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The Effect of Root Canal Cleansing on the Retention of Glass Fiber-reinforced Posts

Faisal Dhaifallah Al-Qarni

LOMA LINDA UNIVERSITY
School of Dentistry
in conjunction with the
Faculty of Graduate Studies

The Effect of Root Canal Cleansing on The Retention of Glass Fiber-reinforced Posts

by

Faisal Dhaifallah Al-Qarni

A Thesis submitted in partial satisfaction of
the requirements for the degree
Master of Science in Prosthodontics

December 2014

Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

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DEDICATION

الحمد لله اولاً وآخراً...
اللهم انفعني بما علمتني، وعلمني ما ينفعني، وزدني علماً

إهداء
إلى أمي الغالية
إلى أبي الغالي
وزوجتي العزيزة

This project is dedicated to my parents who have been my constant source of inspiration. To my wife for being there during the hard times.

Without their love and support this project would not have been made possible.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my committee members for the useful comments, remarks and engagement through the learning process of this master thesis; Dr. Nadim Baba for introducing me to the topic as well for the guidance on the way, Dr. Mathew Kattadiyil and Dr. Robert Handysides for their help and support throughout the study. Also, I like to thank Dr. Khalid Bahjri for his help with the statistical analysis, Dr. Charles Goodacre for reviewing my manuscript, and Dr. Yiming Li and Dr. Serkan Inceoglu for their help with the universal testing machine. Thanks to every person who has helped me to complete this project.

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ABBREVIATIONS

SEM	Scanning Electron Microscopy
NaOCl	Sodium hypochlorite
EDTA	Ethylene-diamine-tetracetic acid
MTAD	Mixture of Tetracycline, an Acid and a Detergent
NaCl	Sodium Chloride (Saline)
ITR	Intelligent Torque Reduction
LED	Light Emitting Diode

ABSTRACT OF THE DISSERTATION

The Effect of Root Canal Cleansing on The Retention of Glass Fiber-reinforced Posts

by

Faisal Dhaifallah Al-Qarni

Master of Science, Graduate Program in Prosthodontics
Loma Linda University, December 2014
Dr. Mathew Kattadiyil, Chairperson

Esthetic glass fiber-reinforced posts are being used more often. The most commonly reported complication associated with these posts is debonding. Dentine conditioning with solutions such as EDTA or MTAD results in removal of smear layer and might improve the retention of posts to root canal dentin. Therefore, the purpose of this study was to investigate the effect of cleansing the post space with MTAD or EDTA on the bond strength of glass fiber-reinforced posts, when cemented with self-adhesive resin cement.

Forty-five (n=15) extracted human premolar teeth were sectioned at the cemento-enamel junction to obtain root length of fifteen millimeters. Endodontic instrumentation and obturation was performed. Post space was prepared to a length of ten millimeters. Post spaces were irrigated using one of two solutions: MTAD for five minutes and 17% EDTA for one minute. No irrigation was used in the control group. After irrigation, excess moisture was removed and posts were cemented with RelyX Unicem. Retention of posts was evaluated with pull-out test using universal testing machine (0.5 mm/min) to pull the posts from the teeth. Maximum load-to-failure was recorded. One-way analysis

of variance was used for the statistical analysis (α=.05). Dislodged posts were examined at 8X magnification to determine the mode of failure.

Mean bond strength (N) for the MTAD, EDTA and control group were 146.7, 142.8 and 151.4 respectively. The difference among the groups was not statistically significant (α>.05). Most dislodged posts exhibited mixed mode of failure.

Based on these observations, it was concluded that the use of either EDTA or MTAD as a final rinse prior to post cementation does not influence the retention of glass fiber-reinforced posts, when cemented with self-adhesive resin cement.

CHAPTER ONE

INTRODUCTION

Background

Restoration of endodontically treated teeth may be challenging, as there is no consensus on the ideal treatment. [1] It is well known that after endodontic treatment, teeth become more prone to fractures when compared to vital teeth, which could range from a simple coronal fracture to a catastrophic vertical root fracture. [2] Several factors are thought to contribute to the higher fracture rate such as the extensive loss of tooth structure, reductions in moisture content, flexibility, and decreased proprioception. Although the effect of the latter three factors have conflicting evidence, [3] the strength and the resistance to fractures of the tooth are directly related to the remaining bulk of tooth structure. [4]

The partial or complete removal of anatomic structures such as cusps, occlusal ridges and the roof of the pulp chamber cannot be avoided during endodontic treatment procedures, which can influence the tooth's ability to resist fractures. [5] Reeh et al. evaluated the tooth stiffness after the endodontic and restorative procedures, and showed that it can be reduced as much as 63% by the presence of a mesial-occlusal-distal (MOD) cavity preparation, while pulpal access alone, diminishes the tooth stiffness by only 5%. [6] Therefore during endodontic treatment, the preservation of tooth structure without compromising the endodontic access is desirable.

The amount of remaining tooth structure also dictates the type of definitive restoration to be fabricated. [1-3] Unlike pulpless anterior teeth, complete coronal coverage is commonly recommended for most pulpless posterior teeth, which would help protect the teeth from fracture and prevent the separation of cusps. [3, 7] Several investigations indicated that the coronal coverage of pulpless posterior teeth is associated with significantly higher rates of clinical success. [1-4] However, posterior teeth that have an intact occlusal surface, with the exception of conservative endodontic access, and on which occlusal overload is not anticipated, may be restored with a composite resin or amalgam restoration. [3, 7]

Restorative materials (amalgam, composite resin or glass ionomer) can be used to provide the core foundation for the crown to be fabricated. If the remaining tooth structure is insufficient to retain a core, the use of a post is indicated to provide adequate retention for the core foundation and subsequently for the crown. [1-3]

Posts can generally be categorized into two categories, based on their materials, metallic, and non-metallic. Metallic posts, cast and prefabricated, have been widely used in the past; however, they exhibit some drawbacks such as corrosion and toxicity from diffusion of metal ions. [8] The corrosion of metallic posts can be visible through translucent all-ceramic restorations, and may make the marginal gingiva appear dark. [9] In addition, rigid metallic posts have a high modulus of elasticity compared to dentin. Upon lateral loading, stresses are transferred internally to the less rigid dentin; these stresses concentrate towards the apical portion, increasing the potential of vertical root fractures and catastrophic failures. [10, 11]

Fiber-reinforced resin posts were introduced in France over 20 years ago. [11] In vitro studies have shown that these posts have high tensile strength, and a modulus of elasticity similar to that of dentin. [12, 13] Therefore, upon loading, fiber-reinforced posts are thought to flex, distributing stresses between the post and dentin and thereby reducing stress concentration. This is believed to contribute to the reduced incidence of root fractures as well as the more favorable pattern of fractures of fiber-reinforced posts, which is predominantly within the core or the post, when compared to metallic posts, where fractures are mostly within the root, and more frequently encountered. [11-13] Initially, fiber posts were reinforced with carbon, which were longitudinally arranged and embedded in a resin matrix. The matrix usually consists of epoxy resin that provides bulk and resists compressive stresses while the fibers provide tensile strength. The black carbon fiber posts were rapidly replaced by quartz or glass fibers, which exhibit translucency that improves optical properties, facilitating the fabrication of natural looking restorations. [11, 12] Also, when dual-polymerization cements are used, this translucency is thought to help transmit the polymerization light to deeper layers of the cement. However, it was demonstrated that the amount of light reaching the apical portion of the canal might not be sufficient to effectively cure the cement at that level. [14] Overall, the excellent biocompatibility, superior esthetic appearance and mechanical properties of glass fiber-reinforced posts have contributed to their wide use among clinicians. [11]

