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Currently used systems of dental posts for endodontic treatment

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Abstract

An advanced stage of a tooth decay promotes an extremely damaged tooth that needs endodontic treatment to be restored. When satisfactory coronal tooth structure remains, an artificial crown can be placed without a post. On the other hand, the treatment of seriously damaged teeth often require an endodontic post. The main reason for using post is to enable rebuilding of the tooth structure prior to crown restoration. Dentists believe that endodontic posts provide a stable and solid restoration of the tooth, as well as providing strengthening of the tooth root, which constitutes the solid basis for a dental crown restoration. However, some authors reported that the strength of the tooth is directly related to the remaining dentin, and because of that, an endodontic treatment can present a higher risk of biomechanical failure. A number of different materials have been used for the manufacturing of dental posts. The fundamental posts requirements include high tensile strength, high fatigue resistance to occlusal and shear loading and a good distribution of the forces affecting the tooth root. The purpose of this article is to review the current literature and identify the various characteristics of a dental post, as well as some principles on the endodontic treatment for tooth decay.

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Keywords: Dental post, endodontic treatment, post design, post material, mechanical tests;

1. Introduction

Most of teeth failures are due to tooth decay, also known as dental caries. Dental caries are characterized by the appearance of cavities, which are caused by bacteria or acids that are present in human mouth. These cavities begins

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in the main portion of the tooth and progress deeper into the tooth structure, affecting the dentin and reaching the nerve, eventually causing severe pain.

An advanced stage of a tooth decay requires endodontic treatment to rehabilitate the damaged tooth. Being so, as a result of dental caries or trauma, the endodontic restoration of teeth is part of the routine of dental clinics. This kind of treatment is required when a substantial coronal tooth structure is lost. When satisfactory coronal tooth structure remains, an artificial crown can be placed without a post. On the other hand, the treatment of seriously damaged teeth often require an endodontic post. The main reason for using posts is to allow the rebuilding of the tooth structure prior to crown restoration, (1–3).

Generally, in an endodontic root canal treatment the infected tissue, that can cause an infected abscessed tooth, is removed and an opening is made through the crown of the tooth into the pulp chamber. This pulp is removed and the root canals of the tooth are cleaned and molded. After that, the root canals and tooth pulp chamber are filled with an adequate cement or resin. Posteriorly, a metal or plastic post is placed in the root canal to help retain the after core filling material, which will support the restoration - crown. The crown is then restored. With this approach dentists believe that endodontic posts provide a stable and solid restoration of the tooth, as well as they provide the strengthening of the tooth root being the solid base for a dental crown restoration.

However, authors reported that the strength of the tooth is directly related to the remaining dentin, (2), which leads to the fact that an endodontic treatment may pose a higher risk of biomechanical failure than vital teeth, (1). It has also been reported that a post preparation and the post itself can weaken the tooth and make the root more vulnerable to fracture, (1–6), due to structural change in the dentin, which loses water and collagen after the treatment, as well as its natural structural integrity, (7). In this regard, some of the current literature still disputes the potential of posts applied to teeth restorations, (1,2,8,9). Therefore, some authors stated that posts should only be used in cases where the remaining tooth coronal structure is not enough to provide sufficient support to the restorative material (core) and when there is no other options available to retain this core, (6,7,10,11).

This article is a review of the currently used systems for an endodontic treatment. Presently, there are multiple systems in use for this purpose, and the selection of the most adequate is left to the dentist, who ultimately has the responsibility to balance all the factors and select the most suitable system for each patient. Nevertheless, some comparison is made between data published by different authors relating the mechanical characteristics of different posts.

2. Materials and Methods

This article reviews the literature to identify the various characteristics of a dental post, as well as some principles on the endodontic treatment of tooth decay. About forty papers have been revised with publishing date range from 1984 to 2017. The authors then decided to revise the following fields of the literature: post material, post design, core material and mechanical behavior of dental posts.

