Evaluation of Fracture Strength of Endodontically Treated Teeth Restored By Milled Zirconia Post and Core with Different Post and Core Systems

(An in Vitro Comparative Study)

A thesis submitted to the Council of College of Dentistry
at the University of Baghdad, in partial fulfillment of the
requirements for the degree of Master of Science in
Conservative Dentistry

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2013 1434

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عَلَّمَهُ الْبَيَانَ (٤)

صدق الله العظيم

سورة الرحمن (الآية ١ـ٤)

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Dedication

To my

Mother & Father

With love & respect

To my

Husband & Daughter with love and appreciation

To all my wonderful family.

Huda

Acknowledgment

First of all, I would like to thank **ALLAH** for helping me the willingness and strength to accomplish this work.

My sincere appreciation goes to **Professor Dr. Nabeel Abdulfatah,** dean of the college of Dentistry, University of Baghdad for his continuously supporting the post graduate students.

My deepest gratitude and respect to **Professor Dr. Adel F. Ibraheem**, Head of Department of Conservative Dentistry my supervisor for his support and generous help, his valuable advice, guidance, kindness and encouragement during the study.

My appreciation goes to the I would like to express my sincere appreciation to the committee of post graduate studies in the Department of Conservative Dentistry **Prof. Dr. Haitham Al-Azzawi, Prof. Dr. Waleed AL-Hashimi, Prof. Dr. Ali Al-Khafaji, Prof. Dr. Maan Rasheed Zakaria, Prof .Dr. Majida Al-Hashimi, Prof. Dr. Abdul-Karim Al-Azzawi, Prof.Dr.hussain faysal Al Huwaizi, Assist.Prof.Dr.mahammed Rasheed, Assiat.Prof.Dr.zainab mahammed Husain, Dr. Abdullah M. Wajeeh , Assist. Prof. Dr. Anas F. Mahdee,Prof.Assist. Dr. Manhel, Assist. Prof. Dr. Saif Al –Arab A. Mohmmed and Dr. Lamees Abdul Hameed** for their scientific support throughout the clinical sessions and for their continuous follow up.

Deep thanks to **Dr. Mohammed Nahidh**, for his assistance in performing the statistical analysis of this study.

Thanks to **Dr. Abdul Rahman Al-Mashhadani, Dr.Haider Kalhan** and **Dr. Wjdan Fadil** for their help and assistance.

Special thanks to **Mr. Raad Zaid, Mrs. Layla Hussain, Miss. Inaam Hamed** and **Mr. Alaa Abd Al-Sahib** For their help.

I would like to thank **prof. Dr. Ali Hussain Itawee,** the chief of department of materials engineering (University of Technology) and **Miss Dalia Rydh** for their generosity and help in testing procedures of the specimens during this study.

Finally, my admiration to all of the postgraduate students in the department of Conservative Dentistry for their cooperation throughout the M.Sc. program.

Abstract

This in vitro study was performed to evaluate and compare the fracture strength of endodontically treated teeth restored by using custom made zirconium posts and cores, prefabricated carbon fiber, glass fiber and zirconium ceramic posts.

Forty intact human mandibular second premolars were collected for this study and were divided into five groups. Each group contains 8 specimens (n=8):

Group1: Endodontic treated teeth restored with Carbon Fiber Posts;

Group2: Endodontic treated teeth restored with Glass Fiber Posts;

Group3: Endodontic treated teeth restored with Zirconium Ceramic prefabricated Posts;

Group4: Endodontic treated teeth restored with Zirconium Posts and Cores (copy milling);

Group5: Sound teeth (Control Group).

For groups 1, 2, 3, and 4; crowns were removed horizontally using diamond disc bur at the level of cement-enamel junction. Endodontic therapy was then done for all specimens in these groups using step-back instrumentation technique. The root canals, for all these specimens, received standardized dowel posts preparation (10mm depth). All specimens were then mounted in acrylic resin blocks with a layer of elastic impression (condensation silicon impression material light body) to stimulate periodontal ligaments.

Panavia F 2.0 dual cure resin cement was used for cementation of posts to the prepared canals, 2 Kg load applied during cementation. In order to have standardized core build up technique, a cylindrical shaped plastic matrix was used as a mold. Also it permits packing of the composite (Filtek P60) in one increment (bulk technique). The specimens were then stored in saline until the time of testing. The specimens were subjected to compressive loads parallel to their long axes using universal testing machine (WP 300) until failure was occurred.

Data obtained were analyzed statistically using analysis of variance (ANOVA) and student t-test. The results showed that zirconium posts and cores exhibit the highest mean failure load followed by glass fiber posts, carbon fiber posts, and prefabricated ceramic zirconium posts. There were no significant differences between glass fiber, carbon fiber and control group.

The specimens were examined using a magnifying lens to determine the root fracture patterns and locations; the fracture patterns were divided into two groups coronal fracture (desirable fracture)and root fracture (not desirable fracture). In the present study the fiber post treated teeth showed significantly more desirable fracture patterns compared to those restored with zircon posts.

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List of Abbreviations

Symbol	Abbreviation
4-META	4-Methacryloxyethyl trimellitic anhydride
Al_2O	Aluminium oxied
Bis-GMA	Bisphenol A glycol dimethacrylate
Bis-EMA	Ethoxylated bisphenol A glycol dimethacrylate
C	Carbon
ºC	Temperature celsius
c	Zirconia cubic phase
CEJ	Cemento-enamel junction
CeO_2	Cesium oxide
Cr	Chromium
Er:YAG	Erbium: yttrium aluminum-garnet
FPD	Fixed partial denture
FRC	Fiber reinforced composite posts
GPa	Gigapascals
Li_2O	Lithium oxide
m	Zirconia monoclinic phase
MAD/MAM	Manual-aided design/manual-aided manufacturing
MAF	Master apical file
MgO	Magnesium oxide
Mn	Manganese
Mo	Molyenum
MPS	pre-hydrolyzed monofunctional-methacryloxypropyl-trimethoxysilane
Na_2O	Sodium oxide
NaOCl	Sodium hypo chlorite
Ni	Nickel
pH	Hydrogen electrode
RPD	Removable partial denture
S.D	Stander deviation
S.E	Stander error
Si	Silicon
SiO_2	Silicon oxide
t	Zirconia tetragonal phase
TEGDMA	triethylene glycol dimethacrylate
TZP	Tetragonal zirconium polycrystaline

Y_2O_3	Yttrium oxide
Y-TZP	(yttrium stabilized tetragonal zirconia polycrystal)
ZrO_2	Zirconium oxide

Introduction

Restoration of root canal treated teeth with a durable permanent restoration plays an important role in the success rate of endodontically treated teeth **(Martinez *et al.*, 1998).** An optimal permanent restoration should provide esthetic; function and protection for endodontically weakened teeth **(Goldman *et al.*, 1984).**

As a rule, endodontically treated teeth are weaker than intact teeth due to loss of tooth structure, reduction in tooth flexural strength, **(Michael *etal.*, 2010)** changing the collagen cross-links, and moisture content reduction and tooth dehydration. Canal enlargement and cavity preparation can reduce the stiffness of the teeth. Brittleness could be a final result of a root canal treatment **(Sedgley and Messer, 1992)**.

A post is a rigid structure that can be inserted in the root canal after appropriate root canal treatment **(Michael *et al.*, 2010; Garg and Garg, 2010).** Recent studies suggest that the rigidity of the post in the best situation should be similar to the root. In addition, they should show an elastic modulus similar to dentin, which can efficiently transmit the stress from the post to the root structure**(Michael *et al.*, 2010)**.There are a wide range of endodontic posts from metallic to nonmetallic, rigid to flexible and esthetic to non-esthetic **(Rosentritt *et al.*, 2000).**

Cast post and core do not have any bonding ability, and is prone to corrosion. Its elasticity is different from the tooth structure, producing stress and the potential for a root fracture. FRC (Fiber Reinforced Composite posts) are composed of carbon, glass, or quartz fibers embedded in epoxy resin. They have bonding ability to dentin and the core material. They can reinforce the tooth, and as their elasticity is compatible with dentin, they can absorb stresses and protect the root from fracture. **(Newman *et al.*, 2003) Saupe *et al.*** in **1996** reported that FRC posts treated teeth had more resistance to masticatory forces.

The use of zirconia as a post-and-core material began when introduced by **Meyenberg *et al.*** in **1995**. **Rosentritt *et al.*** in **2000** stated that the physical and mechanical properties of zirconia posts could increase the strength of the tooth.

Aim of the Study

The aim of this study is to evaluate and compare the effect of different types of post systems on fracture strength of endodontically treated teeth which are restored by zirconium posts and cores, prefabricated carbon fiber, glass fiber and zirconium ceramic posts.

Chapter One
Literature Review

Literature Review

1.1 Dental Post

1.1.1 Terminology

The American terminology for post is a dowel; a dowel is essentially a cylindrical devise with constant cross sections throughout its length, extending approximately 2/3 of the length of the root canal. This term is still wrongly applied to all shapes and types of posts **(Salman, 2010).**

1.1.2 History

For more than 250 years, clinicians have written about the placement of posts in the roots of teeth to retain restorations. As early as 1728, Pierre Fauchard described the use of “tenons,” which were metal posts screwed into the roots of teeth to retain bridges.

In the mid-1800s, wood was used as the post material, and the “pivot crown,” a wooden post fitted to an artificial crown and to the canal of the root, was popular among dentists **(Smith and Schuman, 1998)**. These wooden posts would absorb fluids and expand, frequently causing root fractures.

In the late of 19th century, the “Richmond crown,” which was a single-piece post-retained crown with porcelain facing, was designed to function as a bridge retainer.

During the 1930s, the custom cast post-and-core was developed to replace the one-piece post crown. This procedure requires casting a post-and-core as a separate component from the crown. This two steps technique improved marginal adaptation and allowed for a variation in the path of insertion of the crown. The traditional custom-cast post core provides a better geometric adaptation to excessively flared or elliptical canals, and almost always requires minimum tooth structure removal **(Smith, 1998).**

Patterns for custom cast posts can be formed either directly in the mouth or indirectly at the laboratory. The cast posts and cores have been regarded as the basic standard for the restoration of endodontically treated teeth because of their high mechanical properties and desirable fit to the abutment tooth **(Martínez-Insua *etal.*, 1998; Fraga *etal.*, 1998).**

But on the other hand main causes of failure of post-retained restorations have been identified, including: recurrent caries, endodontic failure, periodontal disease, post dislodgement, cement failure, crown-core separation, loss of post retention, loss of crown retention, tooth fracture, and root fracture **(Asmussen *et al*, 1999; Sirimai *etal.*, 1999).**

Also, corrosion of metallic posts has been proposed as a cause of root fracture. However, vertical root fractures are often observed in teeth restored by them, caused by increased stress concentration at the end of the post and on the alveolar bone ridge because of the difference in the flexural modulus of dentin and the post materials **(Sirimai *etal.*, 1999; Coelho *etal.*, 2009).**

Prefabricated composite post systems are replacing metal post systems because an adhesive property of fiber-reinforced composite post systems and they have a similar modulus of elasticity to the dentin after bonding, whereas the metal post assembly has an appreciably higher modulus of elasticity. Although the quest for the ideal material to restore lost tooth structure continues to be a focus of modern dental research, but there are many post-and-core materials and techniques that are available to the clinician for a variety of clinical procedures and thus each clinical situation should be evaluated on an individual basis (**Douglas and Edward, 2010).**

1.2 Factors associated with fractures of the endodontically treated teeth

The impact of endodontic treatment on the likeliness of the treated tooth to fracture has been studied at the laboratory. The mean fracture load of a mandibular molar tooth with an endodontic access and MOD cavity is 35% of an intact tooth, but with an endodontic access cavity alone, the fracture load increased. Fracture resistance is shown to increase when both cusps of the root treated posterior teeth are protected under an onlay restoration **(Howe and MeKendry, 1990).**

The minimum dentine thickness left after root canal instrumentation had to be more than 0.2-0.3 mm for the purpose of withstanding lateral compaction forces. Lately introduced rotary instrumentation has been showed to be able to distribute stress on dentin evenly They concluded that the use of engine driven nickel-titanium files might reduce root fracture **(Mayhew *etal.*, 2000).**

Post has little contribution for reinforcement of the root-filled teeth but it has been shown that it reinforced the cervical region **(Pierrisnard *etal.*, 2002).** The new tooth colored material post and core systems have been studied in vitro with regard to its fracture resistance under dynamic loading and compressive load. They are found to have lower strength against fracture **(Sirimai *etal.*, 1999; Heydecke *etal.*, 2002)** but mostly have less catastrophic root fracture.

1.2.1 Physical changes in endodontically treated teeth

Both caries and endodontic procedures can weaken endodontically treated teeth. Intact tooth was hypothesized to behave as a pre-stressed Laminate. This stress condition was believed to be due to crown development. The outward movement of the ameloblasts and the inward movement of the odontoblasts set up the pre-stressed condition. It was stabilized by the mineralization of the matrix. Access cavity of endodontically treated tooth removed most of the central tooth structure; weaken the tooth by causing the loss of the stressed laminate **(Tidmarsh, 1976)**.

Several classical studies have proposed that the dentin in endodontically treated teeth is substantially different from dentin in teeth with “vital” pulps. It was thought that the dentin in endodontically treated teeth was more brittle because of water loss and loss of collagen cross-linking **(Rivera *etal.*, 1993)**.

In **1992, Huang *etal.*** Compared the physical and mechanical properties of dentin specimens from teeth with and without endodontic treatment at different levels of hydration. They concluded that neither dehydration nor endodontic treatment caused degradation of the physical or mechanical properties of dentin.

Sedgley and Messer in 1992 also reported that endodontically treated teeth did not become more brittle based on the findings on their biomechanical properties. They suggested that other factors such as loss of tooth structure, trauma, or operative procedures might be more critical to the occurrence of fracture in endodontically treated teeth. These and other studies supported the interpretation that it is the loss of structural integrity associated with the access preparation, rather than changes in the dentin, that lead to a higher occurrence of fractures in endodontically treated teeth compared with “vital” teeth.

Reeh *etal.* in **1989** reported that endodontic access cavity only reduced the relative stiffness (cuspal flexure) by 5%, whereas the largest reduction in stiffness was related to the loss of integrity of marginal ridge. Some 46% of loss in tooth stiffness resulted from cavity preparation that destroyed one marginal ridge and 63% from MOD preparation so access preparations resulted in increase cuspal deflection during function, which increases the possibility of cusp fracture and microleakage at the margins of restorations **(Panitvisai and Messer, 1995)**

Randow and Glantz in **1986** reported that teeth have a protective feedback mechanism that is lost when the pulp is removed, which also may contribute to tooth fracture.

Loewenstein and Rathkamp in **1995** found that endodontically treated tooth had a higher loading threshold than a vital tooth by 57% Loss of proprioceptive receptors of the endodontically treated teeth might contribute to its susceptibility of fracture, the medicament and the irrigant used during the endodontic treatment might have some effect to the mechanical property of dentine. Flexural strength of dentine after being exposed to calcium hydroxide and sodium hypochlorite was reduced when tested in vitro. Different concentrations of sodium hypochlorite were also tested on dentine for the tooth surface strain but there was no difference found **(Grigoratos *etal.,* 2001; Goldsmith *etal.,* 2002).**

1.2.2. Tooth type

The teeth found to be more prone to fracture were the premolars and molars. The root of premolars, mesial root of the mandibular molars and the mesio-buccal root of upper molars have smaller width mesio-distally and they are thin and flat. Due to the anatomy of these roots, they are more prone to fracture. Furthermore, these teeth are frequently exposed to heavy masticatory force and therefore may predispose them to a higher risk of fracture **(Tamse *etal.,* 1999)**.

1.2.3. Gender and age

Most patients had one fractured tooth; the others had two or three fractured teeth. Of all vertical root fractures, 40% occurred in non-endodontically treated teeth. In comparison with those in endodontically treated teeth, vertical root fractures in non-endodontically treated teeth tended to occur in patients with a higher mean age (55 years vs. 51 years) and were more frequent in male patients .Vertical root fractures occurred in non-endodontically treated teeth more often in molars, less often in premolars and seldom in anteriors **(Wah, 2003)**

1.2.4. The Ferrule Effect

Conservation of tooth structure and proper selection of restorative materials are crucial for a favorable prognosis of endodontically treated teeth. The longevity of a restored tooth thus depends on the amount of remaining tooth structure and on the efficiency of the restorative procedure used to replace lost structural integrity **(Fernandes and Dessai, 2001*;* Buttel *etal.,* 2009).**

The importance of preserving a minimum amount (2 mm) of coronal dentine height after preparation, known as ‘‘ferrule effect’’, so it can be defined as a vertical band of tooth structure at the gingival aspect of a crown preparation. It is the fracture resistance and prevention of root fracture of endodontic treated teeth have been reported in various studies **(Ng *etal.*, 2004; Ng *etal.*, 2006; Pereira *etal.*, 2006; Gomez-Polo *etal.*, 2010).**

It has been reported that when the ferrule effect is present, stresses are redistributed in the outer surface regions of the coronal third of the root thus a possible fracture in this area can be repairable. When the ferrule is absent, occlusal forces must be resisted exclusively by a post that may eventually fracture; otherwise vertical root fracture may occur**.** Ferrule adds some retention, but primarily provides resistance form and enhances longevity **(Mezzomo *etal.*, 2003; Theodora *etal.*, 2012).**

A ferrule with (1 mm) of vertical height has been shown to double the resistance to fracture versus teeth restored without a ferrule. Studies have shown maximum beneficial effects from a ferrule with 1.5 to 2 mm of vertical tooth structure **(Stankiewicz and Wilson, 2002; Zhi-Yue and Yu-Xing, 2003).**

A study by **Saupe *etal.*** in **1996** also reports that there is no difference in fracture resistance of teeth with bonded posts with or without a ferrule. In some cases, particularly with anterior teeth, it is necessary to perform crown lengthening or orthodontic eruption of a tooth to provide an adequate ferrule.