Despite their several advantages, nonmetallic prefabricated posts present some limitations. In vitro studies have shown that fiber posts demonstrate loss of flexural strength when subjected to cyclic loading and thermocycling, due to degradation of the resin matrix. Moreover, the flexure of the posts upon loading can possibly results in micro-movements, which in turn may lead to coronal leakage, caries and loss of the restoration. In addition, the drawback of any prefabricated post is the additional removal of sound tooth structure during post space preparation. [9,15]

Post loosening is the most frequent complication with post and core restorations.[11, 15, 16] Moreover, several investigations reported that most of these adhesive failures occurred at the resin cement-dentin interface.[17]

Bonding to Dentin in the Root Canal System

In addition to the difficult access to the deeper portion of the canal, and the number of dentinal tubules that decreases towards the apical portion of the tooth, resin bonding in the root canal system is challenging due to the unfavorable geometry of the canal.[9, 11] The configuration factor (C-factor) is the ratio of bonded to unbonded resin surfaces. The higher the number of bonded surfaces; the more stresses will be placed on the surface due to polymerization shrinkage, in the post space, the stresses may exceed the bond strength of the bonding agent.[9] Theoretically, any ratio above 3 is considered unfavorable for resin bonding, in the root canal system, the ratio may reach 200 because there is only minimal unbonded dentin, which makes gap formation inevitable.[15]

When dentin is prepared with hand or rotary instrument, a layer of shattered mineralized tissues forms. This layer is composed of debris of mineralized collagen matrix and is well known as the smear layer.[18] Eick et al were the first to describe the smear layer in a Scanning Electron Microscope (SEM) study. They found that this layer is composed of small particles of dentin debris ranging in size between 0.5-15 μm.[19] Another SEM investigation of cavity preparation by Brännström and Johnson[20] demonstrated a 2 to 5 μm thick smear layer that extends a few micrometers into dentinal tubules. One year later, McComb and Smith[21] evaluated smear layer in the root canal system, and found that it contains, in addition to dentin debris, remnants of odontoblastic processes, pulp tissue and bacteria, unlike the smear layer on the coronal dentin.

Moreover, it has been reported that the smear layer formed on dentin walls of the root canal system is denser and thicker than the one formed on coronal dentin. [22]

The removal of the smear layer from the root canal system is somewhat controversial. Many reports indicated that the removal of the smear layer is essential to ensure removal of bacteria, proper penetration of disinfecting agents into dentinal tubules and, enhance the effectiveness of adhesive dentin bonding systems. [18]

It is well known that sodium hypochlorite solution (NaOCl) is a very effective antibacterial agent that dissolves necrotic and vital organic tissue. [23] Early investigations evaluated the effect NaOCl on the smear layer. It has been shown that NaOCl is only capable of partial removal of the smear layer. These results confirmed that the smear layer consists of predominantly inorganic debris, and not only organic dentin substance. [24] Other methods evaluated for the removal of the smear layer include chlorhexidine, ethylenediaminetetracetic acid (EDTA), phosphoric acid, ultrasonic and laser techniques; no single technique was found to be effective to completely remove it. [18] However, the alternate use of 17% EDTA and NaOCl seems to be the most effective method reported. [25, 26]

A mixture of doxycycline, citric acid, and a detergent (MTAD) was introduced in 2003, [27] as an aqueous solution of 3% doxycycline (a broad-spectrum antibiotic); 4.25% citric acid, (a demineralizing agent); and 0.5% polysorbate 80 (a detergent). The use of MTAD has been reported to be an effective antibicrobial agent, and also more efficient in removing smear layer as compared with the use of EDTA and NaOCl, especially from the apical third. [27, 28]

Effect of Root Canal Irrigants on Retention of Fiber Posts

Irrigation solutions used after post space preparation for removal of smear layer may affect the structural properties of dentin, and subsequently alter the bonding of fiber posts to radicular dentin. [29, 30] Several studies have been conducted to evaluate the effect of different intracanal irrigants, when used prior to post cementation, on bond strength of fiber-reinforced posts. However, again conflicting results have been reported. [18]

EDTA

EDTA has a low pH and acts a calcium-chelating agent, which tends to be effective in removing the smear layer. [18] In an in vitro study, Gu et al [31] confirmed the opening of dentinal tubules after application of 14% EDTA for 60 seconds. Under SEM, resin tags were observed along the entire length of the canal after application of the self-etch primer and resin cement; most of these tags were 20-30 μm deep. This resulted in significantly higher push-out bond strength, when compared to NaOCl or NaCl. However, when using self-etch adhesive, Demiryurek [32] et al reported the lowest bond strength among the test groups when 17% EDTA was used. In another study, Faria-e-Silva [22] evaluated two different self-adhesive resin cements, and found that irrigation with 17% EDTA after post space preparation resulted in higher bond strength when using one cement, and to the contrary, the same irrigation protocol resulted in the lowest bond strength, when the other cement was used.

The use of EDTA seems to enhance the retention of fiber posts when using etch-and-rinse resin cements, however, with the use of self-adhesive cements, the results are inconclusive, and may actually reduce the bond strength of fiber posts. [33]

MTAD

Use of MTAD may be advantageous over other irrigation solutions since it seems to be effective in removing both organic and inorganic debris, in addition to the anti-microbial effect. To the author's knowledge, the effect of MTAD on bond strength of fiber posts has never been studied. However, some investigations evaluated the effect of MTAD on the bond strength of resin endodontic sealers to radicular dentin. Kumar et al. [34] compared the effect different irrigation solutions on the push-out bond strength at the apical region. Bond strength was found to be higher on the teeth irrigated with MTAD or EDTA, however the difference was not statistically significant compared to NaOCl, Chlorhexidine or no-irrigation.

Statement of The Problem

Some endodontically treated teeth require a post and core prior to complete coverage restoration, which is frequently performed with fiber post systems. As stated above, there seems to be agreement in that the most commonly reported clinical failure with post and core restorations is post loosening, and several studies indicated that these failures were predominantly at the cement-dentin interface. Therefore, it is crucial to improve the bond strength at this interface.

Numerous studies have evaluated dentin conditioning and its effect upon the bond strength. However, no conclusive evidence on the best conditioning solution/technique was reached, and different cements exhibited different results with different irrigation solutions.

Thus, the purpose of this in vitro study was to investigate the effect of different irrigation solutions used after post space preparation, on the pull-out bond strength of glass fiber-reinforced posts.

The null hypothesis was that the irrigation solution used prior to post cementation does not increase the bond strength of glass fiber-reinforced posts to root dentin.

CHAPTER TWO

MATERIALS AND METHODS

Preparation of Specimens

Forty-five extracted human premolar teeth of approximately the same length were selected for this study and stored in saline solution. All teeth were visually examined to ensure there were no caries or defects. Radiographs were taken to evaluate the morphology, number and size of the root canals to ensure standardization. Premolars with fractures, more than one root canal, caries, or restorations were excluded.

The crowns of all teeth were sectioned at the cemento-enamel junction, perpendicular to the long axis of the teeth, to obtain a remaining root length of 15.0 mm. A diamond disc (365.11.220 HP, Brasseler USA Inc., Savannah, GA) was used at low speed with water spray.

