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Fracture Resistance of Endodontically Treatedteeth Restored With Different Types of Post

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I. INTRODUCTION

Dental caries is a multifactorial disease, and if left untreated will lead to pulpinflammation. The inflammatory response by pulp includes the development of edemaand the influx of lymphocytes, plasma cells and macrophages. Due to the pulp, beingcompletely encased in it's rigid dentinal chamber, the inflammatory response increasesthe pressure in the pulp that can cause a collapse of the venous microcirculation. This canresult in areas of pulpal hypoxia and anoxia, that may lead to localized or generalizedpulp necrosis. This is a stage where a tooth can be treated by root canal treatment.

Root canal treatment or endodontic treatment is a common procedure in dentistry. Itincludes gaining access to the pulp chamber, debriding, shaping and finally, filling theroot canal and restoration with a permanent filling material.

Root canal treatment causes certain changes in the tooth. Endodontic access preparationhave shown to cause substantial effect on the relative stiffness of the tooth. Ernest S.Reech have stated a 5% reduction in the stiffness of the tooth after the endodontic accesspreparation. Access preparation results in increased cuspal deflection during functionwhich leads to higher occurrence of fracture. It has also been found that removal ofradicular dentin during biomechanical preparation may increase the propensity of fracturein endodontically treated teeth. Removal of the radicular dentin causes increasedconcentration of stresses on the canal wall at the orifice level in the coronal third of theroot. Removal of radicular dentin increases the magnitude of radicular stresses by upto37%. Considering that in most endodontically treated teeth, there is missing toothstructure caused by caries or existing restoration, associated with endodontic accesspreparation, it is difficult to establish if higher occurrence of fracture is because of thestructural changes in the dentin, missing of tooth structure or both.

Certain chemicals used during endodontic treatment have also been reported to causechanges in the tooth structure. According to Beltz et al sodium hypochlorite dissolves90% of the organic components of the dentin and 17% EDTA dissolves 70% or more ofits inorganic components. Saleh et al reported that irrigating the root canal with 5%sodium hypochlorite and 17% EDTA for 60 seconds significantly reduced the dentinKnoop microhardness. The authors also found a reduction in knoop microhardness insuperficial dentin. Two of the identified dentinal changes are water loss and structuralintegrity loss, highlighted by Faria et al, as the main cause of tooth fracture.

Consequently, the tooth suffers substantial changes in terms of analyzed mechanicalproperties: microhardness, modulus of elasticity, compressive and tensile strength, due tocollagen degradation and the loss of mineral phase.

Regarding the changes in modulus of elasticity of the treated dentin, according toMontouris et al the modulus of elasticity in the coronal dentin did not suffer changes,unlike the modulus of elasticity in the root dentin, which decrease depending on the typeof irrigant and the origin of samples. The differences can be explained because thecoronal dentin has a higher content of calcium and Ca/P ratio and its properties aredependent on the tubule density rather than the intertubular dentin.

Restoration of an endodontically treated tooth is designed to replace the missing toothstructure and also to protect the remaining tooth structure from fracture. The finalrestoration will usually be a combination of post, core and coronal restoration. Theselection of these will depend on the amount of coronal tooth structure remaining. Notevery endodontically treated tooth requires a crown. On the other hand some requires allthe three components. It is critically important to have a proper consideration as to whichcomponent is to be involved in the restoration of the tooth as overuse or underuse of thesecomponents can result in un-restorable fracture of the endodontically treated tooth.

The post is a rigid restorative material placed in the radicular portion of a tooth. Itfunctions primarily to aid retention of the restoration and secondarily to distribute theforces along the length of the root. The post thus has a retentive function and does notstrengthen the tooth as the tooth is actually weakened due to sacrificing the dentin tofacilitate the placement of post. The post should have relatively high hardness to avoidbending. Its proportional limit and tensile strength should be adequate so as to avoidbreaking, it should be biocompatible with surrounding tissues and should be economical, It should have the ability to bind to the tooth structure and core material, capacity to bondto the luting cement, should be dimensionally stable, should be easy to retrieve in caseretreatment is necessary.

There are primarily two types of posts, custom cast post and prefabricated post. The latterone is sub-categorized according to taper, surface characteristics, fit and material. Taperis further classified as parallel, tapered and parallel tapered; Surface characteristics isfurther classified as smooth, serrated and self threading; and fit is further classified asactive and passive; material is further classified as metallic and non metallic. Metallic arefurther subcategorized into titanium, stainless steel, brass and; non metallic aresubcategorized into non esthetic- carbon fibre post and esthetic- polyethelenefibre, glasssfibre, quartz and ceramic.

The traditional custom cast post provides a better geometric adaptation to the excessivelyflared or elliptical canals, and almost always requires minimum tooth structure removal.