It has been shown that the presence of remaining tooth structure between the core and the preparation finish line was more important for fracture strength of endodontically treated teeth than the post type **(Kumagae *etal.*, 2012).**

1.2.5. Types and designs of post and core

The functions for intra-radicular post post are distribution of internal stress concentration and retention of a core for coronal restoration**.** The intra-radicular posts have been designed in many forms with respect to their retention features and the availability of the root canal space. The theoretical or reported influence of the design of post and core on the mechanical properties of the teeth was involved and their resistance to fracture **(Standlee *etal.*, 1978)**.

There was no definitive evidence both laboratory and clinically on the use of different types of post system for strengthening endodontically treated teeth. The common findings of failure in post and core are tooth fracture and its dislodgement**.** Teeth that restored with posts were more prone to fracture. Besides, the cementation stress from the post post placements might cause relative deformation of the root of endodontically treated tooth **(Morfis, 1990; Obermayr *etal.*, 1991; Goodacre and Kan, 2002)**.

Evolution of the material was used for the post and core system had introduced tooth colored-material for better aesthetic. In vitro studies had been carried out for different types of these post and core system, carbon fiber-based post and core system and zirconia post and composite core and heat-pressed ceramic cores. Clinical trials have yet to verify the invitro findings of the beset systems **(Sirimai *etal.*, 1999; Heydecke *etal.*, 2002).**

As regards to the cement used for bonding of ceramic post and core. Bond strength of resin cement and endodontic surface of root dentin had been studied. Penetration of resin into dentinal tubules could contribute in strengthening the tooth structure **(Trope *etal.*, 1985; Gaston *etal.*, 2001).**

(Pia *etal.*, 2006) concluded that direct post-and-core restorations with prefabricated posts had a higher survival rate than posts with cast-cores. The length of the post had no affect on survival of the restored teeth. Survival rates for endodontically treated teeth were less than for vital teeth when used as RPD abutments.

1.3 Requirements of Endodontic Posts

The fundamental requirements of endodontic posts include: high tensile strength, high fatigue resistance to occlusal and shear loading, and stress-free distribution of the forces affecting the tooth root; excellent accuracy of fit and biocompatibility are also essential. Unnecessarily weakening the tooth; root through increased substance loss should be avoided by selecting a suitable post form **(Edelhoff and Spiekermann, 2003)**

For therapy of aesthetically challenging situations these days, all-ceramic crowns and bridges are widely used, especially in the anterior and premolar regions. These are comparable to natural teeth with respect to their light-conducting properties. The expectations of the optical properties of endodontic posts are rising in response to the demand for aesthetic restorations in teeth that have undergone root canal therapy. Unaesthetic effects, originating from the endodontic post shining through and metal or black carbon fiber posts construction, cannot be reconciled with high expectations of aesthetic results**.** Metal-free systems made from high-strength zirconium oxide ceramic and fiber-reinforced composites are available **(Edelhoff and Spiekermann, 2003; Nergiz and Schmage, 2004).**

1.4 Indications for posts

In clinical practice, teeth with minimal coronal structure are seen with high frequency. When the remaining tooth structure is not sufficient to retain a crown, a post is indicated to provide retention and to improve the distribution of functional loads to the root **(Ichim *etal.*, 2006; Zhang *etal.*, 2006).**

The creation of reliable resistance and retention form for the definitive restoration, while preserving the maximum amount of healthy tooth structure, should be the aim when creating coronal buildups in endodontically treated teeth **(Sedgley and Messer, 1992).**

The selection of the most adequate post system for each case is influenced by the treatment plan to restore esthetics and function, the remaining tooth structure, the post design and the mechanical properties **(Peroz *etal.*, 2005).**

Clinical decision is difficult when the teeth are weakened and the root canals are compromised. These situations occur with open apices, over-prepared teeth for previous post-retained restorations, caries, fracture or internal resorption. Pre-fabricated posts associated with resin reinforcement of the root dentin walls have been used to increase fracture strength of flared canals. According to some studies, fiber-reinforced posts are able to reduce root fracture possibility to minimum risk and displayed significantly higher survival rate **(Akkayan and Gulmez, 2002; Yoldas *etal.*, 2005).**

With modern dental materials using adhesive techniques, the use of endodontic posts can now be avoided in many cases. In cases with an insufficient amount of remaining coronal tooth structure, composite resin adhesive bonding techniques offer the possibility of creating additional retention for the core buildup.

1.5 Post Classification

Endodontic posts can be separated into two broad categories; Custom-made posts and prefabricated posts.

1.5.1 Prefabricated Posts

Prefabricated posts are preferably used for ease manipulation, and rapid setting time of the composite resin core, which enables immediate tooth preparation and reduces total cost **(Miller, 1982).** Prefabricated post systems are classified according to shape (parallel or tapered), mode of retention (active or passive) or materials **(William, 2003).**

1.5.1.1 According to Shape

1. Parallel post having its walls parallel to each other.
2. Tapered post having tapered walls.

Parallel posts are better as compared to tapered ones in their retention. Parallel posts induce less stress into the root, because there is less of a wedging effect and are reported to be less likely to cause root fractures than tapered posts **(Martínez-Insua *et al*, 1998)**. It is more difficult to prepare root canal for placement of parallel posts more tooth structure has to be removed from the root to make its walls parallel to receive a parallel post. In general, parallel-sided posts are more retentive than tapered posts **(Ricketts *etal.*, 2005).**

1.5.1.2 According to Mode of retention

Active posts are more retentive than passive posts (serrated and smooth), but introduce more stress into the root than passive posts **(Burns *etal.*, 1990; Standlee and Caputo, 1992).**

1.6.1.2.1 According to Type of Material Used Post can be made from

1. **Metal: Gold or Base metal alloys.**
2. **Non metallic posts.**

1. Prefabricated Metal Posts

Traditional prefabricated metal posts are made of platinum-gold-palladium, brass, nickel-chromium (stainless steel), pure titanium, titanium alloys, and chromium alloys **(Smith and Schuman, 1998; Asmussen *etal.*, 1999).**

Excessive stiffness and post corrosion, in addition to the unfavorable optical properties from many of these metal posts have stimulated concerns about their use. **(Assif *etal.*, 1993)**

2. Prefabricated Nonmetallic Posts

The nonmetallic prefabricated posts have been developed as alternatives, including ceramic (white zirconium oxide) and fiber-reinforced resin posts. In comparison to metal posts, the use of fiber reinforced composite posts are becoming increasingly common as it offers improved esthetics, good fatigue strength, and potential to reinforce a compromised root **(Kimmel, 2000)**.

Numerous studies have remarked the positive properties of FRC posts **(Al-Harbi and Nathanson 2003; Qualtrough and Mannocci 2003).** Their association with resin composite core, besides esthetic properties and low cost, would provide a positive behavior of the tooth/post assembly, since its modulus of elasticity is closer to the human dentin tissue **(Marshall, 1997)**. Also, the mechanical properties are enough to support masticatory loads and prevent catastrophic failure of the tooth in case of fracture. It could be obtained due to the stress dissipation along the root, generating a pattern of fracture usually at the cervical portion of the remaining tooth **(Ottl, 2002; Qualtrough and Mannocci, 2003).**

Moreover, the FRC post would yield prior to root fracture, which makes it possible to save the tooth. Prefabricated carbon and glass FRC posts are designed by the manufacturer to fit specific dimensions **(Cornier *etal.*, 2002)**.

The quality of fiber-reinforced composite posts, which are now offered by a large number of manufacturers, can vary greatly because the manufacturing process determines it. The highest quality is provided by ensuring for the most even distribution of the fiber in the organic matrix possible, optimally dense fibers, a high degree of polymerization of the organic components, and a homogeneous post structure absent of blisters and inclusions. After polymerization, the blanks are brought into their final form through a milling process. There are different post geometries, which also exhibit considerable differences in surface quality due to variations in the milling processes. **(Yoldas *etal.*, 2005)**

Advantages

The fiber-reinforced composite resin post-and-core system offers several advantages:

- One appointment technique,
- No laboratory fees,
- No corrosion,
- Negligible root fracture,
- Conserved tooth structure,
- No negative effect on aesthetics.

1.5.2 Fiber Posts

1.5.2.1 Carbon Fiber Posts

Carbon fiber posts gained popularity in the 1990s. Their main proposed advantage was that they were more flexible than metal posts and had approximately the same modulus of elasticity (stiffness) as dentin. When bonded in place with resin cement, it was thought that forces would be distributed more evenly in the root, resulting in fewer root fractures **(Cormier *etal.*, 2001; Akkayan and Gulmez, 2002).**

The original carbon fiber posts were dark, which was a potential problem when considering post-restorative esthetics. More recent versions are white. They are relatively easy to remove **(Rijk, 2000)** by drilling through the middle of the post with a rotary. The orientation of the fibers helps keep the removal instrument in the proper alignment.

Teeth restored with carbon/graphite fiber posts are found to resist fracture propagation better than teeth restored with prefabricated titanium posts or cast metal posts **(Isidor *etal.*, 1996).** Ongoing clinical trials are also suggesting good results. No post-associated failures during 3 years of follow up were reported in a study where 236 endodontically treated teeth were restored using carbon/graphite fiber posts. The failure rate using prefabricated metal posts was reported to be 8% **(Torbjorner *etal.*, 1995; Fredriksson *etal.*, 1998).**

Carbon-fiber posts, among the many prefabricated fiber post-and-core systems, to reduce the failure rate. These posts are made of equally aligned carbon fibers attached to an epoxy resin matrix and present an interesting property, anisotropic behavior. In other words, the material has different physical responses when loaded in different directions. This characteristic is of clinical relevance, as it may strongly reduce the possibility of root fracture and de-cementation**. (Morgano and Milot, 1993)**

1.5.2.2 Glass fiber posts

In recent years, various types of fiber posts have been introduced and excellent long term clinical performances of pulpless teeth restored with a combination of fiber posts and resin in conjunction with dentin bonding systems were reported **(Pierrisnard *etal.*, 2002; Li *etal.*, 2006; Toksavul *etal.*, 2006)**

Glass fiber posts can be made from different types of glasses such as electrical glass, S-glass, quartz-fibers and fiber reinforced composite posts. Electrical glass is the most commonly used glass type in which the amorphous phase is a mixture of SiO_2, CaO, B_2O_3, Al_2O_3 and some other oxides of alkali metals **(Qing, 2007)**.

With regard to the fiber posts that are currently available on the market, they are composed of unidirectional fibers embedded in a resin matrix in which reinforcing quartz or glass fibers are immersed. Fibers are pre-stressed, and subsequently resin (as a filler) is injected under pressure to fill the spaces between the fibers, giving them solid cohesion **(Grandini *etal.*, 2005; Perdigäo *etal.*, 2007)**

The fibers are responsible for the resistance against flexure, while the resin matrix provides resistance to compression, and forms the surface so the functional monomers contained in the adhesive cements will interact with **(Mannocci *etal.*, 2001)**.

According to the manufacturer, the mechanical properties of these posts are similar to those of carbon posts and provide an additional esthetic benefit. Fiber posts appear to be biocompatible, easy to insert, and time and cost effective. Moreover, there is no need for temporary fillings, since the post is placed using a one-stage technique. The system is conservative with regard to the remaining dental structure. It offers the possibility of retreatment incases of endodontic failure. **(Rijk, 2000)**

Comparatively, the flexural modulus of prefabricated glass fiber posts is similar to that of human dentin. Therefore, vertical root fractures are not often expected and the failure mode is not so severe when using prefabricated glass fiber posts **(Lassila *etal.*, 2004; Plotino *etal.*, 2007).**

Some authors have reported that endodontically treated teeth restored with fiber posts show a decreased fracture resistance compared with teeth restored with metal posts **(Möllersten *etal.*, 2002; Newman *etal.*, 2003).**

Other author, **(Teixeira *etal.*, 2006; Seefeld *etal.*, 2007)** however, have indicated that the fracture resistance of teeth restored with glass-fiber posts is equal to or greater than that of teeth restored with metal posts.

Failures of endodontic posts, however, predominantly result from either loss of retention **(Torbjorner *etal.*, 1995)** or from root fracture. Post retention can be improved by the adhesive luting technique comprising dentin adhesives and resin-based luting cements**.** In addition, resin-bonded posts were demonstrated to reinforce the restored roots **(Mendoza *etal.*, 1997**) and showed less microleakage than conventionally cemented posts**.**

Other types of fiber posts also are available, including quartz fiber, glass fiber, and silicon fiber posts **(Figure 1-1).** They are claimed to offer the same advantages as the carbon fiber posts, but with better esthetics.

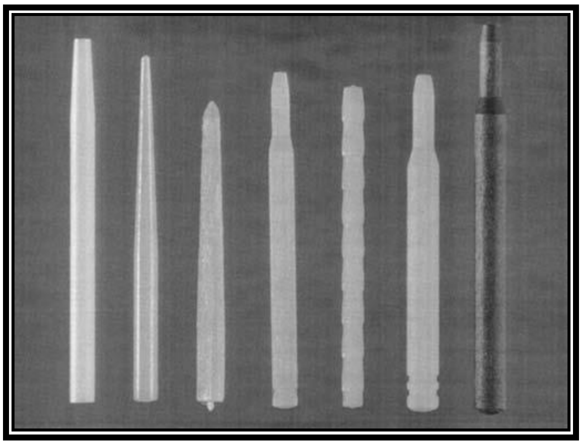


Figure 1-1: Types of fiber posts

1.5.2.3 Zirconium Ceramic Posts

One factor that has reduced the use of metal posts is esthetics. Metal posts are visible through the more translucent all-ceramic restorations and even with less translucent restorations may cause the marginal gingiva to appear dark. These concerns have led to the development of posts that are white or translucent. Among the materials used for "esthetic" posts are zirconium and other ceramic materials. These posts will work clinically, but have several disadvantages.

Disadvantages:

1. As a group, they tend to be weaker than metal posts, so a thicker post is necessary, which may require removal of additional radicular tooth structure. Zirconium posts can not be etched, therefore, it is not possible to bond a composite core material to the post, making core retention a problem **(Butz *etal.*, 2001)**
2. Retrieval of zirconium and ceramic posts is very difficult if endodontic re-treatment is necessary or if the post fractures. Some ceramic materials can be removed by grinding away the remaining post material with a bur, but this is a tedious and dangerous procedure. It is impossible to grind away a zirconium post **(c *etal.*, 2004).**

3. All-ceramic posts made from zirconium oxide are indeed almost tooth-colored; however, these represent an increased risk in the occurrence of stress peaks. This is due to extremely hard and inelastic materials (*E* modulus, ca. 200 GPa) that are not in harmony (from a biomechanical perspective) with the relatively elastic dentine (*E* modulus, 18 to 20 GPa) of the tooth root, resulting in an increased risk for root fractures.

Zirconia posts exhibit high flexural strength and fracture toughness, aside from that they can be silanated and bonded with resin luting agents **(Ahmad, 1998; Derand and Derand, 2000)**.