Endodontic Instrumentation and Obturation

Two enodontists performed root canal treatment for all of the teeth using a single cone technique. A number 10 K-file (K-file; Dentsply Maillefer, Ballaigues, Switzerland) was first used to ensure canal patency. Instrumentation performed with Profile series 29 0.04 taper files (Dentsply, York, PA) in an Endo ITR – Intelligent Torque Reduction (AEU-20; Dentsply Tulsa Dental, Co., Tulsa, OK) handpiece at ratio 1:8, torque 2 and 350 rpm to achieve the required 0.04 mm taper. Throughout the instrumentation procedures, canals were alternatively rinsed with 2.6% sodium hypochlorite and 17% EDTA (Pulpdent, Watertown, MA) using a disposable 5 ml syringe (Ultradent Products, South Jordan, UT) and a 30-gauge needle (Endo Eze Tip; Ultradent Products, South Jordan, UT), followed by a final rinse with saline. Then, all root canals were dried with absorbent paper points (Henry Schein, Melville, NY).

Canals were obturated with MF – Medium Fine - Gutta purcha master cone (Dentsply, Tulsa, OK) and Zinc Oxide Eugenol sealer (Roth Root Canal Cement, Roth International LTD, Chicago, IL), followed by injectable gutta purcha (System B, SybronEndo, Orange, CA). After obturation, all roots were stored in humid environment for one week to allow the sealer to set.

Post Space Preparation

A post space was prepared in each tooth to a standarized length of 10 mm length, leaving 5 mm of gutta purcha to maintain the apical seal. Size number 3 Gates Glidden drills (L.D. Caulk/Dentsply International hie, Milford, DE) with endodontic reference stop were utilized to remove gutta percha to the desired length. The length of the post space was verified using a periodontal probe (Hu-Friedy Inc, Chicago, IL) fitted with an endodontic reference stop. Then, a post space was prepared with a matching drill of the fiber-reinforced post size 50 (ER DentinPost, KometUSA, Rock Hill, SC) to the depth of 10 mm. The fiber reinforced post and the matching drill are shown in Figure 1.

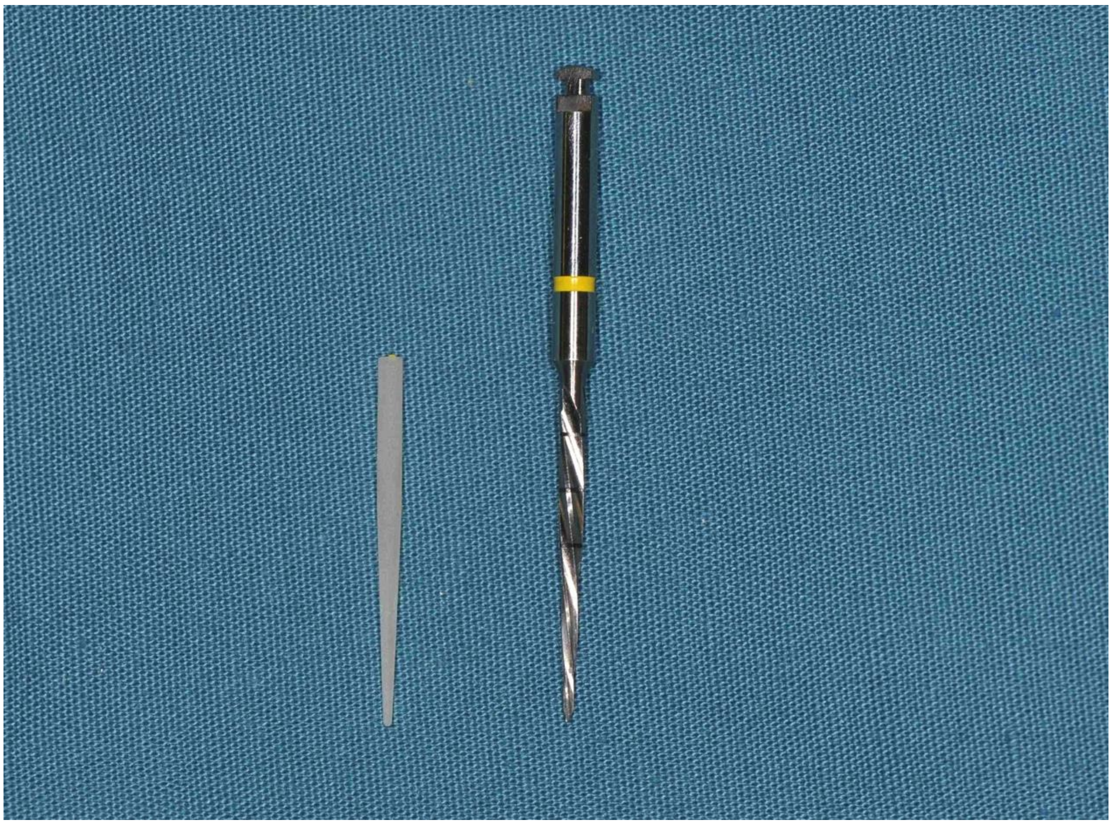

Figure 1. ER DentinPost (epoxy resin matrix with 60% glass fiber proportion) size 50 with the matching drill.

Irrigation Protocols

The specimens were randomly divided into 3 groups:

Group 1: MTAD (BioPure MTAD, Dentsply Tulsa, Johnson City TN) was used to rinse the root canal prior to post cementation following the manufacturer's instructions; the liquid was injected into the powder and mixed for 60 seconds, drawn with the 5 ml syringe provided with the system. 1 ml of MTAD was injected into the post space, and left for 5 minutes, then withdrawn with another syringe. The remaining 4 ml was used to rinse the post space, followed by drying with paper points.

Group 2: 17% ETDA solution was injected into the canal space, left for one minute, and the canals were then dried with paper points.

Group 3: was the control group, no final rinse was used in the post space. Groups and irrigation solution tested are listed in Table 1.

Table 1

List of different groups and irrigation solutions tested

Group	Irrigation solution	Lot number
Bio Pure MTAD (Dentsply)	A mixture of: • 3% Doxycycline • 4.25% Citric acid • 0.5% Polysorbate 80	131029
EDTA (Pulpdent)	17 % Ethylenediaminetetracetic acid	130913
Control	None	None

Post Cementation

Fiber-reinforced epoxy resin posts (ER DentinPost, KometUSA, Rock Hill, SC) of the same size 50 were used for all groups. The posts were tried in the post space to verify their fit then cleaned with alcohol prior to cementation. A self-adhesive resin cement (RelyX Unicem Clicker, 3M ESPE, St Paul, MN) was used to cement the posts of all groups. Two clicks of cement were dispensed onto a mixing pad (3M ESPE, St Paul, MN) and mixed for 20 seconds with a plastic cement spatula (Hu-Friedy Inc, Chicago, IL) and applied directly on the post. Then the post was gently placed into the standardized 10 mm post space and stabilized with finger pressure. Excess cement was removed with a microbrush (Plasdent, Pomona, CA) prior to light polymerizing for 40 seconds with a Light Emitting Diode (LED) polymerization light (3M ESPE, St Paul, MN) at a distance of approximately 2 mm. Composition of the fiber post and resin cement used for this study are shown in Table 2.