Custom cast posts adapts well to the canal with extremely tapered canals or those with anoncircular cross section and/or irregular shape and roots with minimal remainingcoronal tooth structure. Patterns for custom cast post can be formed directly in the mouthor indirectly in the laboratory, regardless, this method requires a two appointment visitand a laboratory fee. Also, because it is cast in an alloy with a modulus of elasticity thatcan be as high as ten times greater than natural dentin, this possible incompatibility cancreate stress concentration in the less rigid root, resulting in post separation and failure.

Additionally, the transmission of occlusal forces through the metal core can focusstresses at specific regions of the root, causing root fracture. Furthermore, upon aestheticconsideration, the cast metal post can result in discoloration and shadowing of the gingivaand the cervical aspect of the tooth.

An alternative consideration is the prefabricated post and core system. Prefabricated postand core system are classified according to their geometry (shape and configuration) andmethods of retention. The modes of retention are designated as active and passive. Activeposts engage the dentinal wall of the preparation upon insertion, whereas passive post donot engage the dentin, relying instead on cement for retention. The basic post shape andsurface configuration are tapered serrated; tapered smooth sided; tapered threaded;parallel serrated; parallel smooth sided and parallel threaded. Prefabricated posts aresimple to use, requires less chairside time, can be completed in one appointment and areeasy to temporize. The major disadvantage of the prefabricated post and core system isthat their application is limited when considerable coronal tooth structure is lost,chemical reactions are possible when the post and core materials are made of dissimilarmetals. Attachments for removable prosthesis cannot be applied, unless a separate castingis fabricated.

The use of glass fiber post has become popular in the last few years. The main advantage of these posts in that they flex slightly and under load distribute stresses to the root dentin in a more favourable manner than any other post. Also, they have esthetic advantages, including increased transmission of light through the root and the overlying gingival tissues. Moreover, they eliminate the problems of corrosive reaction that can occur with metal alloy prefabricated posts. Glass fiber posts also have the advantage of easy removal if endodontic retreatment is required. An important property of this post is their elastic modulus, which is similar to that of dentin, resin cements and resin core materials.

Carbon fiber post system was developed by Duret and Renaud in France and introducedin Europe in early 1990's. Epoxy resin is reinforced with unidirectional carbon fiberswhich are parallel to the long axis of the post and forms the matrix of the post. Onapplication of stress, the post is reported to absorb and distribute it along the entire postchannel. The carbon fiber post has been reported to exhibit high fatigue strength, hightensile strength and a modulus of elasticity similar to dentin. Several studies haveindicated that carbon fiber post exhibit acceptable physical properties when compared tometal post. Carbon fiber post have shown a low failure rate and are clinically satisfactoryin 2-3 years follow up cases. However, Sidoli et al in an in-vitro study found that carbonfiber post revealed a low performance when compared to cast post and core. Multiplestudies indicate that there is a decrease in the strength of carbon fiber post afterthermocycling and cyclic loading. In addition contact of the post with oral fluids reducedtheir flexural strength values. Therefore newer posts systems like fiber reinforcedcomposite posts, glass fiber posts, quartz fiber posts etc were introduced into the market.

Currently an increased demand for clinically convenient post and core system to replacethe lost tooth structure has provided the clinician with the plethora of simplified one visitpost and core restorative system. According to the studies by clinical research associates,the glass fiber postare superior to the metal prefabricated posts. In the last fewyears, there has been a major shift away from metal custom cast post and core towardsresin based composite core. Prefabricated composite posts systems are replacing metalpost system because an adhesive procedure with the glass fiber postsystem adds strength to the tooth restorative interface after bonding. Therefore the glass fiber post system has a similar modulus of elasticity to the dentin after bonding, whereas themetal post assembly has an appreciably higher modulus of elasticity

Therefore, the aim of the study was to compare the fracture resistance of the teethrestored with glass fiber post, metal post, and carbon fiber post.

II. MATERIALS AND METHODS

Forty-five human upper central incisors were collected and cleaned, placed individually into 1% thymol, and stored at 4ºC, in 100% humidity. Teeth with pronounced apical curvatures, with less than 21 mm length and greater than 24 mm length, were excluded from the sample. In addition, teeth with caries, cracks, fractures and previous endodontic treatment were excluded.

Samples were decoronated with diamond disc to obtain a uniform root length of16mm. Working length was determined by inserting a size 10K file in the root canal untilthe tip of the file was visible at the apex, and 1mm was subtracted from the length, whichwas considered as the working length for biomechanical preparation. The root canal wasthen instrumented with Protaper Next from X1 till X3. Between each instrument change,root canal was irrigated with 3ml of 3% sodium hypochlorite followed by 1ml of 17%EDTA and then final irrigation was done using 10ml of 0.9% saline. The root canal wasobturated with 2% 30 size gutta percha point as master cone using lateral compactiontechnique with AH plus sealer. The specimens were then randomly divided into threegroups of fifteen teeth each. Radiographs were taken for each tooth to assess the qualityof obturation and then the post space preparation was done using size 3 peeso reamer toa depth of 11mm. The teeth were then restored with different post systems as mentionedbelow.