3. Post Material

A number of different materials have been used for the manufacturing of dental posts. The ideal post would provide core retention without creating unwanted stresses within the residual tooth structure, (2,5). The fundamental posts requirements include high tensile strength, high fatigue resistance to occlusal and shear loading and a good distribution of the forces affecting the tooth root, (5,6). Accuracy, biocompatibility and harmless electro chemical activity are also essential, according to Manhart, (5). As such, metal alloys have been the chosen material for years. The main disadvantage of these structures was the concentrated stresses in zones that are vital to the tooth root, (1,12). Many authors believe that the use of a dental post with a Young modulus higher than the dentin can create stresses at cement interfaces and can cause the separation of the post or a root fracture, (2,6). Moreover, the use of posts with a high elastic moduli is potentially risky. The stress concentration in the area of the dental root may result in root rupture, which can cause the need of tooth extraction, (2,13).

Some authors have highlighted the need to use posts made with biomechanical properties similar to dentin. In recent years, fiber-reinforced resin posts (like glass and carbon fibers), and woven-fiber composite resin material for posts and cores were introduced. Compared with metallic posts, fiber posts are less stiff and consequently show a more favorable stress distribution in the root, which may result in a decreasing of fractures after the restoration, (1,4). Also, the fact that these kind of materials has a white translucent color (except for the carbon fiber) improves the aesthetics of the restoration. Many times, the metallic posts turn the tooth into a dark color, which is not a favorable characteristic for restorations of the anterior teeth. However, metallic post offer a better retention of the post-and-core system, while fiber-reinforce composite has a higher risk of debonding, (1).

4. Post Design

Post designs can be categorized according to their surface and shape characteristics. Related to surface, the posts can be active or passive, (14,15). The active post has threads that mechanically engages the dentin. The passive post has a smooth surface and depends on the cement and core material for its adaptation to the tooth canal. Regarded to the shape, dental posts are cylindrical or conical structures that can be parallel, tapered or parallel-tapered combination. Parallel post designs have been reported to increase retention and produce uniform stress distribution along the post length. Parallel-tapered design permits conservancy of the dentin at the top and at the same time achieves sufficient retention, (16).

Some authors suggest that the greater the post length, the better the retention and stress distributions. Yet, it may not always be conceivable to use a long post, especially when the remaining root is short or curved. For this reason, a consideration of the root size and length is important and consequently, root anatomy dictates post selection, (14,17).

Recently, a German company developed a new type of dental posts, which is basically a bundled of glass fiber-reinforced composite post, (18). Different from conventional root posts, this new approach is not a single post, but rather composed of a bundle of thin individual posts. The company claims that once a sleeve is removed, the bundle is spread in fine individual posts that are distributed in the entire root canal, which adapt optimally to suit any root canal anatomy. Accordingly, this approach can be used in situations where strongly curved root canals or oval root cross-sections and pronounced conicity occur, as in the case of maxillary anterior teeth. Contrastingly to conventional root posts, this innovation provide homogeneous reinforcement of the entire tooth restoration. However, there is still no experimental evidence or reported studies on the effectiveness of this type of dental post.

5. Core Material

Dental resin-based composites have been widely used in restorative dentistry since their launch in the 1960's, according with Calabrese et al., (19).

A good result for endodontic treated teeth restored with posts build-up depends on a wide range of factors, like post material and design, core build-up material, ferrule height and amount of coronal tooth surface, (14,16). The core should be built up with composite materials, but according with Signore et al., (16), there is no agreement concerning the greatest composite material to be used for the direct core build-up of endodontically treated teeth.

Regarding the core build-up material, Signore et al., (16), found that dual-cure composite exhibits lower flexure strength and a lower modulus of elasticity that hybrid composite materials. The authors also shown that where there is more residual dentin the mechanical qualities of the build-up material play a less significant role, (14,16,20,21).

Concerning to the survival rate of teeth restored with this material, Aquilino et al., (22), reported that stiffness of the core material did not affect the fracture resistance of the entire reconstruction. Signore et al., (16), reported a survival rate of 98.48% for restorations made of glass-fiber posts with parallel-sided or tapered shape in combination with either hybrid composite or dual-cure composite resin core material in endodontically treated maxillary anterior teeth.

6. Mechanical behavior of dental posts

6.1. Experimental tests

Several authors reported studies on the mechanical behavior of a post system. One of the experimental tests commonly used to evaluate the mechanical behavior of dental posts is 3-point bending test to identify flexural strength and moduli of elasticity, (2,3,23–25). The diameter, type of fiber and the resin material can influence the elastic limit of a pre-fabricated post, (21). The elastic modulus is related to the stress transmitted to the root, which is one of the most important factors in the fracture mechanism, (26).

