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Apikal Rezeksiyonda Kullanılan Üç Farklı Retrograd Dolgu Malzemesinin Mikrosızıntısının AutoCad Programı ile Değerlendirilmesi

Evaluation of Microleakage of Three Different Retrograde Filling Materials in Apical Resection using an AutoCad Program

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ÖZ

GİRİŞ ve AMAÇ: Endodontik tedaviler yüksek başarı oranına sahip olmakla birlikte, tedavilerin başarısız olduğu ve yenilenmesinin mümkün olmadığı vakalarda dişleri ağızda tutabilmek için cerrahi endodontik işlemler gerekebilmektedir. Bu çalışmada; Cam İyonomer Siman (CİS), Mineral Trioksit Agregate (MTA) ve Biodentine (BD)'in retrograd dolgu materyali olarak apikal sızdırmazlık direncinin in vitro koşullarda karşılaştırılması amaçlanmıştır.

YÖNTEM ve GEREÇLER: Çalışmada 70 adet tek köklü daimi insan dişi kök ucundan 3 mm kesildi. Kök ucu kaviteleri ultrasonik uç yardımıyla hazırlandıktan sonra CİS, MTA ve BD ile dolduruldu. Tüm örnekler %2'lik metilen mavisinde 48 saat 37°C'de bekletildi. 1 mm kalınlığındaki kök kesitleri stereomikroskop altında dijital olarak fotoğraflandı. Boya penetrasyon alanı, AutoCad programı kullanılarak metilen mavisi ile boyanan yüzeylerin tüm dentin yüzeyine oranlanması ile hesaplandı. Gruplar arasındaki farklılığı saptayabilmek için Kruskal-Wallis H ve çoklu karşılaştırma (post-hoc) testlerinden yararlanıldı ($p<0,05$).

BULGULAR: Deney gruplarında % 0 ila % 95,45 arasında değişen derecelerde mikrosızıntının olduğu belirlendi. MTA ve BD gruplarının, CİS grubuna göre istatistiksel olarak anlamlı derecede daha az sızıntı gösterdiği ancak MTA ve Biodentine grubu arasında sızıntı açısından istatistiksel olarak anlamlı bir fark bulunmadığı saptandı.

TARTIŞMA ve SONUÇ: Bu in vitro çalışmada, retrograd dolgu materyali olarak MTA ve BD'nin apikal sızdırmazlık yeteneğinin CİS'e göre belirgin ölçüde üstün olduğu görülmektedir.

Anahtar Kelimeler: Apikal rezeksiyon, apikal mikrosızıntı, mineral trioksit agregat, cam iyonomer siman, biodentine

ABSTRACT

INTRODUCTION: Endodontic treatments have a high success rate but endodontic surgery procedures may be necessary to preserve teeth when the treatments are unsuccessful. The purpose of this study was to compare the sealing ability of glass ionomer cement (GIC), mineral trioxide aggregate (MTA),and BiodentineTM (BD) in vitro.

METHODS: 70 human single-rooted permanent teeth were resected at 3 mm from the apex. Root-end cavities were prepared using an ultrasonic tip and filled with GIC, MTA, or BD. All specimens were soaked in %2 methylene blue at 37°C for 48 hours. The 1-mm thick roots sections were digitally photographed under a stereomicroscope. With the use of an AutoCad program dye penetration area was calculated as the methylene blue-infiltrated surface divided by total dentin area. The Kruskal–Wallis H test and post-hoc multiple comparison test were used to determine which groups differed from each other ($p < 0.05$).

RESULTS: The experimental groups presented different microleakage values varying between 0% and 95.45%. MTA and BD showed a statistically significant difference in microleakage compared with GIC, but no significant difference was obtained between MTA and BD.

DISCUSSION AND CONCLUSION: When used as a retrograde filling material, MTA and BD were significantly superior in terms of apical microleakage compared with GIC.

Keywords: Apicectomy, apical microleakage, glass ionomer cement, mineral trioxide aggregate, biodentine

INTRODUCTİON

Conventional endodontic treatment has a high success rate; however, failures have also been observed and retreatment may be indicated. In cases where retreatment is not feasible or fails again, endodontic surgery may be necessary to preserve the tooth.[1, 2]