They are biocompatible and radiopaque. Direct application of a composite material for the definitive core shape is the most common technique. **(Qualtrough and Mannocci, 2003; Soares *etal.*, 2005; Goracci and Ferrari, 2011)**

1.5.3 Custom-Made:

1. Custom- cast posts.
2. All-ceramic posts and cores

1.5.3.1 Custom-Cast Posts

For many years, custom cast posts and cores have been considered to be the standard of care when restoring endodontically treated teeth. Cast posts and cores can be fabricated by using either a direct or indirect technique. Gold, silver-palladium and base metal alloys are the most commonly used metals **(Ingle, 2008).**

1. Advantage:

1. Conforming closely to the configuration of the prepared canal, this is especially significant when the canal is severely flared.
2. Preferable because of their strength and durability.
3. Have little or no stresses associated with installation **(Weine, 1989).**

4. When multiple teeth require posts, it is sometimes more efficient to make an impression and fabricate in the laboratory rather than placing a post and build up in individual teeth as chair-side procedure **(Schwartz and Robbins, 2004).**

2. Disadvantages

1. They are less retentive than parallel-sided prefabricated posts.
2. They act as a wedge during occlusal load transfer.
3. Cast restorative technique is more difficult and costy.
4. Cast restoration involves multiple visit procedures with the associated problems of temporization **(Weine, 1989; Nu'man, 2001).**

1.5.3.2 All-ceramic posts and cores.

All-ceramic posts and cores can be used in combination with all-ceramic crowns to prevent these problems. All-ceramic posts and cores are highly biocompatible and will almost always increase the translucency of an all-ceramic restoration. In addition the post has low solubility and is not affected by thermocycling. **(Koutayas and Kern, 1999; Ingle, 2008)**

1.6 History of Zirconia

Zirconia (ZrO_2) is a metal oxide of zirconium. It was identified in 1789 by German chemist Martin Klaproth. After stabilization, high levels of toughness and strength as well as good wear resistance can be achieved. Because of these properties, zirconia has been used in many applications such as knife blades, thermal shock resistant liners in foundries and valves for combustion engines **(Piconi and Maccauro, 1999).**

In medical applications zirconia has been used in the femoral heads of hip prosthesis since the 1980s **(Christel *etal.*, 1988).** Currently more than (600 000) zirconia femoral heads have been implanted world wide **(Chevalier *etal.*, 2007).** In dentistry, zirconia has been widely tested, mainly as a prosthetic material. One of the first attempts was made in the 1990s by adding 50 wt% of ZrO_2 to glass porcelain, which resulted in 20 to 80 % higher bending strength and fracture toughness than with porcelain alone **(Kon *etal.*, 1990).**

Subsequently the development of zirconia as a dental material has been rapid and today it is used in root canal posts, brackets, and substructures for FDPs, implant abutments and oral implants.

1.7 Material Properties

1.7.1 Physical properties

Certain zirconia-based materials have shown good mechanical properties. Zirconia has been shown to be stronger than other dental ceramic materials Flexural strength of zirconia ranges from 800 to 1500 MPa **(Yilmaz *etal.,* 2007; Teixeira *etal.,* 2007; Chen etal., 2008).**

In addition to good flexural strength zirconia has shown high fracture toughness values, ranging from 6.3 to 11.5 MPa, **(Yilmaz *etal.,* 2007; Aboushelib *etal.,* 2008b).**

Zirconia is chemically stable and does not dissolve in saliva**.** The thermal conductivity of zirconia is low, which prevents the sensitivity of the abutment tooth during temperature changes in mouth **(Piconi and Maccauro, 1999; Chai *etal.,* 2007)**.

1.7.2 Phase transformations – transformation toughening

Pure zirconia is a polymorphic material that occurs in three forms: monoclinic, tetragonal and cubic. The monoclinic phase (*m*) is stable below 1170 ºC. Zirconia is in tetragonal (*t*) form between 1170 and 2370 ºC and in cubic (*c*) form over 2370 ºC. The transformation of pure zirconia from the tetragonal to the monoclinic phase takes place during cooling after material sintering. Cooling is associated with a volume expansion of 3–5 %. Monoclinic zirconia is a very fragile material and may have some flaws and microcracks. By adding stabilizing oxides, such as Y_2O_3, MgO or CeO_2, zirconia can be stabilized in the most durable tetragonal phase also at room temperature **(Piconi and Maccauro, 1999)**. Y_2O_3 is the most commonly used stabilizer of dental zirconia material. The name zirconia is commonly used for dental ceramic material, that is partially stabilized with 3 Mol% of yttrium oxide. Other names used in the literature are Y-TZP (yttrium stabilized tetragonal zirconia polycrystal) and partially yttrium stabilized zirconium dioxide

The high strength and durability of zirconia is based on a phenomenon called transformation toughening. When a crack occurs in the material, the local stresses can lead to *t-m* transformation at the crack tip and the local compressive stresses caused by volume expansion (3-5%) will prevent crack propagation (Figure1-2) **(Piconi and Maccauro, 1999).**

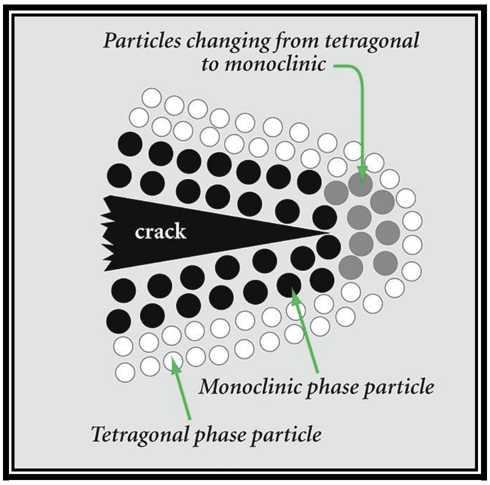


Figure 1-2: The stress-induced transformation toughening process

This stress-induced phase transformation mechanism makes the material more resistant to crack propagation. However, in the presence of high enough stress the crack will propagate through the whole bulk of the material. The tetragonal phase is meta-stable and the surface *t-m* phase transformation can be initiated by surface grinding, sandblasting, stress or temperature changes **(Swab, 1991; Kosmac *etal.*, 1999)**. The transformation induced by grinding generates thin surface layer with compressive stresses. Thickness of the phase change on the surface depends on the severity of surface treatment.

1.7.3 Low temperature aging

Low temperature degradation or aging of zirconia is a negative phenomena related to the transformation ability of the tetragonal phase. Slow surface transformation to the stable monoclinic phase occurs through environmental stresses, usually in the presence of water molecules, hot water vapor or body fluids such as saliva **(Swab, 1991; Lawson, 1995)**. Aging proceeds more rapidly in a warm environment and the critical temperature range is 200 - 300 ºC **(Yoshimura, 1987)**. However, aging can occur even at room temperature. The water enhances aging process. It has been shown that water molecules can penetrate the zirconia lattice during exposure in a humid atmosphere. In the presence of water molecules the outer tetragonal grains of zirconia transform into monoclinic grains **(Chevalier *etal.*, 1999).**

This leads to a cascade of events as the transformation of one grain results in local volume expansion and causes stress to neighboring grains. Due to the stress the neighboring grains also transform into the monoclinic phase. The sudden volume expansion leads to swelling of the surface and the grains. This enables penetration of water molecules through the grain boundaries into the zirconia, causing the transformation of the grains deeper in the bulk of the material **(Figure 1-3) (Deville and Chevalier, 2003; Chevalier and Gremillard, 2008).**

The *t-m* phase transformation leads to micro- and macro-cracking of the zirconia. The sintering temperature seems to play a role in the aging process. **Chevalier *etal.*** in **2004** demonstrated that the amount of the cubic phase in zirconia increases during a long sintering time (5h) the sintering temperature reaches 1500 ºC. The presence of cubic grains in zirconia material seems to diminish the resistance to low temperature degradation. The cubic grains are likely to be enriched with yttrium stabilizer ions while the surrounding tetragonal grains are less stable.

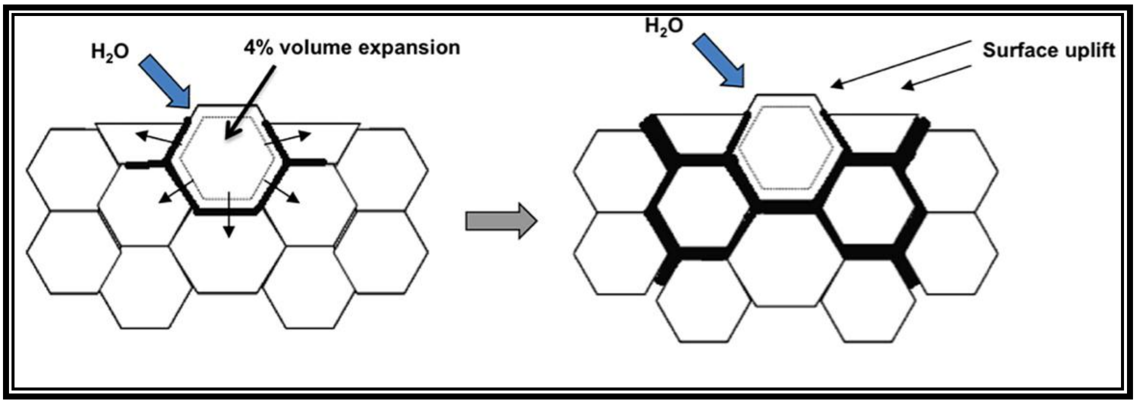


Figure 1-3: Low temperature degradation in zirconia

The microstructure of zirconia material affects aging related phenomena. The higher the density zirconia has, the less aging occurs. The low density offers water molecules easy access to the bulk of the material and aging occur internal surfaces of the material as well as resulting in the decrease of mechanical properties **(Chevalier and Gremillard, 2008)**. Surface stress of zirconia affects the aging process. The surface tensile stresses caused by machining can initiate the *t-m* transformation, because the stresses decrease the energy needed for phase transformation. Compressive stresses do not seem to have a major effect on phase transformation as they stabilize the zirconia grains **(Li *etal.*, 2001; Deville *etal.*, 2006)**.

Aging during preparation of zirconia material can be prevented by careful machining of the restorations and avoiding the formation of scratches on the surfaces. Aging seems to be a concern when using zirconia in moist environments such as in the oral cavity. However, some in vitro and in vivo studies have shown that aging does not affect the clinically related mechanical properties of zirconia **(Cales *etal.*, 1994)** even if some *t-m* phase transformation has occurred. No problems with aging have been reported so far in the clinical use of zirconia in dentistry. A major weakness of dental zirconia is its inferior ability to adhere to resin cement **(Kosmac *etal.*, 1999).** As zirconia has a polycrystalline structure and limited vitreous phase, neither hydrofluoric acid etching nor silanization can achieve durable zirconia- resin bonding **(Kern and Wegner 1998; Janda *etal.,* 2003)**. Nevertheless, some manufacturers do not recommend airabrasion prior cementation taken into consideration that air-abrasion might affect the ceramic surface by creating microcracks which might reduce the fracture strength of the ceramic **(Zhang *etal.,* 2004).**

1.8 Zirconia in Dentistry.

1.8.1 Root canal posts

Zirconia root canal posts were introduced at the beginning of the 1990s. The white color of zirconia provides a more esthetic outcome for the posts and cores of ceramic crowns compared with dark metal posts. These metal-free constructions have excellent biocompatibility and do not exhibit galvanic corrosion that might be detrimental to the root of the teeth **(Koutayas and Kern, 1999)**. **Asmussen *et al*** in **1999** showed that zirconia posts have high mechanical strength, but their plastic properties are inferior compared with less stiff prefabricated metal and fiber posts. In the study of **Spazzin *etal.*(2009)** zirconia root canal posts showed higher stress concentrations compared with glass fiber posts. **Nissan *etal.*** in **2007** showed that there was no significant difference of the failure loads between ceramic and metal post systems. In short term clinical studies with zirconia posts no failures have been reported **(Kakehashi *etal.,* 1998; Nothdurft and Pospiech, 2006)**. In a four-year retrospective study of zirconia posts no failures were observed in teeth restored with direct resin composite crowns **(Paul and Werder, 2004)**. However, three failures out of 58 posts placed were seen in a group restored with indirect glass-ceramic crowns. The failures were all because of loss of retention. A 10-year retrospective clinical study showed a survival probability of 88.4% for zirconia posts with ceramic cores and 76.5% for posts with composite build-ups **(Bateli *etal.,* 2010)**. The main reason for failure was extraction of the tooth. The type of zirconia used for dental posts is posed of TZP with 3 mol% yttrium oxide (Y_2O_3) and is called YTZP (yttria-stabilized tetragonal polycrystalline zirconia).

YTZP is composed of dense fine-grained structure (0.5 µm average diameters) that provides the post with toughness and smooth surface.

Disadvantages of zirconia posts are nearly impossible to remove zirconia posts from the root canal when a failure occurs **(Mannocci *etal.*, 1999)**. It is impossible to grind away a zirconia post, but removal of a fractured zirconia post by ultrasonic vibration has been found to cause temperature rise of the post and on the root surface. Another disadvantage is from the rigidity of zirconia posts. Loss of retention and fracture of posts under intraoral forces are more desirable than tooth fractures **(Satterthwaite *et al*, 2003; Dilmener *etal.*, 2006).**

1.8.2 Zirconia single-coping and framework fabrication by manually controlled system or manual-aided design/manual-aided manufacturing (MAD/MAM) method

Dental laboratory technology is evolving at a rapid pace. The use of zirconia as a metal substitute is a principal driving force behind the ever-increasing development and use of computerized dentistry. Most zirconia single copings and fixed partial denture (FPD) frameworks are milled from blocks of zirconia through the use of computer technology. This could explain the increase in the number of new computer companies entering the computer-aided design/computer-aided manufacturing (CAD/CAM) marketplace. There are short-term zirconia-based successes reported, **(Raigrodski *etal.*, 2006; Sailer *etal.*, 2006)**

Unlike metal copings and multiple-unit frameworks that are virtually indestructible, zirconia has to be treated differently. The decision to use this material is based on improved esthetics and the patient’s desire to be metal-free.

Referred to as copy milling, this method is based on the pantographic principle that was employed hundreds of years ago to copy or enlarge paintings, then later for engraving. The same principle is used at the hardware store when making duplicate keys, using exact mechanical-tactile model surveying and analogous milling **(Reichert *etal.*, 2007).** It is considered to be highly precise in transfer accuracy. First, a coping or framework is manually fabricated in wax or metal, and then the pattern is placed into the pantographic machine. The copying arm of the machine traces the wax pattern while the cutting arm, which has a carbide cutter, mills a selected pre-sintered zirconia block. The final shape is 20% to 25% larger to account for shrinkage during the sintering step. The zirconia block has a density barcode label, so the copy milling machine can be adjusted properly to allow for shrinkage during the sintering phase.

1.9 Preparing the Post Space

As stated earlier, preservation of radicular dentin is important, so there should be minimal enlargement of the canal beyond the shape that was developed during root-canal instrumentation. Gutta-percha can be removed with the aid of heat or chemicals, but most often the easiest and most efficient method is with rotary instruments. The classic literature generally states that the timing of the post-space preparation does not matter **(Mattison *etal.*, 1984)**. Other article showed that immediate post preparation was better **(Fan *etal.*, 1999)**, whereas another showed no difference **(Abramovitz *etal.*, 2000).**

1.9.1 Posts length

Several studies have shown that most failures occurred in endodontically treated teeth are due to the post dislodgment. Therefore, retention of the post can be critical for the long term success of a restoration. Retention depends on various factors including post length, diameter, and design, as well as luting agents and canal shape **(McLean, 1998).**

Leary *etal.* in 1987 also found that posts with a length of at least three quarters of the root had the greatest rigidity and the least root deflection when compared to the short posts. **Nergiz *etal.*** in **2002** indicated that the post retention is highly influenced by its length.

Some authors have indicated that the length of the post is related to root fracture, and that the post should be two thirds of the length of the root, when this cannot be achieved, the post should have at least the same length as the clinical crown. **(Goerig and Mueninghoff 1983; Sokol, 1984)**

According to **Braga *etal.* (2006)** if neither goal can be reached, the post must extend at least half of the root length. Importance of the post length has been emphasized in previous studies; while many studies have focused on metal posts **(Stockton *etal.,* 2000). Gallo etal.** in **2002** evaluated the retention of composite fiber and stainless steel posts. They concluded that the length in retentive potential of fiber posts was not a determinant factor because of the bonding properties of the adhesive cement**.**

Nissan *etal.* in **2001** revealed when the post length is short, resin cement could compensate the retention of prefabricated posts.

According to **Neagley in 1969**, 8 mm is the minimum length required for a post. It has been shown that forces concentrate at the crest of bone during masticatory function. In teeth with metal posts forces also concentrate at the end of the post. Therefore, a post should always extend apically beyond the crest of bone **(Hunter *etal.*, 1989).**

According to traditional teachings, a minimum of 3 to 5 mm of gutta-percha should remain in the apical portion of the root to maintain an adequate seal **(Madison and Zakariasen, 1984; Goodacre and Spolnik., 1995)**

A study by **Abramovitz *etal.*** in **2001**demonstrated that 3 mm of gutta-percha provides an unreliable apical seal, therefore, 4 to 5 mm is recommended.