Pull-out Test

A mold formed by milling a Teflon block (Figures 2 and 3) was used to make a composite resin grip (4.0 mm deep x 3.5 mm diameter) in order to prevent post fractures during the pull-out test. Prior to cementation, the post was placed into the mold, the composite resin (Vitalescence, Ultradent, South Jordan, UT) was packed to form the composite resin grip, and light polymerized for 40 seconds (Figure 4). The completed specimen prior to pull-out testing is illustrated in Figure 5.

Table 2

Compositions of the post and cement used in the study

Material	Composition	Lot number
ER DentinPost (Komet)	60% glass fibers embedded in epoxy resin matrix	196064
RelyX Unicem Clicker (3M ESPE)	Base: methacrylate monomers containing phosphoric acid groups, methacrylate monomers, silanated fillers, initiator components, stabilizers Catalyst: methacrylate monomers, alkaline fillers, silanated fillers, initiator components, stabilizers, pigments	537561

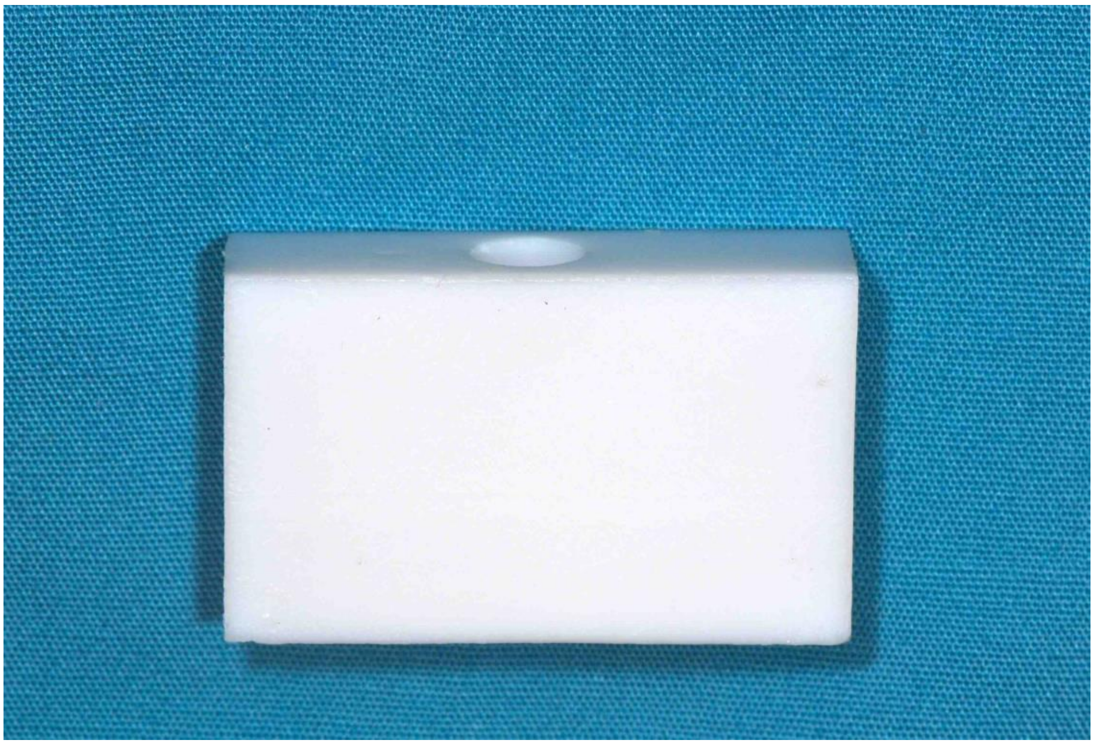

Figure 2. Teflon mold used to fabricate the composite resin grips

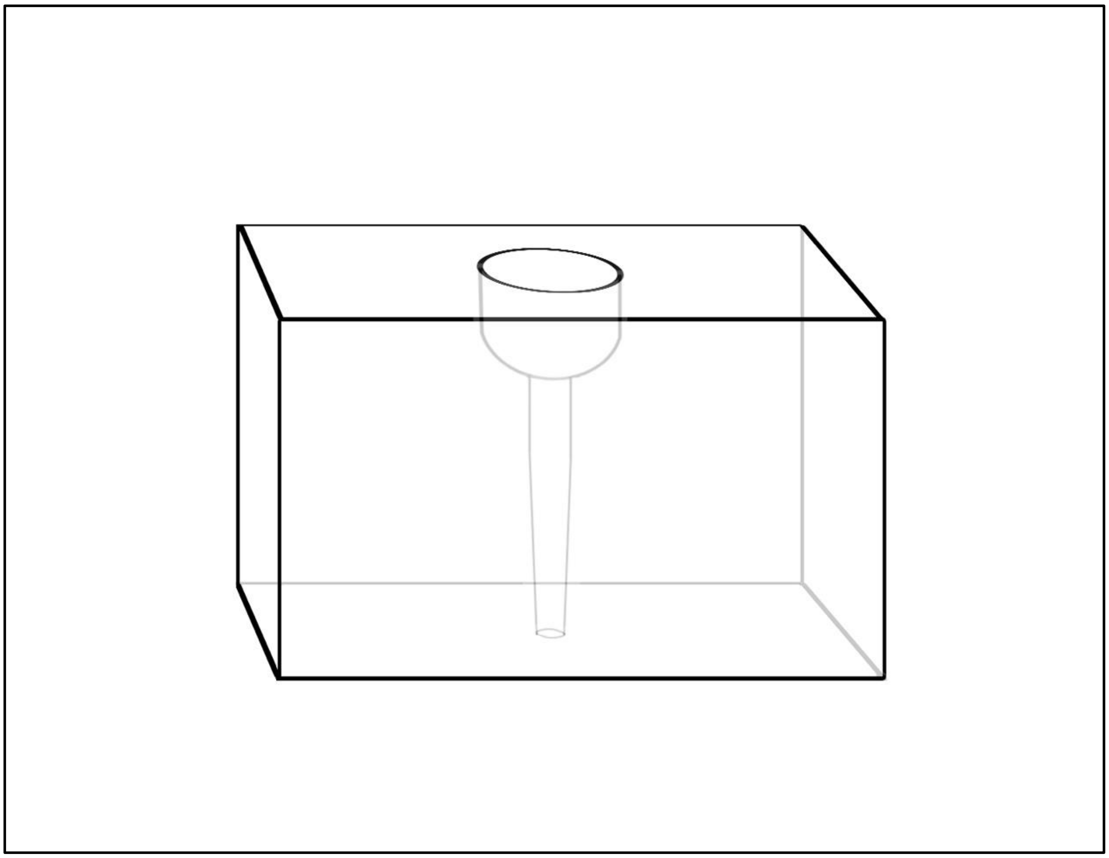

Figure 3. Illustration of the Teflon mold

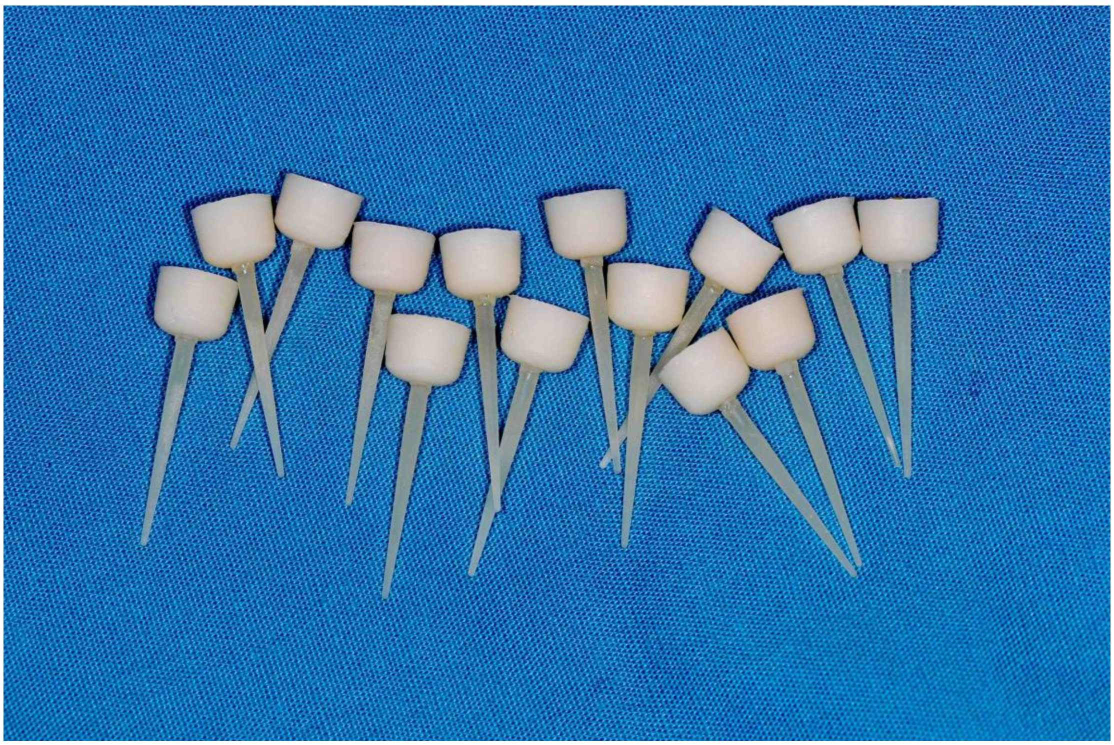

Figure 4. Fiber reinforced posts after the with the composite resin grips

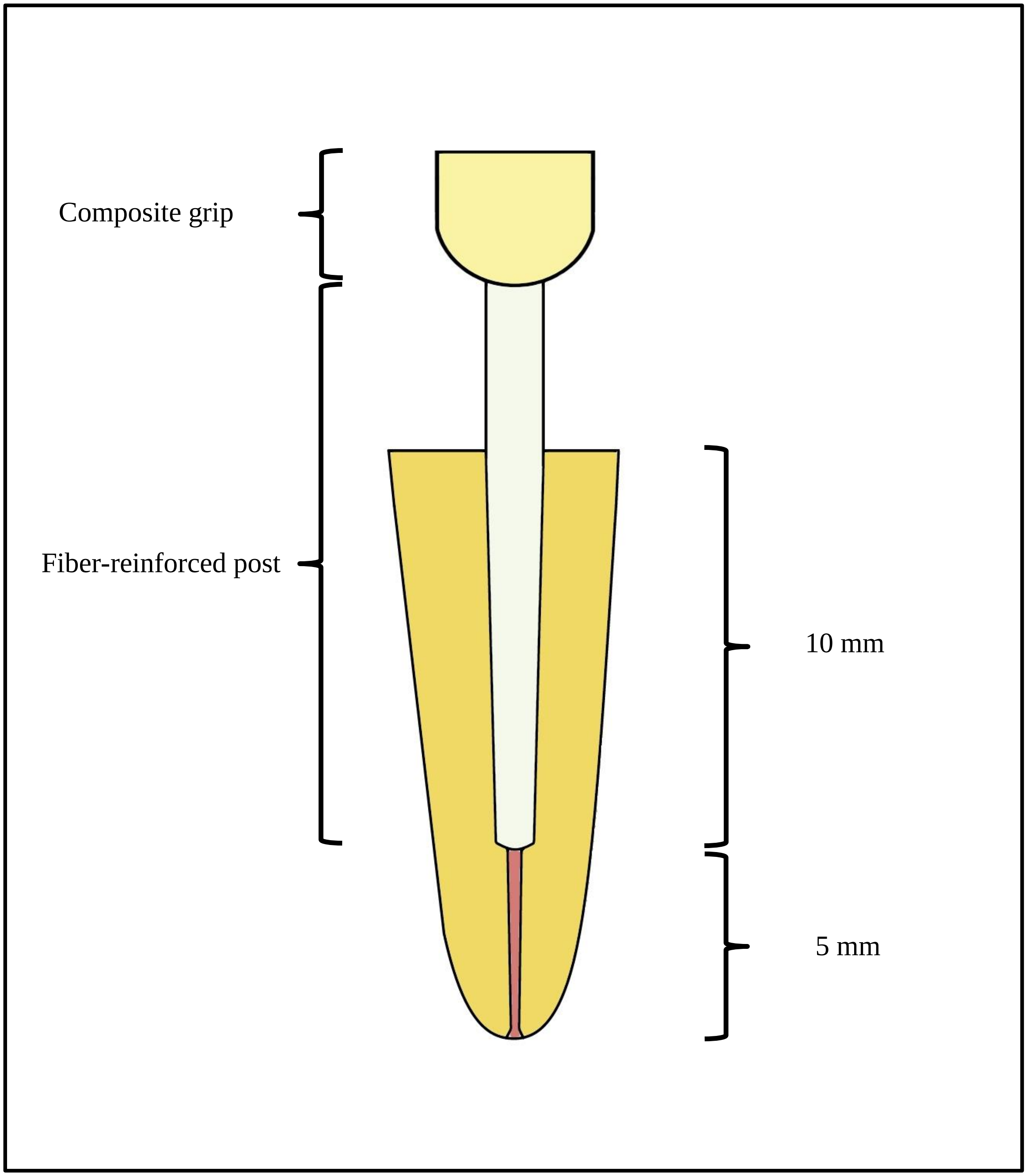

Figure 5. Illustration of the premolar tooth with the composite grip and the cemented glass fiber-reinforced post

A special holding device, similar to the devices used previously [35, 36] was made and used for this study (Figures 6-8). The device was composed of two members; the upper member held the root and contained a 3 mm-wide groove in the middle to accommodate the post, while the lower member held the composite resin grip. An internal round slot was made in the lower member, using the same bur that was used to mill the Teflon block, therefore creating close adaptation between the composite resin grip and the testing jig, avoiding stress concentration. A universal testing machine (ElectroPlus E10000, Instron, Norwood, MA) was used to separate the post from the tooth by applying a tensile force at a crosshead speed of 0.5 mm/min until failure. The point of failure was defined as the maximum tensile force recorded by the machine. Since all of the posts used were placed in the canal with the same length, the force was expressed in Newton rather than Megapascal.

The dislodged posts were examined at x8 magnification to determine the type of failure. The type of failure was classified into one of three categories: (1) adhesive between post and resin cement (no resin cement visible around the post); (2) mixed, (with resin cement partially covering the post surface); (3) adhesive between resin cement and root dentin (post completely covered by resin cement). The percentage of each type of failure within each group was calculated.

