



EVALUATION OF DIFFERENT ROOT-END FILLING MATERIALS IN POINT OF APICAL MICRO-LEAKAGE BY THE COMPUTERIZED FLUID FILTRATION METER

FARKLI KÖK UCU DOLGU MATERYALLERİNİN APİKAL MİKRO-SIZINTISI AÇISINDAN BİLGİSAYARLI SIVI FİLTASYON METRESİ İLE DEĞERLENDİRİLMESİ

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ABSTRACT

Aim: The aim of this study was to test apical micro-leakage of n-butyl-2-cyanoacrylate as a root-end filling material by the computerized fluid filtration meter.

Material and method: Seventy-nine extracted human mandibular premolar teeth with one root canal were selected. The specimens were divided into five groups of 13 teeth each and filled with the AH Plus root canal sealer. After obturation, the roots were resected at 30° angle and filled with a root-end filling material. The sealing qualities of the five different root-end filling materials were measured using computerized fluid filtration method.

Results: The mean values of apical micro-leakage were $5.0 \pm 1.07 \times 10^{-4}$, $4.0 \pm 1.5 \times 10^{-4}$, $4.0 \pm 2.2 \times 10^{-4}$, $1.0 \pm 0.6 \times 10^{-4}$, and $4.0 \pm 1.1 \times 10^{-4}$ $\mu\text{l.cmH}_2\text{O}^{-1}.\text{min}^{-1}$ at 120 kPa, in groups 1 to 5, respectively. The statistically significant differences were not found among the retrofilling materials ($P > 0.05$).

Conclusion: This type of cyanoacrylate has been used firstly as retrograde filling material. Tissue Adhesive can be used as a root-end filling material in apical surgery.

Keywords: Tissue adhesive; root-end filling materials; apical micro-leakage, computerized fluid filtration meteri

ÖZET

Amaç: Bu çalışmanın amacı, kök ucu dolgu maddesi olarak kullanılan n-butyl-2-cyanoacrylate'ın bilgisayarlı sıvı filtrasyon metresi ile apikal mikro-sızıntısının test edilmesidir.

Gereç ve Yöntem: 79 adet çekilmiş tek kök kanallı insan mandibular premolar diş seçildi.

Örnekler her grupta 13 diş olacak şekilde beş gruba ayrıldı ve AH Plus kanal patı kullanılarak kök kanalları dolduruldu. Obturasyondan sonra, kökler 30° açı ile rezeke edildi ve kök ucu dolguları kök ucu dolgu materyalleri ile yapıldı. Beş farklı kök ucu dolgu materyalinin sızdırmazlık dereceleri bilgisayarlı sıvı filtrasyon metodu kullanılarak ölçüldü.

Bulgular: Apikal mikro-sızıntı ortalama değerleri, 120 kPa'da grup 1'den 5'e sırası ile $5.0 \pm 1.07 \times 10^{-4}$, $4.0 \pm 1.5 \times 10^{-4}$, $4.0 \pm 2.2 \times 10^{-4}$, $1.0 \pm 0.6 \times 10^{-4}$ ve $4.0 \pm 1.1 \times 10^{-4}$ $\mu\text{l.cmH}_2\text{O}^{-1}.\text{min}^{-1}$ 'dir. İstatistiksel olarak kök ucu dolgu materyalleri arasında anlamlı farklılık gözlenmedi ($P > 0.05$).

Sonuç: Bu tip cyanoacrylate ilk defa kök ucu dolu materyali olarak kullanıldı. Doku adezivi apikal cerrahide kök ucu dolgu materyali olarak kullanılabilir.

Anahtar Kelimeler: Doku adezivi, kök ucu dolu materyali, apikal mikro-sızıntı, bilgisayarlı sıvı filtrasyon metresi.