1.9.2 Posts Diameter

Appropriate guideline for posts diameter is not to exceed one-third of the root diameter. It has been determined that when the root canal is prepared for a post and the diameter is increased beyond one third of the root diameter, the root becomes exponentially weaker each millimeter increase (beyond one third of he root diameter)causes a six-fold increase in the potential for root fracture **(Ingle, 2008).**

1.10 Luting Cements

Any of the current luting cements can be used successfully with a post if the proper principles are followed. The most common luting agents are zinc phosphate, resin, glass ionomer, and resin-modified glass-ionomer cements **(Schwartz and Robbins, 2004).**

For the bonding of FRC posts to root canal dentin, various luting cements and accompanying adhesive systems have been proposed for this purpose. These materials can be divided into self-etching adhesive and total-etching adhesive systems **(Zicari *etal.,* 2008).**

FRC post placement involves the formation of two equally important interfaces, i.e., at the dentin/resin composite and resin composite/fiber level **(Radovic *etal.,* 2008).**

With the recently developed self-adhesive resin cements, no pretreatment of dentin is required. By eliminating the phosphoric acid pretreatment step, the step of rinsing off the phosphoric acid is also eliminated **(Meerbeek *etal.,* 2003).** In other words, the simpler self etching adhesive approach requires a reduced number of clinical procedural steps, hence offering the advantages of a shorter adhesive application time and more importantly, and reduced technique sensitivity.

A number of studies particularly focused on the possibility of improving adhesion at the fiber post-composite interface through various treatments of the post surface **(Bitter *etal.*, 2006; Balbosh and Kern., 2006; Radovic *etal.*, 2007).**

In an attempt to maximize resin bonding to FRC posts, several surface treatments were recently suggested.

These procedures can be divided into following categories:

(1) Silanization and/or adhesive application,

(2) Acid etching, sandblasting, and silica coating, and

(3)Alternative etching techniques (i.e., treatments that combine both a micromechanical and chemical component) **(Monticelli *etal.*, 2008)**

(4) Due to improvements in lasers used in dentistry, erbium: yttriumaluminum-garnet (Er:YAG) laser treatment is considered an alternative method to other surface treatment methods because of its optical penetration depth**.(Shiu *etal.*, 2007)**

As far as laser treatment on FRC posts, no experimental research has been undertaken to date. **Kurt *et al*** in **2012** in his study found that Er:YAG laser treatments significantly decreased the bond strengths compared with the control group. Thus, the Er:YAG laser treatments tested cannot be recommended for clinical use due to possible weakening effects on the stability and integrity of FRC posts. He also found that the acid-etched group showed higher bond strengths than the control group, the highest bond strength in his study was observed in the airborne-particle abrasion group. Additionally, airborne-particle abrasion may produce increased bond strength to FRC posts.

The adhesive properties of post–core materials to root canal dentin have been widely investigated. They found to be affected by various factors in complex manners. Several studies on the bonding performance between FRP and root canal dentin using light cured and dual-cured adhesives reported that bond strengths were affected by their vertical location in the post space **(Mallmann *etal.*, 2007; Aksornmuang *etal.*, 2007).**

Inferior bonding performances in apical areas when using light-cured adhesives demonstrated that achieving high bond strength throughout an entire root canal is difficult. Imperfect curing of the adhesives in the apical portions may be the cause of the inferior bond strengths. To overcome this disadvantage of insufficient light penetration in a narrow post space, prolonging the photo-irradiation time for light-cured dentin bonding systems has been found to be effective in improving the bonding strength to root canal dentin **(Aksornmuang *etal.*, 2006).**

Other options, such as using a translucent fiber post, a LED fiber or a transparent light-guiding attachment, which can be inserted into the deepest parts of the apical portions, may be considered in clinical use. **(Mallmann *etal.*, 2005; Zicari *etal.*, 2012**)

1.10.1 Factors affecting the cement-post interface

1.10.1.1 Smear layer

Another problematic consideration in achieving firm bonding in a root canal is the thick smear layer which is produced during the preparation of a post space. **Goracci *etal.* in 2005** reported that a total-etching resin cement showed greater bonding strength to root canal dentin than a self-etching cement. This may be because acidic monomers responsible for substrate conditioning in the self-etching resin cement were less effective in etching the thick smear layer, and in consequence, the resin cement could not reach the root canal dentin because the remaining thick smear layer blocked it. If firm bonding in a root canal is to be achieved when using self etching adhesive systems, treatment of the thick smear layer must be considered.

Hongxia in **2009** concluded that the better light access and removal of the smear layer in the post space are important in improving the bonding performance of self-etching adhesive systems to root canal dentin with FRP.

1.10.1.2 Chemical post-surface pre-treatments

Chemical post-surface pre-treatments that are today employed clinically, involve coating of the post with a silane primer, and/or with an adhesive resin, this potentially combined with beforehand acid-etching of the post surface. In particular, silanization of the post has quite often been investigated, but unfortunately has also often revealed contradictory results **(Bitter *etal.*, 2007; Wrbas *etal.*, 2007).**

The most common silane-coupling agent used in dentistry is a pre-hydrolyzed monofunctional-methacryloxypropyl-trimethoxysilane (MPS) that is diluted in an ethanol-water solution to a pH between 4 and 5 **(Matinlinna *etal.*, 2004)**. Its working mechanism is based on improved wetting along with chemical bridge formation between the glass phase of the post and the resin matrix of the adhesive resin or composite cement.

Most common micro-mechanical post-surface pretreatment is sandblasting, which is intended to remove the top layer of resin, making the glass fibers reachable for chemical interaction. Naturally, sandblasting also roughens the surface, thereby significantly increasing the surface area and energy **(Sahafi *etal.*, 2003).**

Zicari *etal.* in (2012) concluded that Laboratory testing revealed that different variables like the type of post, the composite cement and the post-surface pre-treatment may influence the cement–post interface. In addition, several interactions between the post system, the composite cement and the post pre-treatment appeared contributing, making guidelines for routine clinical practice hard to define.

1.10.2 Most Common Luting Agent

Five main groups of dental materials are used to cement posts in situ; zinc phosphate, polycarboxylate, glass ionomers, resin-modified glass ionomers and composite resins.

1.10.2.1 Zinc phosphate

It is the most traditional luting cement with a long and satisfactory history. It has been shown to give superior retention to polycarboxylate cement when tapered posts are used**.** When parallel-sided serrated posts are used, there is little difference in retentive properties between zinc phosphate, polycarboxylate and glass ionomer **(Hanson and Caputo, 1974)** despite the latter two having adhesive properties.

It has adequate strength, a film thickness of about 25µm and reasonable working time. It is compatible with zinc oxide eugenol, which is contained in most of root canal sealers. Excess material can be easily removed. As disadvantages, zinc phosphate cement lacks adhesive to tooth structure, has no an anticariogenic properties and its irritant to the pulp (**Abdulfatah, 2012).**

1.10.2.2 Zinc Polycarboxylate Cement

This cement could exhibit chemical adhesion to the calcium and proteinaceous portion of the tooth substance under suitable condition and also possessed similar physical properties to the phosphate cement with the exception of a low irritancy comparable with the eugenol cement and a very low solubility in water. **(Smith, 1968**)

The advantage of this luting agent is its relative biocompatibility, which stem from the fact that polyacrylic acid molecule is large and therefore dose not penetrate into dentinal tubule. **(Rosenstiel, 2006)**

1.10.2.3 Glass Ionomer Cement

Glass ionomer cements have certain characteristics. Thy bond adhesively to enamel and dentin, release fluoride ions over a prolonged period of time, biocompatible and have approximately the same coefficient of thermal expansion as that of tooth structure. In spite of these advantages, conventional glass ionomers suffer from the disadvantages such as short working times and rather long setting times, brittleness, low fracture toughness, poor resistance to wear, susceptible to moisture contamination or dehydration during the early stages of the setting reaction. **(Upadhya *et al*, 2005)**

1.11 Resin Cement

Failures of endodontic posts predominantly result from either loss of retention **(Torbjorner *etal.*, 1995)** or from root fracture. Post retention can be improved by the adhesive luting technique and resin-based luting cements **(Balbosh *etal.,* 2005)**. In addition, resin-bonded posts were demonstrated to reinforce the restored roots **(Mendoza *etal.,* 1997)** and showed less microleakage than conventionally cemented posts **(Bachicha *etal.,* 1998)**

Resin-based luting agents are commonly used in dentistry. During the cementation of indirect restorations and intra-radicular posts using resin cements, proper polymerization of the luting material is essential for clinical success of restorations **(Andrè *etal.,* 2009)**

Advantages of the resin cements

1. They increase retention **(Mezzomo *etal.,* 2003; Nissan *etal.,* 2001)**
2. Tend to leak less than other cements **(Mannocci *etal.,* 2001)**
3. Provide at least short-term strengthening of the root **(Mezzomo *etal.,* 2003)**.

A study by **Bachicha *etal.*** in **1998** reported less leakage when resin cement was used with stainless-steel and carbon fiber posts compared with zinc phosphate or glass-ionomer cements.

Junge *etal.* in **1998** reported that posts cemented with resin cements were more resistant to cyclic loading than those cemented with zinc phosphate or resin-modified glass-ionomer cement. Bonded resin cements have been recommended for their strengthening effect in roots with thin walls **(Saupe *etal.,* 1996; Katebzadeh *etal.,* 1998).** Examples include immature teeth or teeth with extensive caries. Resin may be bonded to some types of posts; so theoretically, the dentin/resin/post can be joined via resin adhesion into one unit, at least for a period of time.

It is rather difficult to achieve an effective bonding within the root canal because of the specific conditions for the adhesive technique. Due to the small root-canal geometry, any controlled application of several agents of the adhesive bonding system is difficult. A visual control is almost impossible. Remnants of post space preparation and conditioning may remain **(Serafino *etal.,* 2004).** Moreover, the application of adhesive systems is technique sensitive **(Sano *etal.,* 1998; Meerbeek *etal.,* 2005)**. As a consequence of cement application technique and polymerization shrinkage a number of gaps, voids and bubbles are observed within the cement interface **(Bouillaguet *etal.,* 2003; Grandini *etal.,* 2005; Bolhuis *etal.,* 2005)**. All these imperfections reduce the ability of a luting material to sufficiently adhere to the post surface and finally to retain the endodontic post.

Thus, it is of major interest to reduce the number of imperfections in order to increase post retention by the use of easier-to-handle luting materials and application aids. Bonding resin cement to the dental wall of the root canal space must be done carefully to improve the bonding and minimize microleakag. The actual method of post cementation is critical to ensure complete seating within the post space and that the luting cement adapts completely to both the dentine and post, thus completely sealing the interface between the two. **(Ricketts *etal.,* 2005)**

Occasionally, posts need to be removed to endodontically retreat teeth, or a post may fracture. Metal posts cemented with conventional cements such as zinc phosphate are removed by making a small gutter around the post followed by the application of ultrasonics. **(Smith, 2001)** Adhesive resin cements make removal difficult, if not impossible, as the retention from a parallel-sided post can be as high as with an active, threaded post. When such posts are removed under force, up to 80% will result in root fracture. **(Standlee and Caputo, 1992)** Whilst failure to remove the post in a tooth with a failed root canal filling may lead to peri-radicular surgery or extraction, in a tooth with a fractured post, extraction is the only realistic option. Adhesive resin luting cements should not be used as a routine with metal-based posts, but reserved for those situations where retention is compromised. **(Ricketts *etal.,* 2005)**

While adhesive luting cements should not be used as a rule with metal-based posts the reverse is true for fiber-based posts, as these are removed in a different manner.

Most studies have found carbon-fiber posts to be either equally or less retentive than stainless-steel posts. **(Kurer, 2001)** When failure occurs this has always been at the cement–post interface, thus there is benefit seen from a mechanically retentive fiber post design. **(Ricketts *etal.*, 2005)**

1.11.1 Chemical composition

Bisphenol A glycol dimethacrylat (Bis-GMA) is the most common monomer in the resin phase, presenting high molecular weight and low polymerization shrinkage. Due to its high viscosity, the Bis –GMA is usually diluted with triethylene glycol dimethacrylate (TEGDMA). However TEGDMA has been linked to increased water sorption and polymerization shrinkage **(Moraes et al., 2008)**. In order to overcome the drawbacks of the dilution process using TEGDMA, ethoxylated bisphenol A glycol dimethacrylate (Bis-EMA) has been investigated as an alternative monomer. This is structurally analogous to Bis-GMA, but without the two pendant hydroxyl groups responsible for the high viscosity and water affinity of Bis-GMA. Therefore, the addition of Bis-EMA could minimize or eliminate the use of TEGDMA as diluents commoner, while potentially reducing the polymerization shrinkage and stress due to the higher molecular weight and lower mobility of Bis-EMA molecule compared with TEGDMA **(Moraes et al., 2008)**.

ISO 4049 for polymer-based filling restoration and luting materials (ANSI\ADA No. 27) describes the following three classes of composite cements **(Craige and Power, 2006)**:

Class1: self- cured materials.

Class2: light-cured materials.

Class3: dual-cured materials.

1.11.2.1Self-cured materials :

These resins are two-paste systems, with one paste containing the organic amine (tertiary amine) as activator and the other containing the organic peroxide (benzyl peroxide) as initiator **(Craige & Power, 2006)**.

1.11.2.2 Light-cured material :

These resins contain a camphoroquinone (0.25%) photoinitiator and organic amine (tertiary amine) in a single paste. The tertiary amine is known as a conditioner, which is compound, that dose not absorb light but interacts with an activated photoinitiator to produce the reactive free radical; inhibitors are also present to enhance ambient light stability **(Anusavic, 1996)**.

1.11.2.3 Dual-cured materials:

Combine self-curing and light-curing material. Conventional dual-cure resin cements are indicated for luting procedures because they have low solubility, high mechanical quality and adhesive properties. The characteristics of the dual-cure cements are independent and complementary to those of light-activated chemical cements, which make them ideal for deep cavities such as the root canal, the use of the dual-cure cements requires pretreatment of the root with adhesive system **(da Silva et al., 2010).**

1.12 Dual-Cure resin cements

Dual-cure resin cements have been extensively indicated for a large variety of luting procedures that include all-ceramic restorations and intra-radicular fiber-reinforced composite posts (FRCP).

Advantages are mostly due to:

- Their low solubility.
- Superior mechanical and adhesive properties **(Hofmann *etal.*, 2001).**

Nevertheless, intra-radicular adhesive cementation still presents significant challenge to clinicians due to technical variables involved and little knowledge about the clinical predictability of these materials in the long term **(Bouillaguet *etal.*, 2003).**

Dual-cure resin cements were developed with the objective of conciliating the favorable characteristics of self-and light-activated cements. These are effective control of working time and the possibility of achieving adequate degree of conversion, even in the absence of light **(Braga *etal.*, 2002).**

These cements are ideal for situations in which the opacity of the restoration or cavity depth might make it difficult for light to reach the full thickness of the cement layer **(Miller, 2004; Ceballos *etal.*, 2007)**. The two forms of activation of the curing reaction are present, they are supplementary and independent. If light exposure is not sufficient, the light-activate route of curing will be affected and maximum curing can be compromised **(Miller, 2004).**

The literature reports a degree of conversion of 50–80% for dental composites. In light-activated materials, the degree of conversion varies inside the mass of the material, partly due to the dependence on light energy for activation **(Asmussen and Peutzfeldt, 2001)**. Some studies evidenced a significant decrease in the polymerization potential of composites in the intra-radicular environment, as a result of light attenuation **(Lui, 1994; Roberts *etal.*, 2004; Yoldas and Alacam, 2005).**

The degree of conversion attained by a composite provides valid information about the durability and biological safety of the restoration, since it influences the mechanical properties and degradation by water and oral acids **(Caughman *etal.*, 2001),** and the release of uncured residual monomers that is a potentially sensitizing and irritant factor for the oral tissues **(Lee *etal.*, 1998; Ortengren *etal.*, 2001).**

The extent to which the hygroscopic and hydrolytic processes affect the structure of composites remains questionable, but it is recognized that water produces alterations in mechanical properties and dimensional stability of these materials **(Ferracane, 2006).**

The nature and polymeric structure formed during polymerization also influence the mechanical properties of the final polymer (**Soh and Yap, 2004).** While light-activated composites may exhibit similar degree of conversion in areas close and slightly away from the curing tip, density of cross-links may be lower in the region less exposed to light **(Yap *etal.*, 2004).**

The density of the cross-linked network is determinant of the extent to which the polymer is susceptible to softening when submitted to the action of solvents in the medium **(Ortengren *etal.*, 2001).**

Polymers with low cross-link densities are less resistant to softening and consequent degradation because they have increased free volume available for diffusion of molecules from the medium into the polymer **(Ferracane, 2006)**. The density of cross-links can be estimated by means of in tumescence tests **(Asmussen and Peutzfeldt, 2003)**. A 75% ethanol–water solution is the solvent indicated for in vitro simulation of intraoral environment and its role in the softening and aging of composites **(Lee *etal.*, 1998; Soh and Yap, 2004).**

The assessment of some mechanical properties can provide an indirect measurement of the quality of polymerization of composite resins. Microhardness tests have been shown to present good correlation so that hardness values increase as degree of conversion also increases, and vice-versa **(Caughman *etal.*, 2001; Ana Paula *etal.*, 2009).**