SAMPLE PREPARATION FOR GLASS FIBER POST-

A glass fiber post (AngleusReforpostFiber Glass) was selected and tried in the root canal and cut to the required length with a diamond disc. The post was cleaned with alchol and dried. Sialne(Ultradent) was applied on the post surface and left to dry for 1 minute. The canal was cleaned with air water spray and dried with absorbent paper points (API paper points). The canal walls was coated with Ivoclar N etchant gel for 15 seconds and then rinsed for 10 seconds with water and dried using paper points and IvoclarTetric N bond was applied using a microbrush and light cured for 30 seconds. Dual cure resin cement (Ammdent URC), was mixed according to the manufacturer’s instructions coated inside the root canal using a lentulo spiral (Mani) and, also the post surface was coated with the mixed cement, and placed into the root canal. The post was then seated into the canal with light pressure and the cement was light cured for 4 seconds, and excess cement near the orifice was removed. The cement was then cured for 30 seconds with a light curing unit placed over the head of the post. The root face was etched with Ivoclar N etchant gel for 15 seconds and rinsed with water for 10 seconds and then gently air dried. The bonding agent (IvoclarTetric N bond) was applied to the root face using amicrobrush and light cured for 30 seconds. Core buildup was done with DMG Luxacore Z keeping the dimensions as 4X5mm in a cylindrical shape.

SAMPLE PREPARATION FOR CARBON FIBER POST-

A carbon fiber post (Angelus reforpost carbon fiber) was selected and tried in the rootcanal and cut to the required length with a diamond disc. The post was cleaned withalcohol and dried. Sialne (Ultradent) was applied on the post surface and left to dry for 1minute. The canal was cleaned with air water spray and dried with absorbent paper points(API paper points). The canal walls was coated with Ivoclar N etchant gel for 15 secondsand then rinsed for 10 seconds with water and dried using paper points and IvoclarTetricN bond was applied using a microbrush and light cured for 30 seconds. Dual cure resincement (Ammdent URC), was mixed according to the manufacturer's instructionscoated inside the root canal using a lentulo spiral (Mani) and, also the post surface wascoated with the mixed cement, and placed into the root canal. The post was then seatedinto the canal with light pressure and the cement was light cured for 4 seconds, andexcess cement near the orifice was removed. The cement was then cured for 30 secondswith a light curing unit placed over the head of the post. The root face was etched withIvoclar N etchant gel for 15 seconds and rinsed with water for 10 seconds and then gentlyair dried. The bonding agent (IvoclarTetric N bond) was applied to the root face using amicrobrush and light cured for 30 seconds. Core buildup was done with DMG LuxacoreZ keeping the dimensions as 4X5mm in a cylindrical shape.

SAMPLE PREPARATION FOR METAL POST-

The metal post (Angelus reforpost metallic mini kit) selection was made according tothe dimensions of the root canal, and then the post was placed in the post space and theradiograph was taken to check the fit of the post in the root canal. Zinc phosphate cementwas mixed according to the manufacturer's instructions and coated in the root canalusing a lentulo spiral (Mani) and then the metal post was placed inside the root canal.

The excess cement was removed near the orifice. The root face was etched with IvoclarN etchant gel for 15 seconds and rinsed with water for 10 seconds and then gently airdried. The bonding agent (IvoclarTertic N bond) was applied to the root face using amicrobrush and light cured for 30 seconds. Core buildup was done with DMG LuxacoreZ keeping the dimensions 4X5mm in a cylindrical shape.

All the samples were then thermocycled for 500 cycles from 5-55 degreecelcius with adwell time of 30 seconds in each bath and transfer time of 5 seconds.

FRACTURE RESISTANCE ASSAY-

The specimens (teeth embedded in acrylic resin) were then placed vertically into a metal device, angled at 45° to its base in the labial direction of the teeth. Following, the conjunct was transferred to a universal testing machine (Kratos Model IKCL3, KratosEquipamentosIndustriais, Cotia, São Paulo, Brazil). To perform the fracture resistance test, a spherical load cell (2.0 mm diameter) was positioned on the lingual surface of the coronal area of the specimens with an angle of 135° relative to the long axis of the tooth. This position represented the usual occlusal relation between the upper and lower incisors. The compression force was then applied at speed 0.5 mm/min until fracture was observed. The peak force at the time of fracture was recorded in Kgf. The amount of load required to cause failure wasrecorded in Mega Pascals. The mode of fracture was also observed and was classified into supragingival and subgingival fractures. Supragingival fractures are fractures inwhich the fracture line occurs above the acrylic resin and subgingival fractures arefractures in which the fracture line occurs below the acrylic resin.

The data was collected and tabulated for statistical analysis. Statistical analysis of thedata was performed using One-way ANOVA Test, Tukey's HSD Post hoc Test and ChiSquare Test.

III. RESULTS

The test results demonstrate that the mean fracture resistance for Glass fiber post was the highest (961.757), followed by carbon fiber post (784.975), and then metal post (471.836)