%, demonstrated at the end of the follow-up period. The results demonstrated that these posts were used in the upper anterior teeth with a higher success rate and longer life than in premolars, especially lower premolars, because of the narrow mesiodistal dimension of these roots. Based on this information, occlusion should be considered in a choice of a post because canines and upper incisives, responsible for guide desocclusion and cut food, are subjected to oblique forces, indicating a root post use.

A study that evaluated by clinical and radiographic exams, pulpless teeth treated using three different fiber posts (840 Composipost, 215 Aesthetic posts and 249 Aesthetic Plus posts) associated to four different resin cements in a 6-year

period related that these posts could be routinely used associated to adhesive agents [40].

The choice of a post depends on the rehabilitation planning, once support teeth of fixed partial denture will be demanded differently from tooth that will be restored using a crown. Thus, ceramic or metallic custom posts are recommended for support teeth of fixed partial dentures although preparing a post space requires enlargement of the canal [41]. In addition, these posts let to achieve proper alignment among support teeth. Comparing the use of endodontically treated teeth as support of fixed and removable partial denture, Wegner et al. [42] related a success rate of 92.7% for the former and 51% for the latter.

2. Discussion

The restoration of endodontically treated tooth involves different materials and principles. Conservative prepares restrict to only endodontic access preparation can be restored using amalgam or composites associated to bonding agents to avoid microleakage. However, some posterior teeth whose greater amount of structure was missed needs cuspal protection to direct forces at long axis of the root, avoiding longitudinal fractures while anterior teeth often requires post because of oblique forces. Even though posts are indicated to retain a core when coronal structure is missed (Fig. 1), some authors have advocated the use of posts associated to composites as an alternative to crowns in posterior teeth. Nevertheless, it is necessary to consider that there are metallic, ceramic and fiber posts, prefabricated or customized. Fiber posts have been indicated in situation that there are loss of root structure because its moduli of elasticity is close to dentin, but some coronal remaining structure is necessary to retain the core using adhesive systems. Different from these posts, metal cast posts have been used when greater quantity of coronal structure is missed (Fig. 1) and functional demand is higher such as support tooth of removable or fixed partial prostheses.

The choice of a root post should follow some principles like preservation of tooth structure, retention and resistance, retrievability, ferrule effect and failure mode [3,43]. Preparing of a post space should, whenever possible, conserves coronal and radicular tooth structure. Retention form is associated to prepare geometry including post's taper, length and diameter, surface texture, luting agent and passivity, but professionals can only interfere with post's taper, length and diameter. The resistance is affected by remaining tooth structure that contributes for the ability of the post and tooth to withstand lateral and rotational forces and transmitting occlusal loads. Retrievability should also be considered in a choice of a post, so as the failure mode observed when different posts are used.

3. Conclusion

In summary, endodontically treated teeth are more brittle due to loss of structural integrity associated with access preparation or caries. Because of the brittleness of these elements, planning will be associated to remaining tooth structure and functional demands, once load received depends on tooth position in the arch, occlusion and rehabilitation planning.

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