1.13 Core Build up Materials:

The purpose of the post is to retain the core, which in turn helps retain the crown. With cast post and cores, the core is formed on the post directly on the tooth or indirectly on a cast. The general shape and orientation of the core is developed during fabrication. Prefabricated posts are used in combination with a restorative build-up material which is formed after cementation of the post. The choices are amalgam, composite resin, or glass-ionomer materials. **(Schwartz and Robbins, 2004)**

1.13.1 Core Build up Requirements

There are some of the desirable features of core material **(Salman, 2010)** they include:

1. Adequate compressive strength to resist intraoral forces.
2. Sufficient flexural strength.

3. Biocompatibility.
4. Resistance to leakage of oral fluids at the core-to tooth interface.
5. Ease of manipulation.
6. Ability to bond to remaining tooth structure.
7. Thermal coefficient of expansion and contraction similar to tooth structure.
8. Dimensional stability.
9. Minimal potential for water absorption.
10. Inhibition of dental caries

Unfortunately, as the commonly used materials all exhibit certain strengths and weakness, such an ideal core material dose not exist **(Salman, 2010)**

1.13.2 Types of core build up materials:

The most commonly used core materials are cast gold, amalgam; glass ionomer and resin-based composite. **(Salman, 2010)**

1.13.2.1 Cast gold and amalgam:

Cast gold has been used successfully for many years, as they exhibit high strength and low solubility, it coefficient of thermal expansion is similar to that of tooth substance, and works well in high-stress areas. Placing cast gold post and core, however, is an indirect procedure requiring two visits**. (Salman, 2010)**

Amalgam has been used as a buildup material, with well recognized strengths and limitations. It has good physical and mechanical properties **(Kovarik *etal.*, 1992)** and works well in high-stress areas. In many cases, it requires the addition of pins or other methods to provide retention and resistance to rotation. The crown preparation must be delayed to permit the material time to set. Amalgam can cause esthetic problems with ceramic crowns and sometimes makes the gingiva look dark. There is also a risk of tattooing the cervical gingiva with amalgam particles during the crown preparation. For these reasons, and potential concern about mercury, it is no longer widely used as a buildup material. Amalgam has no natural adhesive properties and should be used with an adhesive system for buildup. **(Schwartz and Robbins, 2004)**

1.13.2.2 Glass-ionomer materials:

The glass-ionomer materials, including resin-modified glass ionomer, was shown to be weak in tensile strength and compressive strengths, and it had low fracture modulus of elasticity, poor bonding characteristics to dentine and enamel, poor condensability and high solubility. Therefore the use of glass ionomer cement as a core material should be avoided and should not be used in teeth with extensive loss of tooth structure. When there is minimal loss of tooth structure and a post is not needed, glass-ionomer materials work well for block-out, such as after removal of an MOD restoration. **(Schwartz and Robbins, 2004)**

1.13.2.3 Composite for Core Build ups

Currently, composite resin is the most popular core material and has some characteristics of an ideal buildup material. It can be bonded to many of the current posts and to the remaining tooth structure to increase retention **(Hsu *etal.*, 2002).**It have high tensile strength and the tooth can be prepared for a crown immediately after polymerization.

Pilo *etal.* in **2002** showed that composite cores have fracture resistance comparable to amalgam and cast post and cores, with more favorable fracture patterns when they fail. It is tooth colored and can be used under translucent restorations without affecting the esthetic result.

These materials have been used for core build-up with stainless steel, quartz fiber, carbon fiber or glass fiber posts instead of cast posts and cores. Some researchers have shown that composite resin cores with glass fiber posts cause vertical root fractures in vitro and in vivo **(Forberger and Göhring 2008; Al-Wahadni *etal.*, 2008).** It has been still unclear whether failure rate depends on the flexural modulus of post material, the bond strength of core material to root dentin or both. **(Kumagae *etal.*, 2012)** conclude that the fracture strength of endodontically treated teeth restored with composite resin cores is not influenced by the flexural modulus of these posts.

Large variety of composite resin materials, from packable to microhybrid to flowable composite, both light-cure and self-cure, are available for core build-up procedure. They differ from each other in terms of strength, stiffness and elasticity. As regards mechanical properties, cores directly built-up with composite resin have shown a fracture resistance comparable to that of cast gold cores. Moreover, failures under compressive load have been reported to be more favorable for the remaining tooth structure fore carbon FRP posts with composite cores than for cast gold alloy posts and cores.

It has been suggested that if a sufficient ferrule can be created, the type of core build-up in a post system dose not play a significant role. Failures between carbon FRP posts and core build up composites have been reported, and it has been suggested that the retention of the composite core material to FRP posts is based more on mechanical inter-lock in than on chemical bonding **(Salman, 2010).**

On the negative side, composite shrinks during polymerization, causing gap formation in the areas in which adhesion is weakest. It absorbs water after polymerization, causing it to swell **(Oliva and Lowe, 1987)**, and undergoes plastic deformation under repeated loads **(Kovarik *etal.*, 1992; Gateau *etal.*, 1999)**.

Adhesion to dentin on the pulpal floor is generally not as strong or reliable as to coronal dentin **(Kijsamanmith *etal.*, 2002)**. Strict isolation is an absolute requirement. If the dentin surface is contaminated with blood or saliva during bonding procedures, the adhesion is greatly reduced.

The durability of a composite resin core restoration depends on the formation of a strong bond between the core material and residual dentin, as well as between the core and post material, enabling the interface to transfer stresses under functional loading. **(Kurt *etal.*, 2011)**

1.14 Universal Testing Machine

A universal testing machine, also known as a universal tester, **(Joseph, 2004)** materials testing machine or materials test frame, is used to test the tensile stress and compressive strength of materials. It is named after the fact that it can perform many standard tensile and compression tests on materials, components, and structures.

The testing method, static loading until failure, has been criticized for not corresponding closely enough to the clinical situation. It may be that a cycling loading test corresponds better to the clinical situation, as it is known that it is fatigue that most often causes root fractures **(Naumann *etal.*, 2009)** however static loading is usually the first step in the evaluation process of a novel dental material and is commonly used in order to obtain basic knowledge regarding the fracture behavior and load capacity of a post restored tooth.

Chapter two

Materials and Methods

Materials and Methods

2.1 Materials and Equipment

2.1.1. Material and equipment used for polishing of the teeth:

1. Pumice.
2. Rubber polishing cup.

2.1.2. Materials and equipment used for root canal instrumentation and obturation:

1. Distilled water (Iraq).
2. Endo clean stands (Dentsply, Maillefer, Ballaigues, Switzerland).
3. Barbed broaches (RADIX, Vlachivicke, LOT. No.1031119, Exp.2015-05-05)
4. Absorbent paper point (Meta, BIOMED, Chuncheongbuk-do, Korea, LOT. PE 1101014. Exp. 2016-6).
5. Endodontic Measuring block (Dentsply, Maillefer, Ballaigues, Switzerland).
6. Endodontic plugger.
7. Endodontic K-File (Dentsply, ballalgues, Switzerland, LOT. 9481260. Exp. 2015-06).
8. Sodium hypochlorite solution 5% (Peros,Turkey.exp.2017-07).
9. Gutta-percha points (Meta, BIOMED, Chuncheongbuk-do, Korea, Lot. No. GE1207750. Exp. 2015-07).
10. Apexit plus root canal sealer (Ivoclar-Vivadent, Schaan, Liechtenstein. Lot No. P75463. Exp. 2013-10).

2.1.3. Materials and Equipment used for posts and posts cementation:

1. Dental surveyor (Cendres & Metaux, Switzerland).
2. Disposable Micro Applicators brushes.
3. Size Nr-4 Ø 1.50 glass Fiber posts (Glassix®, Nordin, Switzerland, LOT. No 11857).
4. Size Nr- Ø 1.50 zircon fiber posts (Zirix®, Nordin, Switzerland, LOT. No.71-30447-1/614).
5. Size Nr-4 Ø 1.50 carbon fiber composite posts (Carbonite®, Nordin, Switzerland. Lot. No.10760/119).
6. Size Nr-4 Ø 1.50 Fiber post drills (Nordin).
7. Light curing unit (Dentsply, Switzerland).
8. Pesso drills No.1 (Largo, maillefer, Switzerland).
9. Dual cure dental adhesive system Panavia F2.0 (Kuraray, Japan. LOT No. 061285. Exp. Date 2014-03)
10. Load of 2 Kg (China).
11. Load holder (Custom-made).
12. Non-precious-dental cast alloy (Eisenbacher Dentalwaren, Germany. LOT No.H121-54).
13. Zircon block (zircon Zahn®, Italy, LOT No. ZB2176K).

2.1.4 Materials and equipments used for core build up:

1. Packable composite (3M Germany Filtek™ p60 Lot. No. N402533 Exp 2015-5).
2. Light cured adhesives bonding agent (3M Germany Adper™ Single bond 2 Lot272300 exp: 2014-4).
3. 37% wt phosphoric acid etchant gel (Swiss Tec self echant gel, Coltène Whaledent® Lt C26982 exp: 2014-9).

4. Small condencer.
5. Disposable Micro Applicators brushes.
6. Cylindrical shaped transparent plastic matrix fore core build up
7. Glass slide cover.
8. Light cure devise (Quayle, dental Detrotor, sussEx.voltag:220,wl400-500nm, No: vcl 1088).
9. Polyester finishing strips.

2.1.5. Materials and equipment used for mounting of the teeth

1. Cold cure acrylic, powder and liquid (Vertex, Netherlands. Lot No.YG493L03 Exp. Date: 09/2015).
2. Condensation Silicon Impression Material light body (Aquasil Ultra LV, Dentsply, Lot. No. 120104 Exp 2015-10).

2.1.6. Equipment needed to perform the tests:

1. Universal testing machine. (WP 300, gunt, Humburg, Germany)

2.1.7. Other Equipments

1. Angle hand piece (W&H, Austria).
2. Cement spatula.
3. Cumine scaler.
4. Dental tweezers.
5. Diamond disc (Delta. China).
6. Digital stop watch.
7. Disposable latex gloves.
8. Engine with straight handpiece (W&H, Austria).
9. Glass cement slab.
10. Magnifying eye lens x20 (China).
12. Spoon excavator.
14. Digital Vernier (Dentaurum, Germany).
15. Lentulo spiral (penumat, Lot. No. D00001).

16. Straight hand pieces (Western Germany KAVO, 10)
17. Copy milling machine (Zirkon Zahn, Germany).
18. Thymol
19. X-Ray films (Kodak. China, Lot. l2689222. 15 mar.2014)

Figure 2-1: Some of the materials used in this study

2.2 Method

2.2.1 Sample Selection

Forty sound lower second premolars recently extracted for orthodontic purposes, of comparable size and shapes, were selected. All teeth were cleaned from soft tissue debris using cumin scaler and stored in 0.1g/L thymol at room temperature. A magnifying lens with the aid of light generated by light cure device was used to demonstrate the absence of cracks. Diagnostic radiograph was taken to confirm the existence of a single straight canal, fully formed apex and no signs of internal resorption, calcification or previous endodontic therapy.

2.2.2 Samples Preparation

The coronal portions of thirty two teeth were removed using a diamond saw mounted on straight hand pieces under water spray, perpendicular to the long axis of each tooth to produce a flat surface. The length was adjusted at 15 mm with digital vernier before cutting. The pulp contents were removed by using a barbed broach, and No. 10 file was inserted until its tip just appeared at the apex, the working length was equal to 14mm. **(Nu'man, 2001)**.

The canals of all teeth were prepared chemomechanically by step-back technique. Starting with file size #15 entered into the canal to full working length (14mm) up to size #45 as a master apical file (MAF); then stepping back 1mm fore every successive larger instrument till size #60. Irrigation and recapitulation were carried out to remove debris and prevent canal blockage. Each file was used to prepare five root canals only **(Abdulfatah, 2012)**. The final irrigation was carried with 5ml of 2.5% NaOCl solution followed by 5ml of distilled water then the roots were dried with paper points.

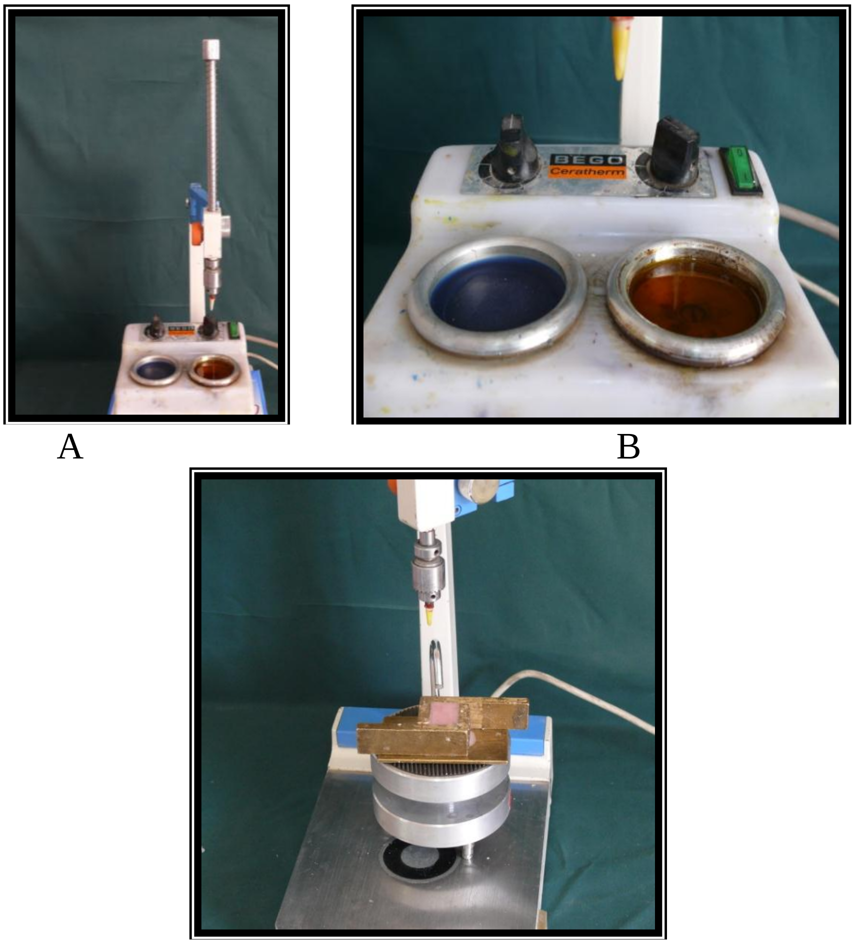
The prepared canals were obturated by cold lateral condensation technique of gutta percha points using apexit plus sealer. Master gutta percha con size 45 was fitted with tug back. The sealar was applied with lentulo; the tip of master gutta percha con was coated with sealer mixed according manufacture instruction. Gutta percha was then condensed laterally by finger spreader. Accessory gutta percha cones (size 25) were used, excess gutta percha was removed by hot instrument and the remaining was condensed apically with endodontic plugger **(Cohen and Kenneth, 2006).**

2.2.3 Mold Construction

To simulate the periodontium, root surfaces were dipped into melted sticky wax to a depth of 2 mm apical to the facial CEJ junction to produce a 0.2 to 0.3 mm layer approximately equal to the average thickness of the periodontal ligaments **(Figure 2-2 A and B).**

Roots were, then, mounted in cold cure acrylic resin using a metal mold with (20 mm length and 20 mm width); the prepared roots were attached to the horizontal arm of the surveyor during impeding into acrylic mold to make assertion that long axes of the root were parallel to the long axes of the mold **(Figure 2-2 C)**. Following the concept of the biological width, 2 mm of root structure was maintained outside the acrylic resin. After acrylic polymerization, root was removed and cleaned from wax (wax spacer). **(Al – Ansari, 2009)**

Condensation Silicon Impression Material light body (Aquasil Ultra LV, Dentsply) was delivered into the acrylic resin alveolus. The tooth was then reinserted into the test block, and the Condensation Silicon material was allowed to set. Excess material was removed to provide a flat surface **(Kumagae *et al.*, 2012)**.



A B

C

Figure 2-2 (A, B and C): periodontal ligament simulation.