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INTRODUCTION

The aim of nonsurgical endodontic treatment is to remove the irritants, which microorganisms and their toxins have the ability to penetrate along the root canal system and unfavorably affect the periradicular tissues, from the root canal system and then 3-dimensionally fill the root canal spaces.¹ Sometimes nonsurgical endodontic treatment can be unsuccessful; hence apical surgery may be necessary to facilitate the healing of periradicular tissues.¹ The studies showed that bacteria and its products have an important role in the development of periapical pathosis.^{2,3} The aim of apical surgery is to eliminate the periapical infection.

This procedure includes; pathologic tissues surrounding the tooth apex are removed periradicular curettage, apical resection and preparation of root-end when re-treating a complex root canal system. Following the apical resection and the root-end cavity preparation, placement of a root-end filling material in most cases.^{1,4}

The apical leakage can occur by two ways potentially. The first one, is leakage along the interface between the root-end filling material and the root canal walls and the second one, is by the flow of fluids along permeable apical dentin because of open tubules at the resected root-end. So that both of them are named "apical micro-leakage". It has been known that the angle of apical resection can influence the apical micro-leakage.

A suitable root-end filling material substantially prevents the transfer of fluid and microbial products into the root canal system from periapical tissues.⁴ One of the most important determinants is a quality of the apical seal for success of periapical surgery.

An ideal root-end filling material should be biocompatible, nontoxic, easy to manipulate, radiopaque, dimensionally stable, unaffected by humidity, non-absorbable, cost-effectiveness and adhesive to dentin.⁴

Many materials have been used for root-end filling, including amalgam, gutta-percha, zinc oxide eugenol cements, polycarboxylate cement, glass ionomer cement, resin-modified glass ionomers, compomers, gold foil pellets, temporary filling materials, composite resin and mineral trioxide aggregate (MTA).⁴ The less commonly used materials

are laser, citric acid demineralization, ceramic inlay, teflon, mixture of powdered dentin & sulfathiazole and cyanoacrylates.

Amalgam

Amalgam has been a frequently used as retrograde filling material for the past years, because of economic, radio-opaque, and insoluble. Espevik & Mjor⁵ stated that biological effects of amalgam are dependent on the property of product and the composition of the alloy. Amalgam has some disadvantages such as, marginal leakage, corrosion, mercury contamination of periapical tissues, wetness sensitivity of some alloys, need for retentive undercut and enough preparation, staining of hard and soft tissues.⁶

Zinc Oxide Eugenol (ZOE) and Reinforced ZOE Cements

In the apical surgery, the zinc oxide eugenol is used as a root-end filling material for seal but it has had limited documentation. There are the new modifications of ZOE like intermediate restorative material (IRM) and Super-EBA which obtain a better apical seal than ZOE. IRM is zinc oxide eugenol cement reinforced by addition of 20% polymethacrylate by weight to the powder. Super-EBA and IRM include only one-third the ZOE and adhere to the root of dentin and cementum in the wetness conditions. In a study, reported that periradicular tissues response to Super-EBA with minimal chronic inflammation.⁷ The studies exhibited that Super-EBA such as root-end filling had almost no leakage at the root apex.⁸ Super-EBA and IRM showed less leakage as compared to silver amalgam.

Mineral Trioxide Aggregate (MTA)

The clinicians use MTA in endodontic therapy commonly which is used as pulp-capping material, root-end filling/root canal filling material and perforation-repair material.⁴ In 1993, it was developed at Loma Linda University, CA, USA that includes tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide and other mineral oxides forming a hydrophilic powder.⁴ The periradicular tissues response to the calcium hydroxide with biocompatible.

