Retention and Fracture Resistance of Prefabricated Metallic and Non-Metallic Posts

Thesis
Submitted to

The Faculty of Oral & Dental Medicine
Cairo University

For Partial Fulfillment of the
Requirements of Master Degree in Fixed
Prosthodontics

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2008

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Acknowledgement

First and forever thanks and gratitude to Allah for his gifts. It is a great honor to express my sincere gratitude and appreciation to ***Prof. Dr. Adel M El Tannir,*** *Professor of Fixed Prosthodontics, Faculty of Oral and Dental Medicine, Cairo University, for his valuable guidance and expert assistance. This study would have not come into light without his remarkable thoughts and notable orientation*

I wish to express my deep gratitude and sincere thanks to ***Dr. Jylan Fouad El-Guindy,*** *Associate Professor of Fixed Prosthodontics, Faculty of Oral and Dental Medicine, Cairo University, for her valuable advice, strenuous effort and constant encouragement in every stage of the work.*

I am really grateful and thankful to ***Dr. Mostafa Gheith,*** *Lecturer of Laser Applications in Dental Surgeries, N.I.L.E.S, Cairo University, for his kind assistance and for the valuable information in the part concerned with Laser applications of this study.*

I am greatly thankful to ***Prof. Dr. Ashraf Hassan, Mokhtar*** *Prof. and Chairman of Fixed Prosthodontics department, Faculty of Oral and Dental Medicine, Cairo University, for his encouragement & support during the work.*

I would like to thank all my colleagues at Cairo University for their help to make this study possible.

Finally this work could not have happened without the extraordinary help, passionate assistance of my family specially my husband.

Arwa Abel Nasser

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INTRODUCTION

The restoration of an endodontically treated tooth with excessive loss of mineralized tissues still presents a challenge to clinicians [96]. In such cases, the risk of fracture is comparably high, as the strength of that tooth is directly related to the bulk of remaining dentin [112].

The cervical part of the tooth is subjected to significant compressive, tensile and torsional forces during function [25] therefore, any canal restoration technique should reinforce the remaining structure [141].The amount of remaining tooth structure will determine the type of final restoration that the tooth will receive [141].

The earliest forms of restoration for the endodontically treated teeth were the cast posts and cores. Due to the increased cost and the high rate of root fracture caused by these types of restorations; they have now given way to prefabricated dowels. These dowels may be tapered or parallel, long or short; smooth or roughened; serrated or threaded [133].

Post materials and designs have been evaluated extensively to determine which are the most retentive and the least stressful to surrounding dentin [97].

It has been suggested that the difference between the elastic modulous of dentin and the post material is a source of stress for the root fracture; the more rigid post resists the forces and transfers the stress to the less rigid tooth structure thus causing failure of tooth structure [97].

Recently there has been an increased use of fiber posts and composite core as their mechanical and esthetic properties allows them to blend with the permanent restoration [150].

New ceramic post and core systems have now been developed with the idea of further improving esthetic appearance, fracture strength and biocombatability [155].

Resin cements are gaining popularity in the dental profession for a number of reasons including improvement of post retention and for providing internal bracing of the root that may substitute for the extra coronal ferrule [139].

Resin cements can be used in cementation of both metallic and non metallic post. Few studies recommended the use of resin cements with dentin bonding agents when the length of the channel hole is less than ideal or when the hole is not rounded, as the resin cement can fill in the spaces and eliminates the need for a cast post. Moreover if the canal is short, the extra retention gained by the bonding procedure compensates for the reduced length [139].

Several ways of post surface treatment were introduced aimed to increase the retentive properties of the post, which are essential for the longevity of the restoration placed into the endodontically treated teeth [109].

REVIEW OF LITERATURE

The restoration of endodontically treated teeth is significantly influenced by the condition of the underlying core. When minimal loss of dental structure has occurred, an amalgam, composite or glass ionomer cement build up should be selected to restore the core. In patients that have experienced extensive loss of coronal tooth structure due to access preparation for the endodontic treatment, pre-existing restorations, tooth fracture, or dental caries, coronoradicular stabilization is required to provide retention [99].