2.2.4 Sample grouping

The simples (n=40) were randomly divided into five groups (n=8) according to the type of posts.as shown in table (2-1)

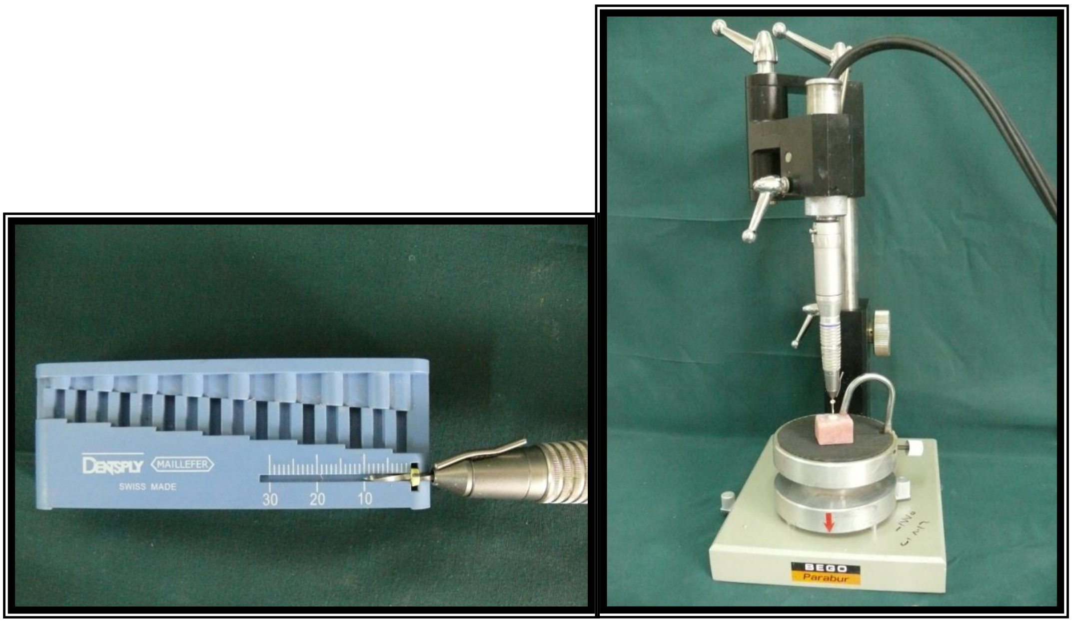
Table 2-1: Sample grouping

Group	Type of posts
1	Carbon fiber posts (carbonite)
2	Glass fiber posts (glassix)
3	Ceramic zircon fiber posts (zirix)
4	Costume made zircon posts (copy milling)
5	Control group with out preparation

2.2.5 Post space preparation

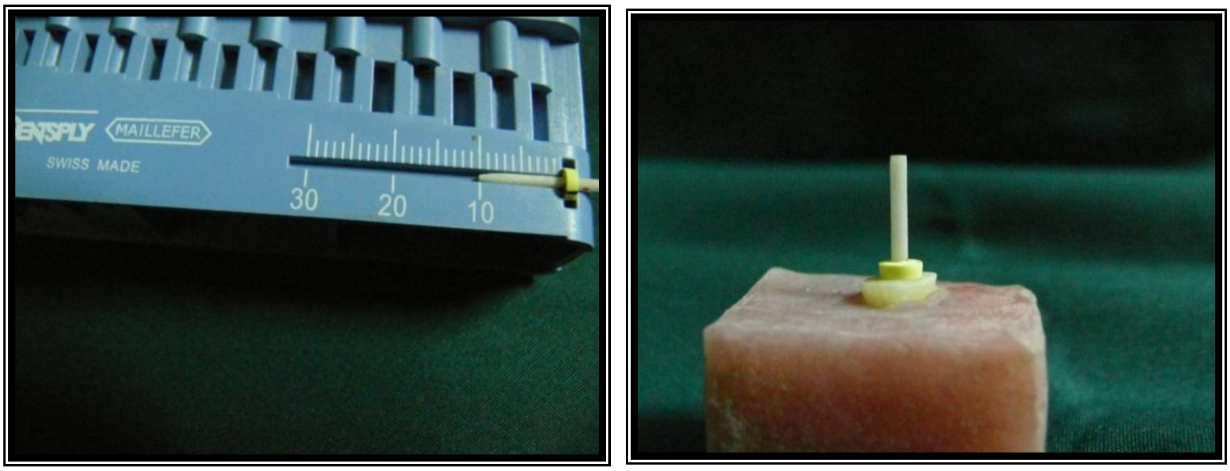
The gutta-percha was removed from the root canals of teeth using pesso drills to the depth of 10mm measured from the coronal end of the root(rubber stopper was attached to the pesso reamer to adjust the depth of entrance(10mm)). Thus 4-5mm of Gutta- Percha kept apically **(Perdigão *et al.*, 2006; Zobra *et al.*, 2010; Hegde *et al*., 2012)**

Post space preparation was done with a low –speed straight hand piece attached to a dental surveyor to obtain vertical preparation with standard diameter and dentinal walls parallel to the long axis of the root **(Figure 2-3 A&B) (Edson *et al.*, 2006; Abdulfatah, 2012**). For each group a drill (size Nr-4 Ø 1.50) supplied with the kit were used. For all specimens in groups 1, 2 and 3 the post were tried in to verify heir fitness **(Figure 2-4 A and B).**



A B

Figure 2-3 (A and B): Post space preparation.



A B

Figure 2-4(A and B): The post checked in its place after length adjustment.

2.2.6 Fabrication of zirconium posts

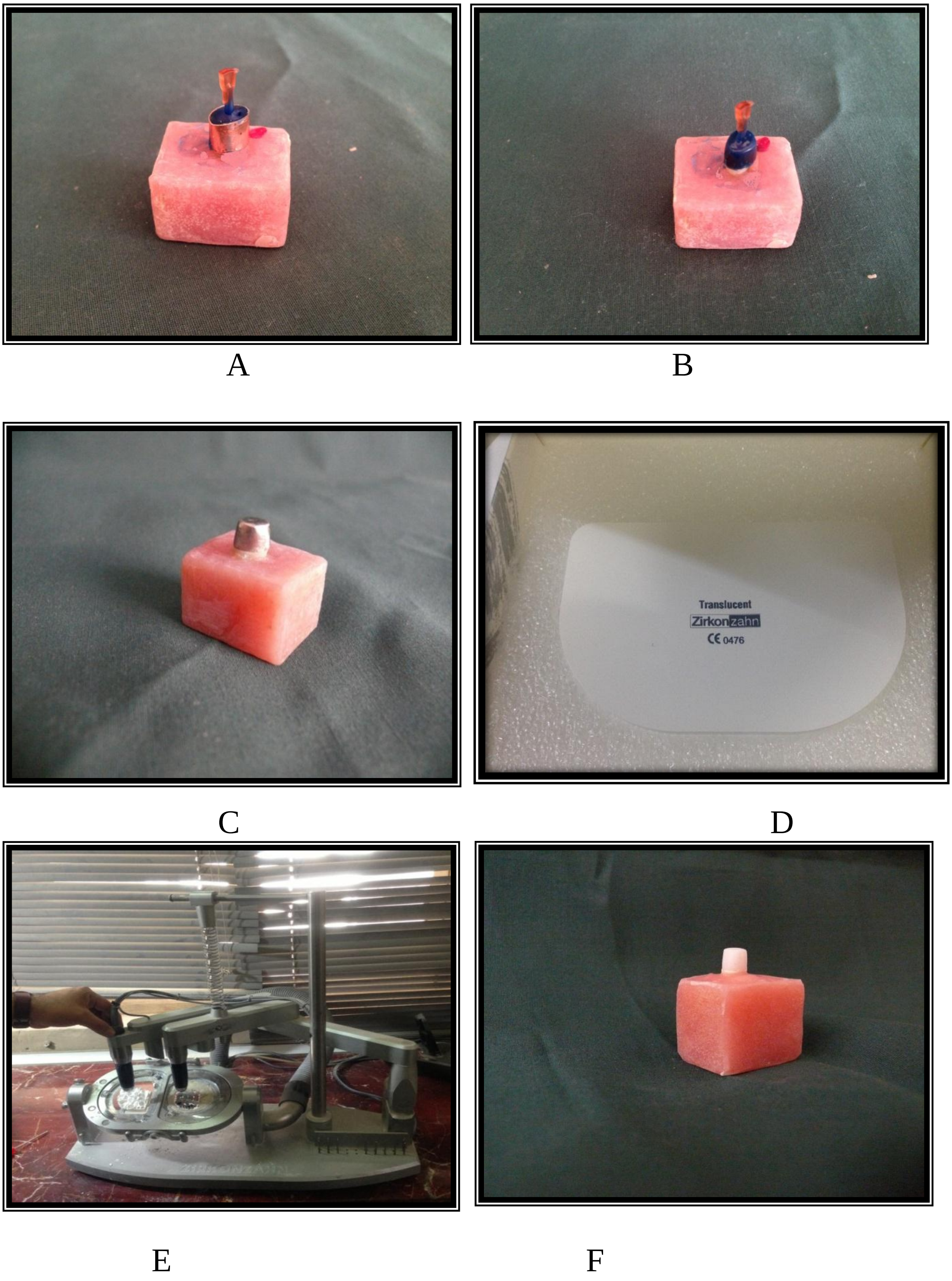
Wax pattern was constructed for each specimen in group 4 by direct waxing technique using type II blue inlay wax. In order to build a standard wax pattern(for core) for all specimens, a copper ring of 6mm diameter and 7 mm length, was adjusted to fit over the root in such a way so that it permits a core 5mm in height to be constructed. The wax patterns were invested, casted in to nickel-chromium alloy and de-invested. The metal cast posts and cores were cleaned, finished and tried on their alternative teeth samples. Table (2-2) shows the composition and physical properties of nickel-chromium casting alloy (manufacturer specification).

The Zirkon Zahn unite used for construction of zirconium posts and cores, consists of a milling unite and scanning unite(milling unite mills zirconium oxide blanks into desired restorations and the scanning unite is capable of scanning cast patterns relaying the information to the milling arm which mills the zirconium blanks into the required dimensions).

The metal posts were then seated in its position in the holding plate of the copy milling machine, the holding plate and zirconium block were attached to the clamping table of the copy milling machine. The zirconium oxide copy was formed simultaneously on the milling side **(Figure 2-5 A, B, C, D, E and F).** The milled structure is 30% larger than the wax pattern as zirconia undergoes shrinkage of 30% after sintering of milled restorations (**Dayalan *etal.*, 2010).**

Table (2-2): The composition and physical properties of nickel-chromium casting alloy (manufacturer specification)

Composition	Physical properties			
Ni ~58%	Milting point	Tensile strength	Elongation	Hardness
Cr 27.38%				
Mo 12.90%				
Si 1.63%	1310-1330˚C	342 MPa	5%	~285 HV 10
Mn 0.001%				
C 0.02%				



Figurer 2-5: Fabrication of zirconium post, **A** and **B.** Construction of wax pattern with copper ring, **C.** Metal cast post and core, **D.** Copy milling machine, **E.** Zirconium block, **F.** Zircon post and core.

2.2.7 Posts cementation

Post spaces for all specimens were cleaned with (5 ml) distilled water using disposable syringe and dried with absorbent paper tips. Panavia F 2.0 dual-cure dental adhesive system was used as cementing medium according to manufacturer instructions **(Figure2-6)**. Before cementation posts, were verified for their complete seating (10mm).

A surveyor was used during cementation procedure in order to standardized seating of the posts. For groups 1, 2 and 3 the coronal part of the posts was attached through the fixing screw of the surveyor. While for group 4 the post and core (single unit) was attached to the horizontal arm of the surveyor by using sticky wax so that it will be parallel to the long axis of the specimen using sticky wax.

Figure 2-6: Panavia F2.0 resin cement used in this study

2.2.7.1 Application of acid echant:

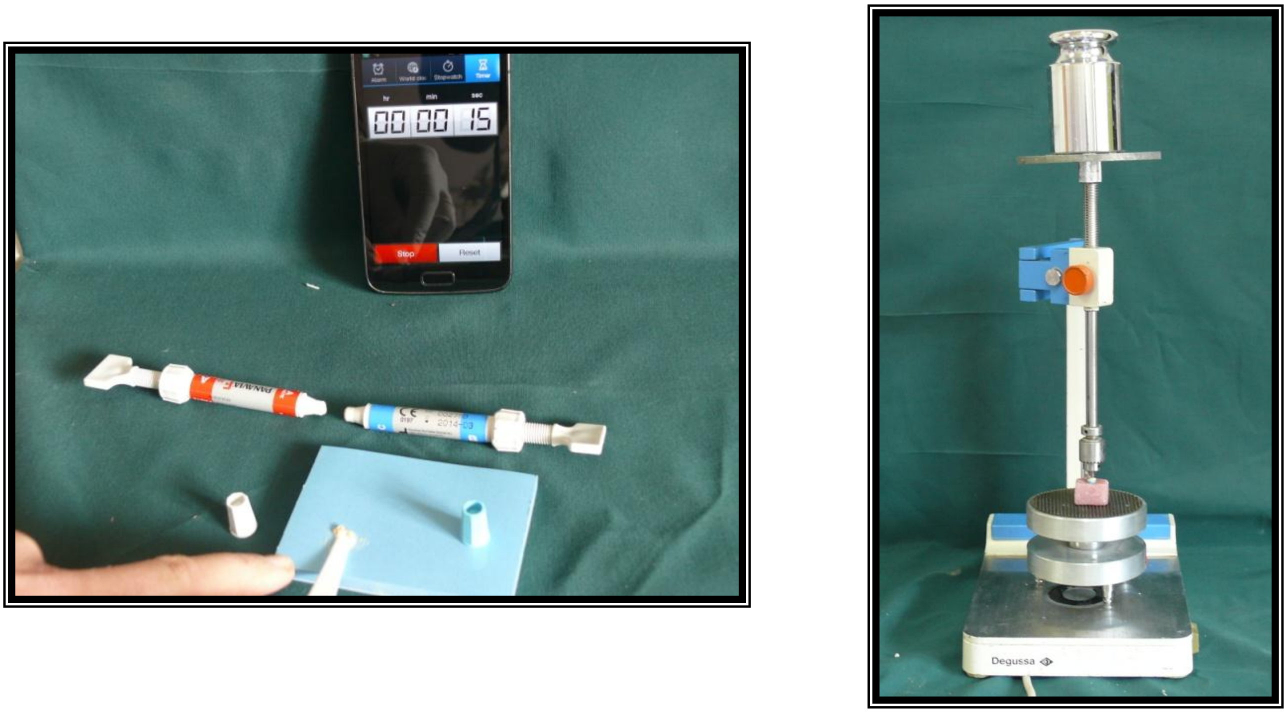
37% wt phosphoric acid gel was applied and left for 10 seconds. The acid was then washed with 5ml distilled water with disposable syring and dried with paper points. **(Pedreira *et al*, 2009)**

2.2.7.2 Application of ED PRIMER bonding agent:

One drop of ED PRIMER II liquid A and B (as a bonding agent) was dispensed into a well of the mixing dish and mixed immediately before application. The ED PRIMERII was then applied to the canal surfaces using disposable brush tip and left for thirty (30 seconds) Excess material was removed with absorbent paper points, air jet for ten (10 seconds) was then applied to the area.

2.2.7.3 Application of the resin cements

Equal amount of base and catalyst were mixed according to manufacture instruction (mixing time 20 seconds), while the post attached to the horizontal arm of the surveyor, the mixture was applied to the post surfaces. The post was then seated in to its respective canal, using 2 kg constant load. Excessive material was removed by a micro brush within 40 seconds, and then light cured applied for 20 seconds. **(Pedreira *et al.*, 2009; Abdulfatah, 2012) (Figure 2-7: A and B)**



A B

Figure 2- 7 (A, B): Application of the resin cements, **A.** Mixing the cement (base and catalyst), **B.** Post attached to surveyor and application of loads.