It is more opaque than super-EBA and IRM. Adamo *et al.*⁹ compared MTA, Super-EBA, Composite and amalgam and found statistically no significant difference in the rate of micro-leakage but studies of Torabinejad *et al.*¹⁰ and Fischer *et al.*¹¹ proved MTA to

be superior as compared to Super-EBA and IRM. MTA, when used as a root-end filling material, showed evidence of healing of the surrounding tissues. However, MTA has some disadvantages, for instance setting time and the difficult handling.¹²

Tissue adhesive [(N-Butyl-2-cyanoacrylate) (Glubran 2)]

Cyanoacrylate has been used in medicine and dentistry for many years due to low levels of inflammation, toxicity and well biocompatibility.¹² Several studies showed clearly that can be safely used in sutures, for pulp capping, for hemostatic and anti-inflammatory features, for high adhesion ability in a wetness environment and also root-end filling material in endodontic surgeries.¹²⁻¹⁶ Winik *et al.*¹² reported that there was dye leakage throughout the length of the canals in no root-end filling material, while there was no dye penetration in retrograde filling material as cyanoacrylate.

Glubran 2 is used in almost all fields of medicine. In a wet environment, it polymerises rapidly, creating a thin elastic film with high stretch resistance, which guarantees solid adhesion of the tissues and an effective antiseptic barrier. It has EU certified for internal use.¹⁷ Although n-butyl-2-cyanoacrylate is used in bleeding after the tooth extraction as a hemostatic agent, instead of surgical suture in incisions, closing sinus membrane perforations and fixation of autogenous bone graft in oral and maxillofacial surgery, it was slightly used before as a root and filling material in apical surgery.¹⁸⁻²⁰ There was no study about n-butyl-2-cyanoacrylate compared with other common used root and filling materials. The purpose of this study was to test apical leakage by the computerized fluid filtration meter of n-butyl-2-cyanoacrylate as a root and filling material.

MATERIALS AND METHODS

Seventy-nine extracted human mandibular premolar teeth with one root canal were selected. The teeth with caries, cracks, or open apices were excluded. Their external surfaces were cleaned with curettes and were stored in deionized water until use. The crowns were removed with carborundum disks leaving a uniform 15-mm root section. The working lengths were determined by placing a size 15 K-file

(Kerr, Romulus, MI) into the root canal until it was visible at the apical foramen and subtracting 1-mm from that length. The coronal 6-mm was flared using Gates Glidden drills (Maillefer, Ballaigues, Switzerland) sizes 2 and 3. The apical portion of the roots was instrumented to size 55 K-file using the step-back technique Apical patency was confirmed between files using a size 10 K-file. Between each file use, the canals were irrigated with 1 ml of 5.25% NaOCl solution and then irrigated with 1 ml of 17% EDTA (Roth International, Chicago, IL). The canals were dried with paper points, and standardized gutta-percha master cones were fitted with tug back at working length. The specimens were divided into five groups of 13 teeth each and filled with the AH Plus root canal sealer (Dentsply DeTrey, Konstanz, Germany) with the cold laterally condensed gutta-percha technique. After obturation, the roots were resected at 30° angle, a 3-mm-deep root end preparation was made under cold saline irrigation and filled with a root-end filling materials (Amalgam, Tissue adhesive, MTA, IRM, and Super-EBA respectively).

After obturation, the access cavities were sealed with Cavit-G (ESPE, GmbH, Seefeld, Germany) and the samples were stored in 100% humidity at 37°C for 7 days. Then, the temporary fillings were removed, and the roots were placed into computerized fluid filtration device²¹. An additional fourteen teeth were used for control (seven for negative control and seven for positive control). The specimens used for the positive control were prepared as described in experimental groups, but root canal spaces were not obturated. In negative control group, the apex of each tooth totally coated with three layers of nail polish, including the apical foramina.

Measurement of Sealing Properties

The sealing qualities of the five different root-end filling materials were measured using the computerized fluid filtration method described by Orucoglu *et al.*²¹ In this system, during the experiment all the operations were controlled with PC-compatible software (Fluid Filtration'03, Konya, Turkey). The pressure (120 kPa) was maintained constant throughout the experiment by means of a digital air pressure regulator (DP-42 Digital pressure and vacuum sensors Red LED display Sunx Sensors, USA) added to the pressure tank. A 5-min pressurization



preload of the system was completed before taking readings. Measurements of fluid movement were automatically made at 2 min during 8 min for each sample by means of PC-compatible software. Leakage quantity was expressed as $\mu\text{l.cmH}_2\text{O}^{-1} \cdot \text{min}^{-1}$. The quality of the seal of each specimen was measured at 7 days.