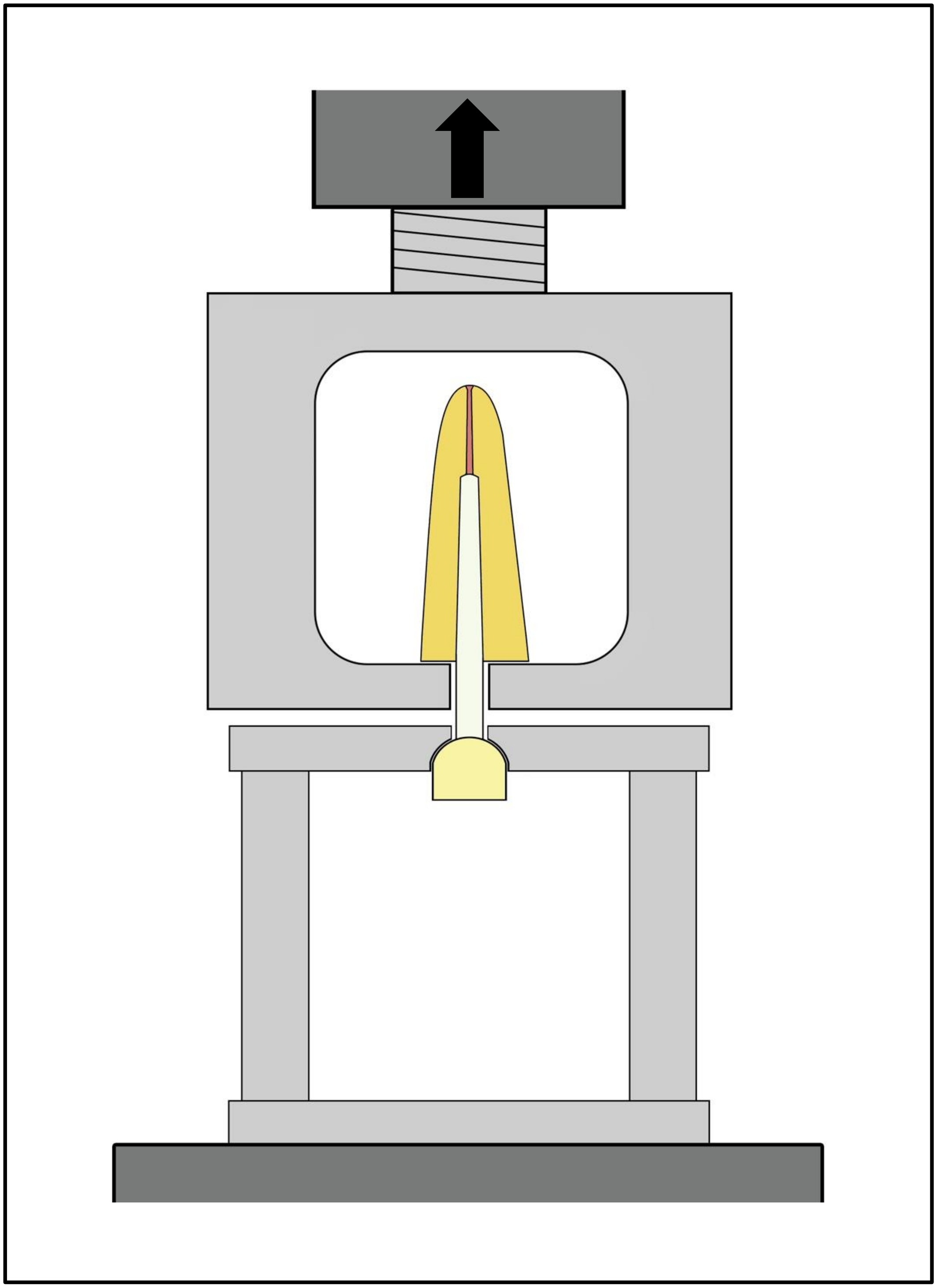

Figure 6. Illustration of the testing apparatus used to apply upward tensile force

Figure 7. Testing apparatus attached to Instron E10000 machine

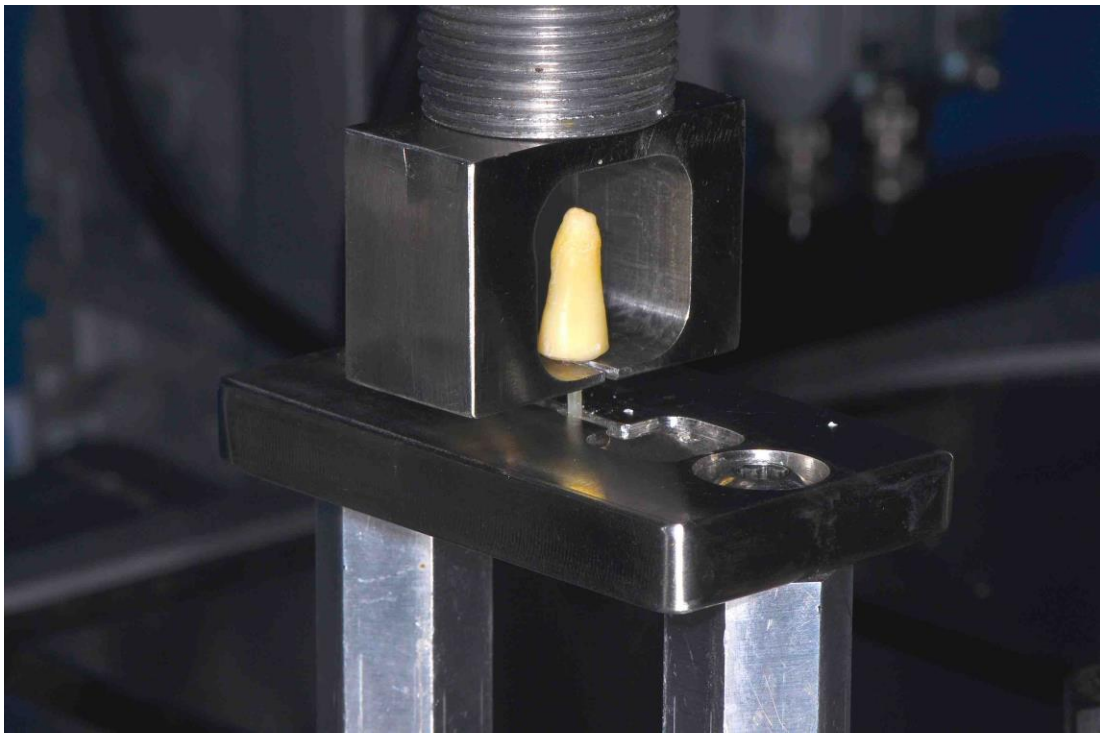

Figure 8. Close-up photograph of the testing apparatus with one of the specimens

Statistical Analysis

One-way ANOVA procedure was used to determine if there was a difference in dislodgement load between the three groups. The α-level of significance was set at 0.05. Descriptive statistics were given as mean and standard deviation for quantitative variables (Table-3). All statistical analyses were performed using IBM SPSS Statistics (Version 20; IBM Corporation 1989, 2011).

CHAPTER THREE

RESULTS

The control group achieved the highest bond strength (214.2 N), while the lowest achieved value was in the EDTA group (81.4 N). The highest mean bond strength was also found in the control group (151.4 N) followed by the MTAD group (146.7 N) then the EDTA group (142.8 N). A summary of the means and standard deviations for the recorded pull-out bond strength are provided in Table 3 and in Figure 9, while the bond strength of individual specimens are listed in Tables 4 – 6.