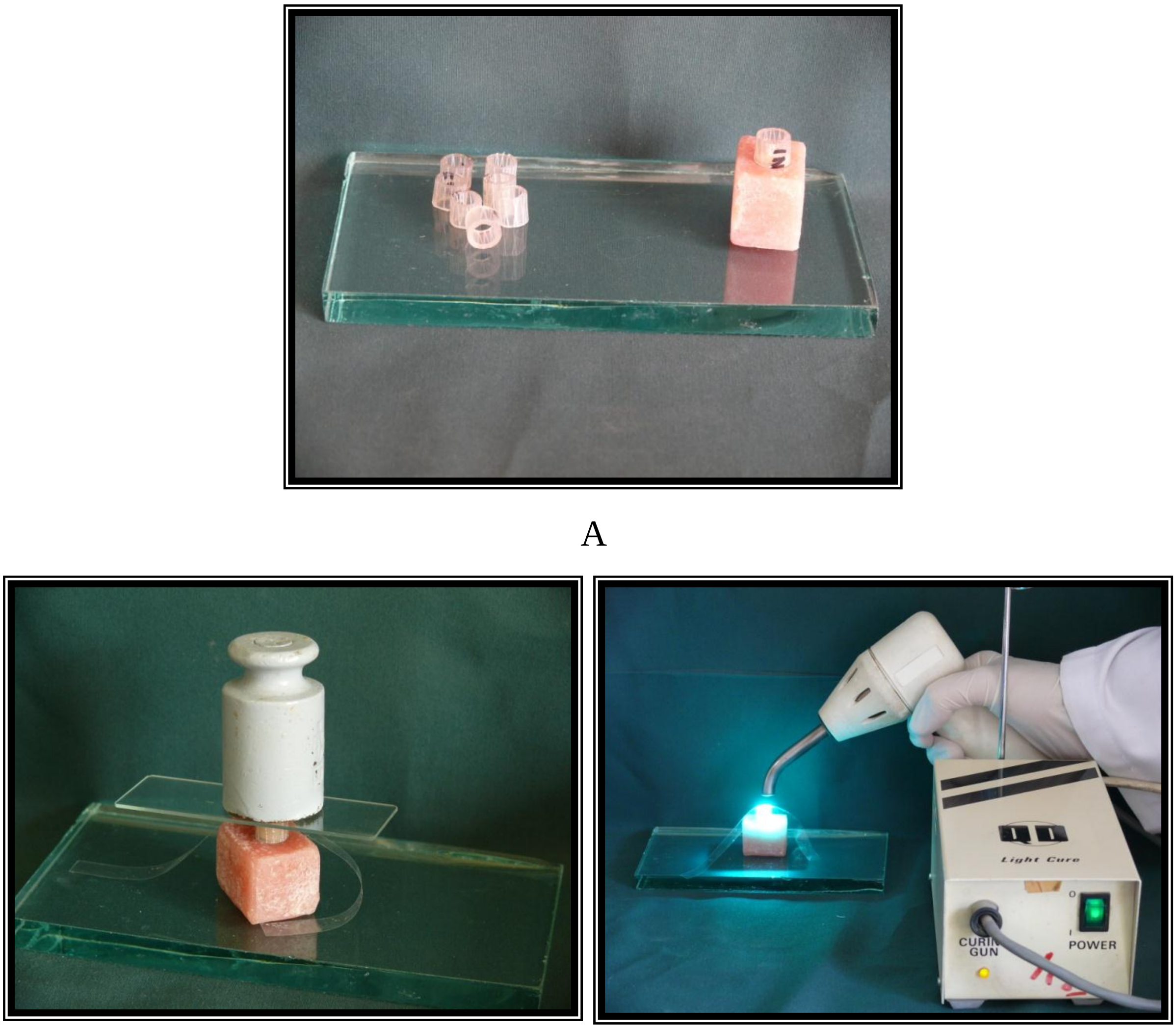
2.2.8 Core builds up procedure

The remaining coronal portion of the posts (3mm) and the surrounding tooth structure (2mm coronal to the CEJ) were cleaned from debris using air water spray using triple syringe. A phosphoric acid 37% were applied to the area for 15 seconds, the acid was cleaned with air water triple syringe free of oil. The bonding resin was the applied using micro-brush and cured for 20 seconds.

A plastic cylindrical matrix of 7mm height and 6mm diameter used as a mold to build a standard core . These were adjusted to fit on the top of the roots so the height of the core will be 5mm. This matrix also permit packing of composite Filtek P60 **(Table 2-6)** in one increment (bulk technique). After packing of composite in plastic matrix celluloid strip was placed over one mm thickness glass slide was pressed under a load of 200gm for 1 minute. The excess material was then removed. **(Ciccone- Nogueria *et al.*, 2007)**. The composite was light cured using a halogen light cure device for 40 second. The light beam was directed through the upper side of the mold. After curing and removing the cylinder plastic matrix from the specimens , a further irradiation of 60 seconds of composite was carried out to all sides in order to guarantee complete polymerization of composite resin core build-up, **(Wrbas *et al.*, 2007)** as shown in **(Figures 2-8 A, B and C)**

Table (2-3): Manufactur's scientific documentation for composite restorative material used in this study.

Product	Filtek P60
Manufacturer	3M Dental products (USA)
Composite type	Packable composite
Method of action	Visible light cure
Resin components	Bis-GMA, UDMA and Bis-EMA
Filler type	Zirconia/ silica
Filler particle size (Range)	0.01-3.5µm
Filler loading (Wt/ vol.)	83%/61%
Shade	A3



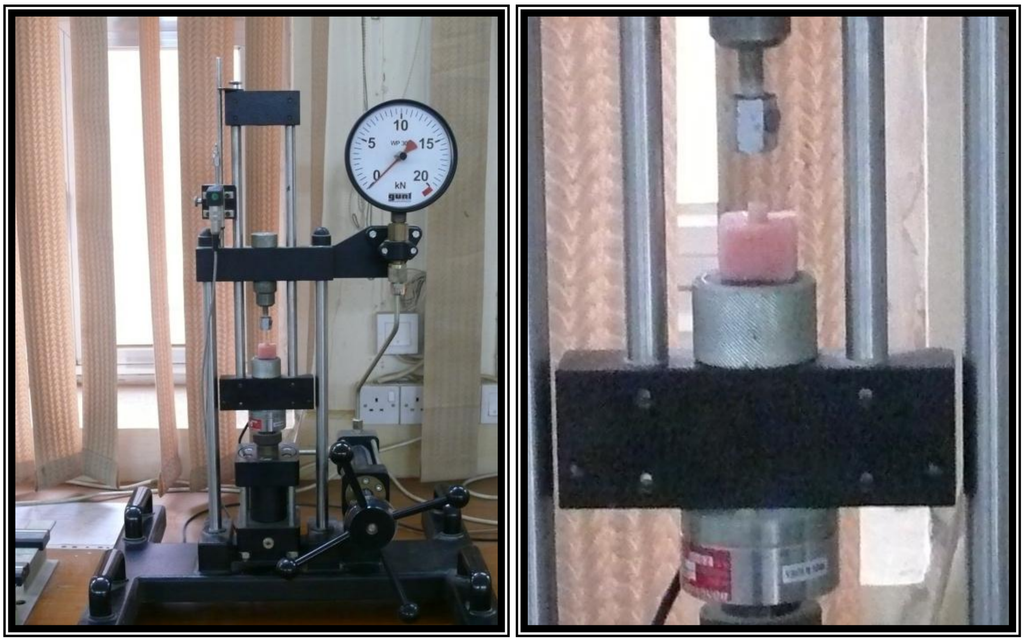
A

B C

Figure 2-8 (A, B and C): Core builds up procedure, **A.** plastic matrix placed over the specimen, **B.** 200 gm load application, **C.** light curing.

2.2.9 Testing procedure

The samples were placed on the flat table of the universal materials tester (WP 300) (Zwick, gunt, Humburg, Germany). A continuously increased compressive load was applied perpendicular on the flat occlusal surface of the core until failure. The load was measured in Newton (N). The mean failure load for each group was calculated. The specimens were inspected for the failure mode to determine the root level at which the fracture occurred **(Bittner *et al.*, 2010)**. **(Figurer 2-9 A and B)**



A B

Figure 2-9 (A and B): Testing procedure

2.2.10 Statistical analysis

The statistical method that is used in this study to analyze the results includes:

A- Descriptive statistics

1- Arithmetic mean.
2- Standard deviation.
3- Graphical representation by bar charts.

B- Inferential statistics

These include:

1- One- way analysis of variance (ANOVA) was used to see if there is a statistically significant difference among all groups. Level of statistical significance will be set at $p \leq 0.05$.
2- Student's t- test was used to find any statistically significant differences between each two groups.

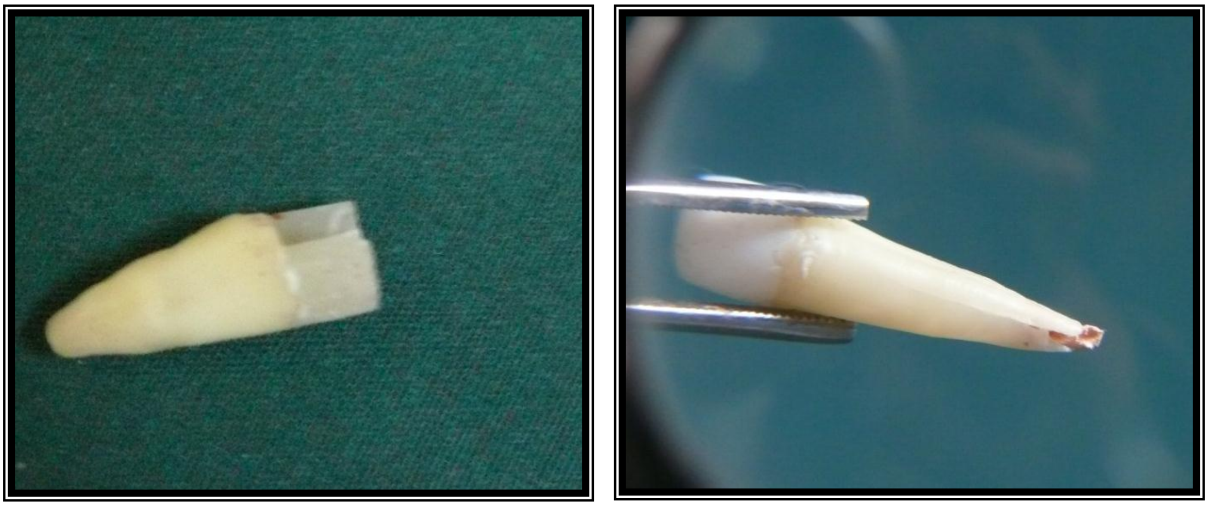
2.2.11 Failure location

After completion of testing procedures, all the specimens were examined using a magnifying lens to determine the root fracture patterns and locations **(Figure 2-10 A and B)**.

The fracture patterns were divided into two groups **(Mortazavi *et al*., 2012)**:

1) Coronal fracture (desirable fracture)

2) Root fracture (undesirable fracture).



A **B**

Figure (2-10 A and B): Failure location. **A.** desirable fracture, **B.** undesirable fracture

Chapter Three
Results

Results

3.1 Descriptive statistics

Measurements of maximum load values in N (Newtons) required to cause failure of each specimen in all groups are listed in the appendix.

The means, standard deviations (S.D) of the fracture strength values with minimum and maximum values of each group are shown in **(Table 3-1).**

Table 3-1: Descriptive statistics of fracture strength in N for all five groups.

Groups	Mean	S.D.	Min.	Max.
1	1679.50	157.78	1420	1945
2	1820.63	135.95	1595	1980
3	1131.00	393.28	645	1512
4	2711.25	553.22	1910	3765
5	1710.50	458.12	1160	2453

This table shows that the highest mean fracture strength value was recorded group 4 (zirconium posts and cores) (2711.25), while the lowest mean of fracture strength was observed in group 3 (prefabricated zirconium ceramic posts and composite core) (1131.0). **(Figure 3-1)**

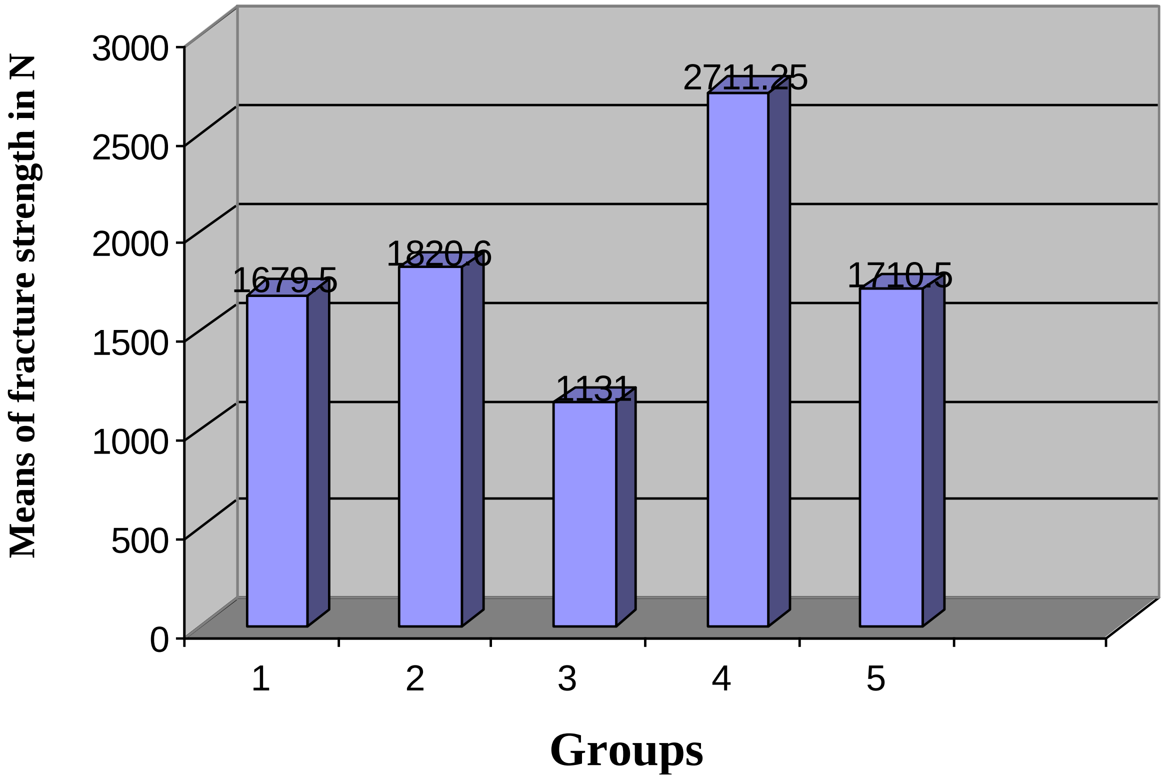


Figure 3-1: The bar charts showing means of fracture strength in N for all groups.

3.2 Inferential statistics

3.2.1 One- way analysis of variance (ANOVA)

To see whether there is a difference among all groups, One- way analysis of variance (ANOVA) was applied **(Table 3-2).**

Table 3-2: One- way analysis of variance (ANOVA).

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.403	4	2.601	18.213	0.000 (HS)
Within Groups	4.998	35	0.143		
Total	15.400	39			

(HS): High significant $P<0.01$.

This table shows that there was high significant difference among groups.

3.2.2 Student's t-test

Further analysis of the result using student's t- test was applied in order to localize the source of significance of the difference between groups **(Table 3-3)**.

Table 3-3: Student t-test between groups.

	Mean difference	d.f	T-test	Significance
Group 1&2	-141.13	14	-1.92	0.08 (NS)
Group 1&3	548.5	14	3.66	0.003 (S)
Group 1&4	-1031.75	14	-5.07	0.000 (HS)
Group 1&5	-31.00	14	-0.18	0.86 (NS)
Group 2&3	689.63	14	4.69	0.000(HS)
Group 2&4	-890.63	14	-4.42	0.001 (HS)
Group 2&5	110.13	14	0.65	0.53 (NS)
Group 3&4	-1580.25	14	-6.59	0.000(HS)
Group 3&5	-579.5	14	-2.72	0.02 (S)
Group 4&5	1000.75	14	3.94	0.001(HS)

NS: No significant difference $P>0.05$.

S: Significant difference $P\leq0.05$.

HS: High significant difference $P<0.01$.

The results of T-test between the Group that were used in the study can be summarized as following

Group 1: Shows non significant difference with group2 and group 5and significant difference with group 3.While high significant difference with group 4.

Group2: Shows non significant difference with group5 and shows high significance with group3 and group 4.

Group3: Shows significance difference with group5 and shows high significance difference with group4.

Group4: Shows high significance difference with group5.

3.2.3 Failure location

The fracture patterns location and percentages, according to the following criteria. Are shown in table **(Table 3-4)**

1) Coronal fracture (desirable fracture)

2) Root fracture (not desirable fracture).

Table (3-4): Mode of failure

	Coronal fracture (desirable fracture)	Root fracture (not desirable fracture)
Group 1	(7)	(1)
Group 2	(8)	0
Group 3	(8)	0
Group 4	(1)	(7)
Group 5	(8)	0

This table shows that:

Group 1: Seven teeth were fractured at the coronal part (composite core) and one tooth was with catastrophic failure (root fracture at the apical part).

Group 2 and group 3: all the fractures were in the coronal part (composite cores). No root failures.

Group 4: one tooth was fractured at the coronal part. The rest seven teeth were fractured at the apical part.

Group 5: all teeth were fractured at the coronal parts.

Chapter Four
Discussion

Discussion

Functional, structural and esthetic rehabilitation of pulpless teeth are critically important to ensure successful outcome **(Alessandro *et al,* 2009)**. The aim of the present study is to evaluate the fracture strength of endodontically treated teeth which are restored with zirconium oxide by (copy milling).

4.1 Discussion of methodology

4.1.1 Sample selection

Since prefabricated posts were used in this study, human lower second premolars have been used because they have round to slightly oval shape canals **(Nu'man, 2001)**

4.1.2 Sample standardization

Although, careful selection of the sample was performed (comparable characteristics) to standardize the experimental procedures, a range of failure load values with in each group could not be avoided. The variability of physical properties of human teeth may be a reason for such data range. Dentin is a heterogeneous tissue, its structure; degree of calcification and degree of cellularity vary from one tooth to another. **(Nu'man, 2001)**

The storage of the extracted teeth, are preserved in 0.1 thymol in distilled water after removing dental calculus and the periodontal tissue, thymol is part of a naturally occurring class of compounds known as biocides, if formaldehyde fixative was used as the preservative for extracted teeth, these chemicals would cause degeneration of root canal-wall dentin **(Francisco, 2008).**

4.1.3 Periodontal ligament simulation

In some studies that evaluated the fracture strength of endodontically treated teeth restored with a post and core, the tooth specimens were embedded in acrylic resin. The resilient effect of the periodontal tissue was disregarded by embedding these specimens without periodontal simulation, which would prevent any dislodgement of the specimens from acrylic resin during testing **(Martínez-Insua *et al.,* 1998; Nu'man, 2001; Ng *et al.,* 2006; Bittner *et al.,* 2010)**.