Statistical Analysis

One-way ANOVA and post hoc Tukey HSD Tests were used to determine whether differences were significant. The confidence level was used 95% ($P < 0.05$).

RESULTS

In this study, the statistically significant differences were not found among the retrofilling materials with using computerized fluid filtration meter ($P > 0.05$). The mean apical micro-leakage was $5.0 \pm 1.07 \times 10^{-4}$, $4.0 \pm 1.5 \times 10^{-4}$, $4.0 \pm 2.2 \times 10^{-4}$, $1.0 \pm 0.6 \times 10^{-4}$, and $4.0 \pm 1.1 \times 10^{-4} \mu\text{l.cmH}_2\text{O}^{-1} \cdot \text{min}^{-1}$ at 120 kPa, in groups 1 to 5, respectively (Table 1). The apical sealing of MTA as a retrograde filling material was determined the best material, while amalgam was seen worse than the other root-end filling materials in terms of apical micro-leakage. Although cyanoacrylate had been used more rarely as a retrograde filling, its sealing was seen like Super-EBA and IRM. And also this type of cyanoacrylate has been used firstly as retrograde filling material; previously it was not used in apical micro-leakage studies. Otherwise the computerized fluid filtration method has been current technique between the micro-leakage methods, for this reason results of the present study are more reliable than the results of previous leakage studies.

Table 1. The mean apical micro-leakage values.

Group No	Group Name	Mean \pm Standard Deviation
1	Amalgam	$5.00 \pm 1.07 \times 10^{-4}$
2	Tissue Adhesive	$4.00 \pm 1.50 \times 10^{-4}$
3	IRM	$4.00 \pm 2.20 \times 10^{-4}$
4	MTA	$1.00 \pm 0.60 \times 10^{-4}$
5	Super-EBA	$4.00 \pm 1.10 \times 10^{-4}$
6	Positive Control	$51.00 \pm 1.90 \times 10^{-4}$
7	Negative Control	0.00 ± 0.00

DISCUSSION

One of the most causes of the root canal treatment failure is apical leakage which may occur along the sealer-dentin and sealer-filling material interfaces or through voids within the sealer. And also the microorganisms in which accessory root canals into the apical piece may not be prepared and shaped completely can survival and it can cause endodontic treatment failure. Thus the apical resection, root-end cavity preparation and retrograde filling have to be applied in apical surgery.

The root-end filling material should provide an apical seal to an otherwise unobturated root canal or improve the seal of existing root canal filling material and be biocompatible with the periradicular tissues.

To present many kinds of root-end filling materials have been used as retrograde filling.¹⁰ And also, many in vitro methods have been used to evaluate the sealing ability of root-end filling materials by using dyes, scanning electron microscopy, fluid filtration techniques, electrochemical methods, radioisotopes, and bacteria in apical surgery studies.^{10,21-25} In this study, the computerized fluid filtration method that was described by Orucoglu *et al.*²¹ used for the sealing qualities of the five different root-end filling materials so as amalgam, tissue adhesive, IRM, MTA and Super-EBA.

Amalgam that is easy to handle and has good radio-opacity has been used in many years. Zinc is considered a major cause of cytotoxicity which is known to be cytotoxic for periradicular tissue.⁵ Pereira *et al.*²⁶ reported that Amalgam showed higher micro-leakage levels than Super-EBA and MTA by dye leakage method. And also Fogel & Peikoff²⁷ obtained that more micro-leakage was found retrograde filling with amalgam than with Super-EBA, dentin-bonded resin and MTA, using a fluid filtration system. Similarly Amalgam has demonstrated higher micro-leakage level according to the Super-EBA, MTA, IRM and Tissue Adhesive in this study. Overall, the studies showed that the biocompatibility and sealing ability of amalgam were poor in the early period and it was neither useful nor practical. Amalgam was not commonly preferred due to some disadvantages, but it was used in some previous studies.^{26,28}

Oynick and Oynick⁶ recommended that Super-EBA was used as a retrograde filling material in 1978.