The one piece post and core can often be established by compressing silver amalgam into the prepared canal and pulpal chamber, while post and core combinations are commonly utilized to restore extensive structure loss. The efficacy of employing posts to reinforce endodontically treated teeth remains a widely debated topic [62].

Various studies have demonstrated that the placement of a post does not necessarily reinforce the endodontically treated tooth, but instead serves only as an attachment apparatus for prosthetic treatment. The purpose of a post is to support the overlying core, which consequently replaces the missing coronal tooth structure [26, 2].

Various methods of restoring pulpless teeth had been reported for more than 200 years. In 1700s ***Fauchard*** inserted wooden dowel in canals of teeth to aid in crown retention, and with time wood expands in the moist environment to enhance retention of the dowel unit. Unfortunately the root would often fracture vertically [114].

Since it was discovered that the post exerted pressure on the root canal wall, the root stamp was stabilized with a gold ring to prevent the

root from fracturing. In newer root canal system, the pressure is absorbed by the core build-up thus reducing the risk of fracture [116].

The influence of a post on retention and fracture strength has been demonstrated in several studies, parameters such as length, diameter, design and surface treatment have been found to affect retention and fracture resistance. Studies have shown that increased length and diameter result not only in superior retention, but also in increased risk of root perforation or fracture [34,134].

Researches regarding posts and cores are evolving towards the development of systems that are strong, corrosion resistant, biocompatible and not affecting the aesthetic results [116, 29].

Post and Core Prerequisites:

For the successful restoration of endodontically treated teeth using currently available post and core systems, several aspects such as ferrule design, passivity, shape and length should be considered prior to treatment [88].

Ferrule:

The ferrule is the remaining tooth structure that surrounds the crown or root of a tooth. The resistance to fracture of endodontically treated teeth is highly dependent on the strength provided by the bulk of the ferrule. In order to ensure long-term post and core performance beneath the crown restoration, a 1mm to 2mm ferrule extension to the tooth structure is required [88].

Passiveness:

Several studies have demonstrated that post passiveness within the root canal is a prerequisite for the prevention of root fracture. When luting cast post and core units, passive insertion is exhibited by the

absence of a cement line between the metal post and the remaining tooth structure [24, 54]. In an optimal clinical situation, intraoral stresses would be uniformly distributed, and any cement line would indicate incomplete insertion into the canal with subsequent localized stress in specific root areas [54].

Shape:

Greater retention is offered by parallel–sided posts when compared to tapered posts [83]. It has also been demonstrated that the parallel-sided shape offers greater stress distribution properties than the tapered version and offers less irreversible damage upon failure. The principal disadvantage is in the preparation of the root for placement of a parallel-sided post, where a greater risk of root perforation exists due to root anatomy. The utilization of a cylindrical bur that is slightly tapered at the apex can significantly reduce the risk of perforation during root canal preparation [54].

Length:

The standard post length is usually two thirds of the canal length. While longer posts offer greater retention and more optimal stress distribution than shorter posts, the additional canal preparation when required increases the potential of root perforation and risks disturbing the apical endodontics seal (3 mm to 5 mm) [102].

Prefabricated posts of different materials have been introduced to the market. Two groups of prefabricated posts exist: metallic posts such as titanium alloy posts and stainless steel posts, and non- metallic posts such as glass fiber post, reinforced resin composite post or zirconia post, which are intended to be adhesively bonded to the root canal [50].

A: Metallic Post

Endodontically treated tooth with defective clinical crown is often needed to be restored with a post and core as a foundation for the final restoration. In the last few decades, cast posts have been the most commonly used form of restoration for these teeth; the materials used for cast post construction may be either non precious metal alloys such as cobalt-chromium and nickel-chromium or precious metal alloys such as gold-platinum and silver-palladium [(114)].