In the present study, thin layers of condensation silicon are used to simulate the periodontal ligament, provide a cushioning effect resembling the clinical conditions, and avoid the external reinforcement of the root structure by the rigid acrylic resin. **(Sirimai, 1999; Adanir and Belli, 2008; Torabi and Fattahi, 2009; Kumagae *et al.,* 2012)**

4.1.4 Post space preparation and length

Post space was determined at constant length of 10 mm **(Bittner *et al.,* 2010)**.To maintain an adequate apical seal, a minimum 4 to 5 mm of gutta-percha is recommended **(Mattison *et al.,*1984).** The minimum post length should be as long as the clinical crown, so the minimum length of 10 mm was selected as post length to achieve the standard condition **(Stockton, 1999; McLean, 1998).** Using short posts has high risk and higher failure rate .The effect of load on shorter post is much greater because of the leverage effect due to the transversal occlusal forces (**Khamverdi and Kasraei, 2007)**.

4.1.5 Compression test

Attempts were made to simulate the force of the oral cavity on the roots on mandibular first premolars, while the teeth were oriented vertically in the alveolar bone (**Torabi and Fattahi, 2009)**. Occlusal surfaces of cores were prepared uniformly so that the forces can be applied at the long axis and at the middle of the teeth. Similar studies compared the different post systems (**Cormier *et al.,* 2001; Stricker *et al.,* 2006)** by using mandibular premolars and loaded them at 90 degrees at the long axis of the teeth.

4.2 Fracture strength

4.2.1 Group 1(Carbon fiber posts) and group 2 (Glass fiber posts)

The results of the present study showed that teeth in group 1 have lower mean fracture strength values compared with group 2, but statistically the difference was not significant. This finding is in consistence with that obtained by **(Dietschi *et al.,* 1996; Mannocci *et al.,* 1999; Barjau *et al.,* 2006).** This is may be due to that the carbon fibers have elastic modulus most similar to dentine, which means the system had more favorable performance with lower failure rate, and it has been experimentally observed that glass fiber post have better biomechanical performance with greater fracture load.

In comparison between Fiber posts and zirconia posts, the fiber posts are more elastic, so it is rational that the fracture strength of fiber treated groups be lower than Zirconia treated ones. These findings are consistent with **Rosentritt *et al.*in 2000** and in contrary to **Mortazavi *et al.*in 2012**

The mean of fracture strength of group 1 was lower than group 5 (control group), but statically the difference was not significant. The result of the present study agrees with **Anna-Maria *et al.*in 2011** who found that intact teeth without posts showed higher mean of fracture load.

The mean fracture strength of group 2 was higher than group 5, but statically the difference was not significant. These results agree with **Torabi and Fattahi in 2009.** These results seem to be more logical as bonding ability of glass fiber posts enables them to reinforce the root, although reinforcement is not enough to support root from fracture.

Fiber post has characteristics simulating natural dentinal structure than cast metal post and it acts as a shock-absorber, dissipating much stresses on the finished restoration with small fraction forces to dentinal walls and thus demonstrating restorable fractures (composite cores failures). These findings are consistent with **Akkayan and Gülmez in 2002 and Maccari *et al.*in 2003.**

4.2.2 Group 3 (Zirconium ceramic prefabricated post):

This group showed the lowest fracture strength mean values than other groups. Statistically the difference was significant. This means that, zirconium ceramic posts failed with least amount of force compared with other groups. These results agree with other studies **(Bakke *et al.,* 1990; Rosentritt *et al.,* 2000; Bittner, 2010).**

One possible case of this low fracture strength mean value in prefabricated zirconium posts could be the lack of homogeneous chemical adhesion between prefabricated zirconium posts and the resin cement used in this study, unlike the other types of posts (Carbone fiber posts G1 and Glass fiber posts G2) which showed greater fracture strength mean values. **(Asmussen *et al.,* 1999; Rosentritt *et al.,* 2000; Ferrari *et al.,* 2000)**

Another possible cause for the low fracture strength mean values in this group may be related to the coronal end design of prefabricated zirconium posts used in this study differ from the other of prefabricated posts (G1 and G2) (appendix). This difference in the coronal shape of the zirconium posts could be the cause of this low strength since it has many sharp angles (unlike other posts) which act as stress concentration areas under the continuous compression loading, causing crack propagation and fracture of surrounding core material.

4.2.3 Group 4 (Zirconium-oxide single unite post and core)

This group showed the higher mean failure load values than other groups with high significant difference. This finding agrees with other study **(Bittner *et al.*, 2010).** In this group, both posts and cores are in single unit (one material) so the load will be directed to the weakest part which is the root.

The failure location in this group root demonstrated fracture at the apical part which can be explained by the fact that when using very rigid material in post system (with high modulus of elasticity) would not show flow the elastic deformation but will create localized stress peek inside the root, eventually leading to system failure (root fracture). This is in agreement with **Hegde *et al.* (2012).**

4.2.4 Group 5 (Control group)

Teeth without preparation served as control group to assess the influence of post and core foundation on over all restored tooth.

4.3 Failure location

When the fracture occurs, the pattern of fracture is important as it acts as guidance for the restorability of fractured teeth. In the present study, the fiber post treated teeth showed significantly more desirable fracture patterns compared to those restored with zircon posts. This result agree with **Mortazavi *et al.*in 2012.**

This result suggests that zirconium posts and cores can be used when esthetic demands are important and the anatomy of the root canal and/or the extensive loss of coronal tooth portion require the use of custom post. Single unit zirconium post and core may be indicated when ceramic crown is used and the definitive thickness of the crown is less than 1.6 mm as determined by **Nakamura *et al.* in 2002**

Test conditions of this in vitro investigation differ from intra oral conditions. The testing machine applied continuous force from a single direction to flat occlusal surface of the restored tooth. However, masticatory forces are not unidirectional and are applied repeatedly over larger surface area. Furthermore, tensile, torsional and lateral shearing forces are important components of mastication and are not reproduced by the universal materials tester (WP 300) machine at the same time. Although the forces used in this study did not directly simulate the intra oral dislodging forces, an estimation of overall strength of post and core system could be made. In some studies, full crown was used on posts and cores, but their results in relation to different post and core systems were still comparable to the present study **(Torabi and Fattahi, 2009, Bittner *et al.*, 2010).**

Chapter Five
Conclusions And Suggestions

Conclusions and Suggestions

5.1 Conclusions

Within the limitations of this in vitro study, the following conclusions were drawn:

1. Fracture strength and failure location in single rooted teeth varied according to the type of post used.
2. Teeth restored with zirconia posts and cores had fracture strength higher than teeth restored with carbon, glass or zirconium ceramic prefabricate fiber posts, but most fractures were unfavorable.
3. All of the systems evaluated present adequate and satisfactory means maximum loads values for restoration of teeth except prefabricated zirconium posts failed under small loads but the fracture mode was favorable.

5.2 Suggestions

1. Further Study evaluates different scanning software to improve the fit, as well as cyclic loading prior to evaluating the 1-piece milled zirconia post and core.
2. Evaluation of fracture strength of teeth with posts and cores systems covered with crowns fabricated by CAD/CAM systems.
3. Study fructure strength of teeth with zirconium posts and cores system with different types of crowns.
4. Study fracture strength of teeth with other posts systems (metal posts).

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Appendix

Appendix I: Group 1Carbonat prefabricated fiber posts.

Tooth no.	Max load KN	Deflection mm
1	1.945	0.75
2	1.673	0.6
3	1.733	0.55
4	1.615	0.3
5	1.770	0.5
6	1.735	0.4
7	1.545	0.6
8	1.420	0.7

Appendix II:Group 2 Glassix prefabricated fiber posts.

Tooth no.	Max. load KN	Deflection mm
1	1.945	0.6
2	1.870	0.45
3	1.690	0.25
4	1.870	0.3
5	1.720	0.25
6	1.895	0.5
7	1.595	0.5
8	1.980	0.7

Appendix III: Group 3 zirix prefabricated fiber posts.

Tooth no.	Max. load KN	Deflection mm
1	1.465	0.46
2	0.735	0.3
3	0.645	0.275
4	1.498	0.375
5	0.885	0.475
6	0.810	0.25
7	1.498	0.35
8	1.512	0.375

Appendix IV: Group 4 Manual milling.

Tooth no.	Max. load KN	Deflection mm
1	1.910	0.125
2	3.765	0.5
3	2.155	0.375
4	2.855	0.75
5	2.730	0.5
6	2.935	0.75
7	2.615	0.5
8	2.725	0.625

Appendix V: Group 5 Control group

Tooth no.	Max. load KN	Deflection mm
1	2.453	0.625
2	1.525	0.375
3	1.380	0.25
4	1.635	0.375
5	1.431	0.4
6	2.330	0.525
7	1.770	0.65
8	1.160	0.275

Appendix VI: The composition of Panavia F2.0 dual cures resin cement(manufacturer specification).

Product Name	Composition	Company
1) Panavia F 2.0 Dual cure dental adhesive system Panavia F 2.0 paste (paste A/ paste B)		Kurary Noritake dental Inc. 1621Sakazu, kurashiki, Okayama 710-0801, Japan
• Paste A	• 10-methacryloyloxydecyl dihydrogen phosphate(MDP) • Hydrophobic aromatic dimethacrylate. • Hydrophobic aliphatic dimethacrylate . • Hydrophilic aliphatic dimethacrylate . • Silanated silica filler . • Silanated colloidal silica. • dl-camphorquinone. • Catalysts. • Initiators	
• Paste B	• Hydrophobic aromatic dimethacrylate. • Hydrophobic aliphatic Dimethacrylate • Hydrophilic aliphatic dimethacrylate	

	• Silanated barium glass filler • Surface treated sodium fluoride • Catalysts • Accelerators • Pigments The total amounts of inorganic filler is approximately 59 vol%. the particle size of inorganic fillers ranges from 0.04µm to 19 µm.	
2) ED PRIMER II Principle ingredients (1) liquid A	• 2- hydroxyl methacrylate (HEMA) • 10-methacryloyloxydecyl dihydrogen phosphate(MDP) • Water • N-methacryloyl-5-aminosalicylic acid[5-NMSA] • Accelerators	
(2) liquid B	• N-methacryloyl-5-aminosalicylic acid [5-NMSA] • Water • Catalysts • Accelerators	
Apexit Plus	• Calcium salts (hydroxide, oxide, phosphate) • Hydrogenised colophony • Disalicylate • Bismuth salts (oxide, carbonate) • Highly dispersed silicon dioxide (silanized) • Alkyl ester of phosphoric acid	Ivoclarvivadent AG, FL-9494 SchaanLiechtenstein

Filtek™ P60 Posterior Restorative	• Zirconia/ silica • Inorganic filler loading is 61% by volume (with out silane treatment) with particle size 0.01 to 3.5µm. • BIS-GMA • UDMA • BIS-EMA	3M ESPE D-41453 Neuss-Germany

Table: Manufactures scientific documentation for carbon fiber posts used in this study

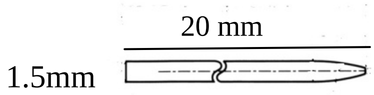
Brand product	**Carbonit fiber posts**
Product description	Carbon- fiber composite root canal posts.
composition	Carbon fiber arrangement: braided plait Braid: 12 bundles of 3K Rowing (30,000 filaments) Diameter . of filament: 6 microns Carbon fiber type: HTA / HTS Matrix: Epoxy resin with approx. 65% carbon fiber content
Size	Nr-4Ø 1.50
Shape	
Manufactures	Nordin, Switzerland.

Table: Manufactures scientific documentation for glass fiber posts used in this study

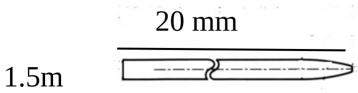
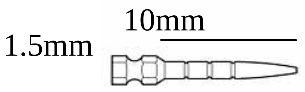
Brand product	**Glassix fiber posts**
Product description	glass- fiber composite root canal posts
Composition	Glass fiber arrangement: braided plait – Braid: 12 Roving 136tex – ø of filament: 6 my. Glass fiber type: ahlstrom R-338 – Matrix: Epoxy resin with apx. 65 % glass fiber content. Intl. PATENTS pending
Size	Nr-4Ø 1.50
Shape	
Manufactures	Nordin, Switzerland.

Table: Manufactures scientific documentation for zirconium dioxide ceramic post systems used in this study

Brand product	**zirix ceramic posts**
Product description	Zirix is a ceramic post system in Zirconium dioxide
Composition	Atomic composition: ZiO_2 + 3% Y_2O_3 Crystalline structure: Cubic-tetragonal monoclinic Grain size (microns): maxi 0.50 Density (g/cm3): 6.07 Water absorption(%): 0
Size	Nr-4Ø 1.50
Shape	
Manufactures	Nordin, Switzerland.

الخلاصة

اجريت هذه الدراسة المختبرية لتقييم ومقارنة مقاومة الانكسار للأسنان المعالجة بحشوات الجذور والمعوضة بالاوتاد الزركونيوم باستخدام ماكنة استنساخ ؛الاوتاد الصناعية الجاهزة من ألياف الكربون ؛الألياف الزجاجية والخزفية الزركونيوم المشاركات. العينة المختارة في هذه الدراسة تكونت من اربعين سنا بشريا من الضواحك السفلى الثانية السليمة والخالية من التسوس. تم تقسيم العينات إلى خمس مجموعات كل واحد منهم تحتوي على 8 عينات (n= 8):

Group1: تكونت من اسنان معالجة بحشوات الجذور و معوضة بالأوتاد الجاهزة من الالياف الكاربون؛
Group2: تكونت من اسنان معالجة بحشوات الجذور و معوضة بالأوتاد الجاهزة من الألياف الزجاجية ؛
Group3: تكونت من اسنان معالجة بحشوات الجذور و معوضة بالأوتاد الجاهزة من الخزف الزركونيوم ؛
Group4: تكونت من اسنان معالجة بحشوات الجذور و معوضة بالأوتاد الزركونيوم باستخدام ماكنة استنساخ ؛
Group5: تكونت من اسنان سليمة.

تم ازالة التيجان للمجموعات 1 و 2 و 3 و 4 أفقيا باستخدام (diamond disk bur) في مستوى مفترق الأسمنت و المينا. تم معالجة بحشوات الجذور ،تم تحضير فراغ الوتد بعمق 10ملم لتلقي الاوتاد . ووضعت جميع العينات في قوالب خاصه.

وقد استخدم Panavia F 2،0 اسمنت الراتنج مزدوج البلمرة ، 2 كجم الحمولة المطبقة أثناء اللصق. تم استخدام قالب أسطواني مصنوع من البلاستك لبناء اللب بمادة الراتنج (P60 Filtek) .بعد اكمال العمل لكافة العينات تمت عملية الخزن في محلول ملحي حتى وقت الاختبار. بعد ذلك تم تعريض العينات الى اثقال ضاغطه كاسرة موازية للمحور الطولي بواسطة جهاز (WP 300) حتى تم الفشل.

النتائج التي تم الحصول عليها حللت احصائيا باستخدام تحليل التباين (ANOVA) واختبار (student t-test).

أظهرت النتائج أن الاسنان معالجة بحشوات الجذور و معوضة بالأوتاد الزركونيوم باستخدام ماكنة استنساخ اعطت أعلى مقاومة الانكسار ثم تلتها الاسنان المعوضة بالأوتاد الجاهزة من الألياف الزجاجية؛الاسنان معوضة بالأوتاد الجاهزة من الالياف الكاربون ؛ الاسنان معوضة بالأوتاد الجاهزة من الخزف الزركونيوم .

بينما لم يتم ملاحظة اي فرق معنوي في مقاومة الانكسار للاسنان المعوضة بالأوتاد الجاهزة من الالياف الكاربون والاسنان المعوضة بالأوتاد الجاهزة من الألياف الزجاجية والاسنان السليمة.

تقييم قوة الكسر للأسنان معالجة لبيا المستعادة بواسطةالاوتاد والنوى المنحوت من زركونيا مع آخر مختلف والنظم الأساسية

(دراسة مقارنة في المختبر)

رسالة مقدمة الى مجلس كلية طب الاسنان/جامعة بغداد كجزء من متطلبات نيل درجة الماجستير في معالجة الاسنان

من قبل
هدى مساعد لفته
بكلوريوس طب و جراحة الفم و الاسنان

بأشراف
الاستاذ الدكتور عادل فرحان ابراهيم
ماجستير معالجة اسنان

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