Static tests are important for assessing the maximum load required for rupture of a specimen. Most articles use the fracture resistance (loaded at 30-45º) and cyclic fatigue tests to evaluate the behavior of fiber posts, (1,2,4,8,10,26–31).

6.2. Numerical simulation tests

The finite element analysis can simulate the interaction phenomena between dental posts, the surrounding tissues and restoration materials. Analysis of the functional adaptation process is facilitated by the finite element method ability to investigate the several loading conditions, (32). Concerning numerical simulation, there are some authors reporting data mainly in the determination of the stresses created with the endodontic treatment methods, (10,33–37).

Pegoretti et al., (35), reported that cast post-and-core systems produced the greatest stress concentration at the post-dentin interface. On the other hand, the glass fiber composite shows the lowest peak stresses inside the root, and the authors concluded that this material induces a stress field quite analogous to that of natural tooth.

Silva et al., (36), studied the influence of different post design and composition on stress distribution. The authors tested the post materials made by titanium alloys and fiberglass and they observed that there was a higher stress concentration on the coronary portion with the titanium posts than with the glass fiber post.

Most of the studies cited above rely on finite element analysis results that indicate that fiber-reinforced composites are better materials for dental posts, since they show a homogeneous stress distribution when compared to the metallic posts. Additionally, authors affirm that, in general, the use of fiber posts do present high stresses in the cervical region of the tooth. On the contrary, metallic posts create a higher stress concentration in the apical region, (35–37).

6.3. Mechanical behavior of dental posts according with post material

Dental posts usually fracture due to shear stress when submitted at oblique forces. (2,26) Wandscher et al., (26), reported failures by shear stress forces when loading at 45º were applied to dental restorations using fiber posts.

Teeth restored with metallic posts commonly have catastrophic failures, such as oblique or horizontal fractures in the middle third of the root or vertical fractures of the root. This can cause the entire removing of the tooth. On the other hand, authors have reported that although failures occur when a fiber post is used on an endodontic treatment, these failures are easily repairable, (38–41). Accordingly with Zhou & Wang, (41), one possible justification for this is that fiber posts have a modulus of elasticity similar to the dentin, which helps stress dissipation.

Loney & Moulding, (29), studied the effect of a load angulation on fracture resistance of teeth restored with metallic posts and the authors concluded that significant differences can occur as a result of differing the load angles. Moreover, Loney & Moulding, (29), found that the failure load increase as the load angle approached the long axis of the tooth.

Nevertheless, according with Grandini et al., (42), there are significant differences among different brands of dental posts in terms of their structural characteristics and fatigue resistance, which is a fact that is important to consider.

7. Conclusion

The survival rate and fracture resistance of teeth restored with endodontic posts has been investigated. The literature is full of controversial conclusions concerning the best post to use for the restoration of endodontically treated teeth. Initially, many dentists and research authors were in favor of reinforcing the teeth with endodontic posts. However, and through the many reported failures of this approach, there is a general agreement that an endodontic treatment can present a risk of biomechanical failure of the tooth. Therefore, many authors reported that posts should only be used in cases where the remaining tooth coronal structure is insufficient to provide support to the restorative material. The dentist thereby choose the most suitable post, depending on each case and restoration work.

The treatment of endodontically treated teeth using posts is arguably more successful if tooth structure loss is limited and a dental post with mechanical properties similar to the natural dentine is used. It has been demonstrated that the use of metallic posts commonly result in failure or fracture of the tooth, due to the high concentration of stresses. Because of this, non-metallic posts were introduced on the market. Fiber-reinforced composite materials are the most used systems nowadays, but there are some dentists that yet still preferred the metallic ones.

In this article, a new dental post system made of a bundle of fine individual posts was highlighted, which is a promising system to decrease the reported failures on endodontic treatment. This new approach is the motivation of the current research, given that no literature support was found regarding this solution. As such, the authors started a thorough study of the mechanic properties of these structures, which will be the basis of a solid comparison with the currently used post systems.

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