Unfortunately, several disadvantages associated with conventional cast post and cores have been reported, such as loss of retention of the post or the crown, a potential for post and root fracture, and a risk of corrosion when different materials were used in the system [(155)].

Over extended function; custom, prefabricated base metal alloy posts and stainless steel prefabricated posts release corrosive products such as iron, nickel, chromium and silver that result in discoloration and increase the potential of fracture. This phenomenon is virtually nonexistent in instances where posts with adequate biocompatibility such as titanium posts and cast gold-platinum alloy dowels are utilized [(46)].

Another disadvantage is that opaque metal posts and cores may shine through semi-translucent all ceramic crowns and impart a grayish color to all-ceramic crowns thus influencing the esthetic outcome of the restoration [(145)].

Metal posts may also shine through thin cervical areas and influence the appearance of the gingival tissue. In addition both root discoloration and corrosion products in the gingival tissues have been reported in connection with teeth provided with non-precious metal posts [(108)].

As an alternative to the individually cast posts and cores, prefabricated metal posts provided with glass ionomer cement or composite cores, are used. However the risk of root fracture is substantial when endodontically treated teeth are provided with metal posts [159].

When Prosthetic treatment is required for anterior teeth, the use of all-ceramic full-coverage crown restoration may be required due to their extraordinary esthetics, translucency, and vitality. Unfortunately, the use of a metallic-cast post and core or a prefabricated post with an amalgam core does not allow adequate light transmission through the restoration. In these circumstances, an esthetic core is indicated to optimize the definitive result [54].

Compared with the cast post and core technique, the use of prefabricated metallic post with direct esthetic build-ups is less invasive and can simplify the restoration procedures; titanium alloy posts have been widely utilized to achieve these objectives [46].

Today, Titanium alloys are the most commonly used materials in restorative dentistry because of their high strength to weight ratio, lower elastic modulus, excellent corrosion resistance and the apparent biocompatibility [107].

Titanium has crystallographic variations which help to categorize the titanium alloys. Based on the phase that can be produced by alloying additions, Titanium alloys are grouped as alpha, alpha-beta and beta alloys. Some alloying elements stabilize the alpha phase such as Tin, Zirconium and Aluminum whereas others stabilize the beta phase such as Vanadium, Chromium, Iron and Manganese [87].

Ti-6AL-4V alloys (alpha-beta) are the most commonly used titanium alloys for dental purposes [20]. Aluminum reduces density,

stabilizes and strengthens alpha phase, while Vanadium provides a greater amount of the more ductile beta phase. This alloy is popular because of its high strength (1100 MPa), high creep resistance at 300Cº, high fatigue resistance and castability [87].

B: Non-metallic posts

Alternative non metallic posts and cores have been introduced into dentistry during the last decades, such as, Carbon fiber posts in an epoxy fiber matrix, quartz fiber posts, and all ceramic posts [81].

These posts are intended to be adhesively luted into the root canal using resin composites and the core consequently builds up with a resin composite [65].

The major advantage of an all ceramic post and core system is its dentin like shade, thus the color of the final all ceramic restoration will be derived from an internal shade similar to the optical behavior of the natural tooth. Moreover, a ceramic post does not reflect intensively through thin gingival tissues, and provides an essential depth of translucency in the cervical root areas. It also provides an excellent biocompatibility and does not exhibit galvanic corrosion [81].

The main advantage of ceramic posts is their elastic modulus that is close to that of dentin. This produces a stress field similar to that of natural teeth. It was reported that using of ceramic posts shows reduced incidence of root fractures. Their mechanical characteristics are more close to dentin than do the metallic posts, thus a mechanically homogenous unit can be easily created [49].

The available all ceramic restorations may be Aluminous porcelain, Glass ceramics (Castable, Mashinable and Pressable), Glass infiltrated, CAD-CAM and Zirconia ceramics [157].