One-way ANOVA showed no statistically significant difference in bond strengths among the irrigation solutions tested. Irrigating the post space with EDTA or MTAD did not improve the retention of glass fiber reinforced posts (P=0.458).

Table 3

Mean pull-out bond strength (N) and standard deviation (SD) for the tested groups

Group	Mean ± SD	P-value
Control	151.40 ± 27.58 N	
EDTA	142.84 ± 31.83 N	0.458
MTAD	146.72 ± 22.10 N	

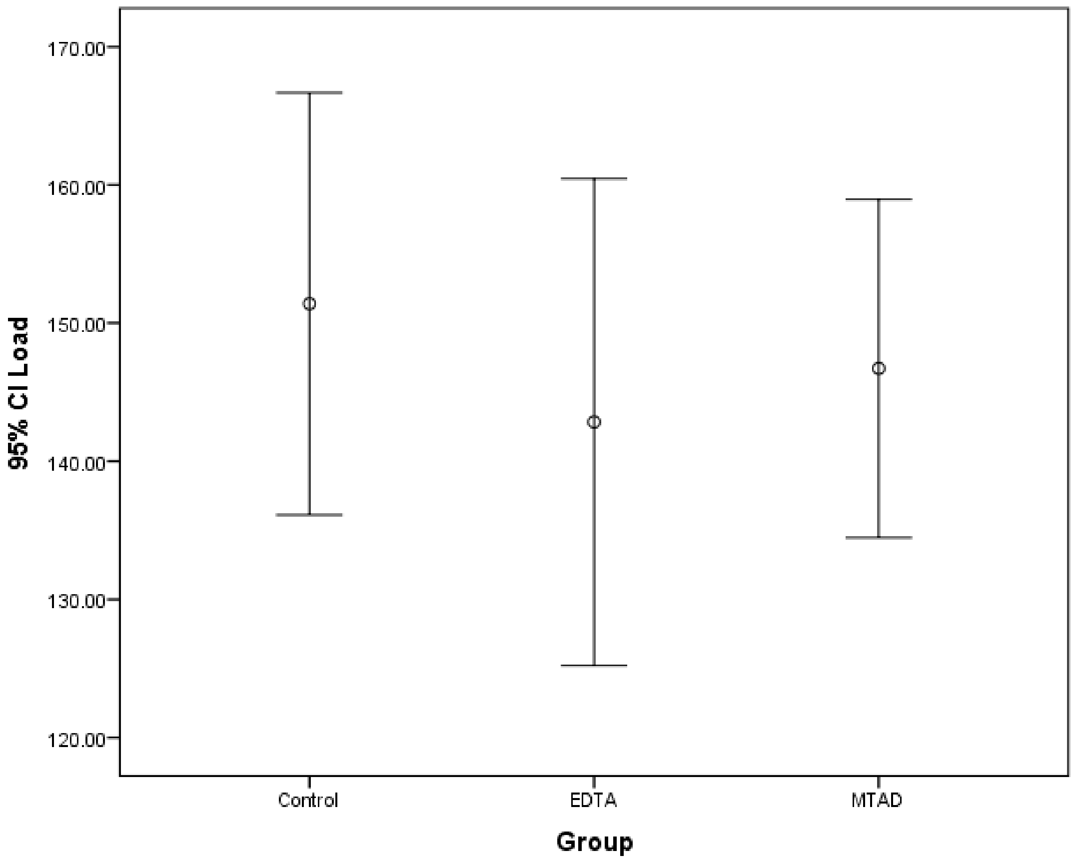

Figure 9. Graphic illustration of the bond strengths (N) for the different groups

Table 4

Bond strength values (N) of the control group

Specimen	Bond strength
1	132.1
2	134.6
3	167.4
4	129.1
5	190.4
6	155.5
7	133.3
8	135.8
9	139.7
10	175.4
11	105.0
12	167.5
13	145.5
14	145.5
15	214.2
Mean	151.4
Standard deviation	27.6
Upper bound (95% CI)	166.7
Lower bound (95% CI)	136.1

Table 5

Bond strength values (N) of the EDTA group

Specimen	Bond strength
1	163.7
2	162.6
3	115.6
4	140.8
5	107.0
6	81.4
7	100.5
8	148.8
9	121.9
10	166.1
11	197.0
12	167.0
13	145.2
14	177.4
15	147.6
Mean	142.8
Standard deviation	31.8
Upper bound (95% CI)	160.5
Lower bound (95% CI)	125.2

Table 6

Bond strength values (N) of the MTAD group

Specimen	Bond strength
1	107.0
2	111.4
3	130.8
4	165.8
5	159.0
6	158.2
7	169.6
8	180.5
9	153.7
10	143.5
11	128.7
12	148.5
13	122.5
14	154.4
15	167.2
Mean	146.7
Standard deviation	22.1
Upper bound (95% CI)	159.0
Lower bound (95% CI)	134.5

The examination of dislodged posts under a light microscope revealed that for the control and MTAD groups, 93% of the dislodged posts were partially covered with cement and therefore had a mixed failure mode. On the remaining 7%, no visible cement was observed on the post, indicating an adhesive failure at the cement-to-post interface. In the EDTA group, all of the posts were partially covered with resin cement, indicating a mixed mode of failure. None of the posts were completely covered with resin cement (Table 7).

In addition, as an unrelated finding, the remaining roots rinsed with MTAD had brown discoloration affecting the entire root (Figure 10).

Table 7

Failure modes (as percentage) of the dislodged posts

Failure mode	Control	EDTA	MTAD
Adhesive (cement-post)	7	-	7
Mixed	93	100	93
Adhesive (cement-dentin)	-	-	-

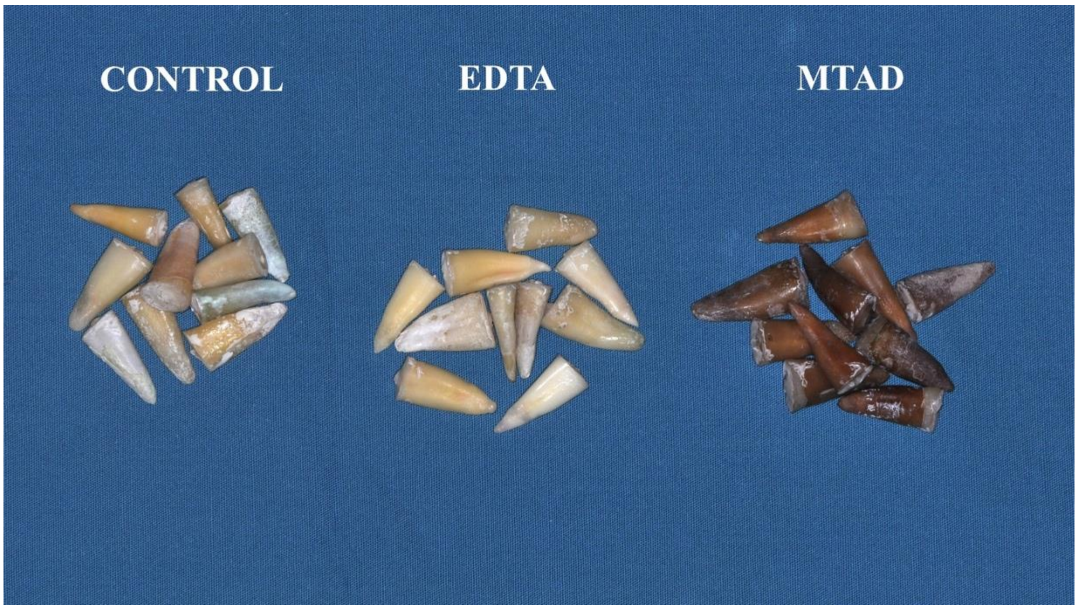

Figure 10. Some specimens from each group, to show the brown discoloration of the MTAD group

CHAPTER FOUR

DISCUSSION

The results from this study showed that the use of MTAD and EDTA did not improve the bond strength of fiber-reinforced posts to dentin when self-adhesive resin cement was used. Therefore this study fails to reject the null hypothesis.