Super-EBA which showed high compressive strength, high tensile strength, neutral pH, and low solubility has much better physical properties than ZOE. It adheres to tooth structure in spite of moist conditions. The leakage studies^{9,11,21-23} showed that Super-EBA and IRM provided an optimum seal. However, Super-EBA is not practical, not easy to mix and to necessitate more effort than tissue adhesive.

Crooks *et al.*²⁹ reported that IRM as a retrograde material has some useful properties including; easier placement, shorter setting time and decreased toxicity and solubility. It was found to be biocompatible comparatively and recommended it may be useful like a retrograde material in the apical surgery. Super-EBA is similar to IRM. Super-EBA adheres to itself very well and if necessary, it may be added incrementally, but IRM does not.⁷ In this study, Super-EBA was not significantly better than IRM or tissue adhesive and also the results of seal were approximately similar.

MTA has been shown to be very effective and it has various clinical applications as a result of ability to set in the presence of blood or moist, biocompatibility, its superior sealing property and bactericidal effects.³⁰⁻³² MTA is not affected from the presence of moisture while it is setting in.³² Torabinejad *et al.*³¹ demonstrated that MTA was less toxic than amalgam, Super-EBA and IRM for periradicular tissues. Moreover, a cytotoxicity study showed that MTA was not cytotoxic, but Super-EBA and amalgam had higher levels of cytotoxicity.³³ Additionally, MTA has few disadvantages that are the long setting time, difficulty to manipulate and placement to the root-end cavity for use as a root-end filling material. Similarly the tissue adhesive was no-toxic for periapical tissues but it is used easily and not necessary to practice.

Many studies have indicated the potential use of cyanoacrylate in dentistry, especially due to its sealing ability, biocompatibility, and bonding property.^{12,15} Winik *et al.*¹⁶ presented that cyanoacrylate had lower rates of marginal permeability and more tubular penetration, independently of the retro preparation method.

Kim & Kratchman⁴ stated that the favorable root-end filling material must be seal and should prevent leakage of microorganisms and their by-products into the root canal system from the periradicular tissues. And also its sealing ability should

be not affect by the wetness.

The type of the root-end filling material and careful preparation of the root-end cavity affect the success of the retrograde filling. An appropriate root-end cavity must be 3 mm deep, locate at the center of the root, and parallel to the long axis of the root.⁴

The depth of root-end cavity and the resection angle affect the sealing ability of retrograde filling materials. In a dye leakage study, the root-end cavity preparations did not extrude toward the coronal level of the bevel and more apical dye penetration was seen in the groups.¹² Tidmarsh & Arrowsmith³⁴ examined the resected the root-ends of teeth by using scanning electron microscopy. According to their study, one of the most important of apical leakage was open dentinal tubules between the resected root surface and the root canal so that the angle of apical resection should be a minimum bevel and the root-end filling should extend to the level of the coronal end of the bevel into the root canal. But the angles of root-end are between 30 and 45 degree in the clinic practices that's why the root-end cavity preparation and placement of retrograde filling is difficult after the apical resection with 0 degree. Hence the root-end was approximately resected at 30 degree angle and 3 mm depth in present study.

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

1. Although MTA has been found to be the least apical sealing ability in the present study, there were no the statistically significant differences among the other tested groups.
2. Tissue Adhesive can be used as a root-end filling material in apical surgery. Because it is non-toxic/biocompatible, economic, practical and easy manipulate.
3. However, long term success study has been not performed in apical surgery; this study was established in vitro situations.

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