Several studies have pointed out that the most frequent failure mode of post-retained restorations is post debonding. [11, 15, 16] Clinical studies revealed that the main reason for restoration failure was the loss of retention between the post and the tooth. [37] While some in vitro investigations reported the bond between the post and resin cement as the weak link. [12] An optimal bond between a post and cement, and between cement and dentin, is essential when restoring endodontically treated teeth. [38] Retention of posts to dentin depends on the post type, the properties of the cement, and bonding of the cement to the post and the dentin in the root canal. [39]

Surface treatments are commonly recommended to improve bonding properties by facilitating chemical and micromechanical adhesion. Reported surface treatments include airborne particle abrasion, acid etching, silane coating, or combinations. [40, 41] In this study, posts were cemented following manufacturer's recommendation, which recommended no surface treatment.

In addition, multiple dentin conditioning techniques were investigated in an attempt to enhance the bond at the cement-to-dentin interface. Multiple studies have evaluated the influence of solutions such as sodium hypochlorite, chlorhexidine, 17% EDTA, citric acid, MTAD, and 37% phosphoric acid on the bond strength of resin to dentin walls. Devices such as lasers and ultrasonic devices have also been reported.

However, conflicting results were found. Dentin conditioning may affect the bond strength, and this effect greatly varies depending on the resin cement used. [33] The irrigation solutions tested for this study were EDTA and MTAD.

EDTA

17% EDTA has been reported to remove smear layer in multiple studies when used in the canal for 1 minute. [42] Shorter irrigation times could significantly decrease smear layer removal. [43] In contrast, using EDTA for periods longer than 1 minute could lead to severe erosion of the radicular dentin surface. [27] Thus in this study, EDTA was used for 1 minute.

Several in vitro investigations tested the effect of EDTA on bond strength of endodontic posts to root dentin, which was reported to be significantly improved. [31, 33] However in this study, the use of EDTA resulted in the lowest tensile bond strength compared to the other groups, though this difference did not reach statistical significance. This might be attributed to the strong demineralizing effect of EDTA on root dentin, which causes enlargement of the dentinal tubules, softening of the dentin, and denaturation of the collagen fibers. [44] These effects may subsequently influence the bonding to dentin in the root canal system. [42]

Similar results were reported by Faria-e-Silva [22] where the use of EDTA prior to cementation with RelyX Unicem resulted in significantly lower bond strength, when compared to the control group, where post space was irrigated with distilled water. Interestingly, when another self-adhesive resin cement (BisCem, Bisco, Schaumburg, IL) was used, EDTA was found to improve the bond strength significantly. This was assumed to be due to different chemical composition and/or different behavior of different self-adhesive resin cements.

MTAD

Although smear layer removal remains a controversial issue, it is generally believed to enhance the bond strength to radicular dentin. MTAD is an acidic solution with a pH of 2.15 that is able to dissolve inorganic substance. [45] Torabinejad et al showed that MTAD is an effective solution for the removal of the smear layer and does not significantly change the structure of the dentinal tubules when used as a final rinse. [27] MTAD used in this study resulted in higher bond strength when compared to EDTA but lower bond strength than using no irrigation. Statistical analysis revealed however that these differences were not significant.

A few hours after the cementation of fiber reinforced posts, brown discoloration of the teeth irrigated with MTAD was observed. Although it has never been reported in vivo, this phenomenon was first observed in vitro in 2003. [45] It has been reported that when MTAD was used followed by NaOCl as a final rinse, a chemical reaction took place, which resulted in the formation of a brown solution in the root canals. It was thought to be due to the dentinal absorption and release of doxycycline present in MTAD solution and the final rinse of NaOCl. [45] Moreover, Tay et al. investigated the potential staining effect of doxycycline in MTAD. [46] The study reported that when MTAD was used as a final rinse, after using NaOCl during instrumentation, it produced a red-purple discoloration of dentin. The probable reason for this phenomenon is the oxidation of doxycycline in MTAD by NaOCl. The discoloration may require exposure to light in order to take place, since it has been reported that when specimens were stored in a dark environment, no dentin discoloration was observed. [46, 47] In this study, teeth were not stored in the dark, which may have caused the discoloration of the teeth irrigated with MTAD. While evidence regarding this phenomenon is not substantial, the presence of discoloration may limit the use of MTAD, as it will contradict the esthetic advantage of using fiber-reinforced composite posts.

Self-adhesive Resin Cements

Self-adhesive resin cements have been introduced in the past decade, which eliminated the need for an extra clinical step for bonding. The presence of water as a component in self-adhesive resin cements provides them with hydrophilic characteristics. The acid component will demineralize the smear layer and the underlying dentin. In addition, water and methacrylate monomer will lead to infiltration of resin into the porous dentin surface. However, insufficient demineralization and limited resin infiltration have been reported, which has been attributed to a slightly higher pH, which is 1.5 to 3.0, when compared to self-etching cements with a pH range of 0 to 1.5. [48] In the present study, EDTA and MTAD were used to verify whether they would provide further demineralization to enhance bonding. Although results of this study show that the MTAD group performed better compared to the EDTA group, the use of either solution as a final rinse did not improve bond strength when compared to the control group.

Pull-out Test

In vitro evaluation of the bond strength of endodontic posts can be performed using one of three common methods; pull-out, push-out and micro-tensile tests. The push-out and micro-tensile tests allow the measurement of bond strength at different regions of the root canal system; apical, middle or coronal thirds. However, sectioning procedure can alter and negatively influence the bond strength of the posts to be tested. [49] On the other hand, the pull-out test is a simple alternative for testing higher specimen amounts. In addition, reported clinical failures of fiber posts usually occur with the entire post being debonded from the post space. Therefore, the pull-out testing may simulate clinical conditions more closely, when compared to the other two testing methods, [50] and thus was used for this study.

Study Limitations

This in vitro study has some limitations. The reported results only true for the fiber posts system used when cemented with RelyX Unicem. The effect of different irrigation solutions with different resin cement brands and types requires further research. It is suggested that future studies should use fatigue loading and thermocycling, as they may better simulate clinical environment and might alter the reported results. Also. More studies are required to evaluate the effect of MTAD on bond strength of different fiber post systems.

Conclusions

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

1. Removal of smear layer does not necessarily influence bond strength when self-adhesive resin cements are used to cement fiber-reinforced posts.
2. The use of MTAD or EDTA as a final rinse did not have a significant impact on the retention of glass fiber-reinforced posts cemented with RelyX Unicem.

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