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Endodontic surgery involves resecting a portion of the root apex, preparing retrograde cavity and inserting a suitable retrograde filling material.[3] Conventionally, a retrograde cavity is prepared by small round or inverted conical burs in high-speed micro handpieces. The retrograde cavity depth should be approximately 2.5-3 mm and parallel to the long axis of the root. However, using rotary instruments can lead to several problems including nonparallel cavity walls, difficult access to the root end and perforation of the involved root.[4, 5] Additionally, inclined plane sectioning may be required to facilitate the insertion of material into the cavity.[6] On the other hand, with the recent development in the ultrasonic surgical tips better shaped retrograde cavities can be prepared easily and safely. Moreover, cutting bevel on the resected root apex can be made perpendicular to the long axis of the root canal with these ultrasonic tips which decreases the number of exposed dentinal tubules and consequent apical leakage.[1, 3-5] Retrograde filling materials are used after periapical surgery for achieving a good seal to prevent the entry of bacteria or bacterial products from the root canal to the periapical region. Long-term clinical success is related to biocompatibility, apical microleakage, and various physical properties, such as dimensional stability and resistance to moisture of the retrograde filling materials.[7, 8] For an ideal retrograde filling material, there are many new or improved materials that have been introduced in the market, including calcium hydroxide cements, modified zinc oxide eugenol-based cements [Intermediate Restorative Material (IRM), Super-EBA, Rickert], composite resins, different types of glass ionomer cement (GIC), Portland cement, and more recently, mineral trioxide aggregate (MTA).[2, 7, 9, 10] MTA is well-known and has a good biological compatibility and sealing property. However, a long setting time (170 min) and difficulty in manipulation are some disadvantages of MTA.[9, 11] To overcome these drawbacks, new calcium silicate materials have been introduced in the market. Biodentine (BD) is one such material, which is mainly composed of highly pure tricalcium silicate, in addition to calcium carbonate and zirconium dioxide. The liquid is a solution of calcium chloride with a water-reducing agent. The reduced curing time (12–15 min) as well as good handling and mechanical properties may make BD a good alternative to MTA as a retrograde filling material.[7, 9, 11]

Various methods such as dye penetration, fluid filtration, bacterial penetration, bacterial leakage, scanning electron microscopy, and confocal laser scanning microscopy can be used to evaluate root-end sealing ability and marginal adaptation of sealing materials.[7, 12]

This study aimed to compare the sealing ability of three different retrograde filling materials using a dye penetration method in which an AutoCad program (AutoCad 2012®, AutoDesk Inc, San Rafael, CA, USA) was used to measure the degree of microleakage from retrograde cavities filled with GIC, MTA or BD. The hypothesis tested was that BD exhibits the least degree of microleakage when compared to MTA and GIC.

METHODS

A total of 70 freshly extracted human single-rooted permanent teeth, except mandibular incisors, with mature apices were selected for the present study. Teeth with multiple canals, fractures, calcifications, resorptions or significant apical curvatures were excluded. Initially, selected teeth were ultrasonically cleaned and following disinfection with 5.25% sodium hypochlorite for 6 h, they were stored in normal saline until required.

The teeth were decoronated at the cemento-enamel junction using a diamond disc under continuous water irrigation to standardize the working length of the roots to approximately 15 mm. After the extirpation of the intra-canal tissue with a barbed broach, working length was identified by visualization and 15 K-flex file used at the apical foramen. The root canals were shaped by a nickel-titanium rotary system (ProTaper rotary system, Dentsply/Maillefer, Tulsa, OK, USA) under irrigation with 3% sodium hypochlorite. A final irrigation was performed with 17% EDTA (Prime Dental Products, India) and 3% sodium hypochlorite followed by normal saline. The root canals were then dried with sterile paper points, and obturation was performed using a lateral condensation technique with gutta percha and AH Plus™ sealer (Dentsply, DeTrey, Konstanz, Germany). A temporary filling material (Cavit G, 3M ESPE Dental AG, Seefeld, Germany) was used to access the cavity sealing, and samples were then stored in 100% humidity for a week.

The apical 3-mm portions of the roots were resected perpendicular to the long axis using a No.701 fissure bur (SS White Dental, Lakewood, NJ, USA) under constant water irrigation. Thereafter, the retrograde cavities were prepared to a depth of 3 mm using an ultrasonic diamond tip (*E31D retrograde endo tip*, *NSK*, Nakanishi Inc, Tokyo, Japan) (Figure 1) in VarioSurg 3 unit (*NSK*, Nakanishi Inc, Tokyo, Japan) at medium power according to the manufacturer's recommendation.

Figure 1. The ultrasonic diamond tip used for preparation of the retrograde cavities

The teeth were randomly divided into three experimental groups, each group containing 18 teeth, with two positive and negative control groups. The retrograde cavities in group 1 teeth were filled with GIC (Riva Self Cure, SDI Inc., Itasca, IL, USA), whereas those of groups 2 and 3 were filled with white MTA (Angelus, Londrina, PR, Brazil) and BD (Septodont, Saint-Maur-des-Fosses, France), respectively according to the manufacturer's instructions. Additionally, eight teeth in the positive control group did not receive any material, whereas eight in the negative control group were completely waterproofed including the apex.

Figure 2. The AutoCad view of a root-end cavity filled with GIC

After the retrograde filling procedure, the samples were kept in 100% humidity at 37°C for 1 week. They were covered with two coats of nail varnish except at the tip where the root-end filling material was inserted. Next, they were immersed in 2% methylene blue at 37°C for 48 h, and excess dye was removed by washing under running tap water for 1 h.

EVALUATION OF MICROLEAKAGE

The teeth were embedded into a block of epoxy resin (Araldite M, Agar Scientific Limited, Essex, UK) and following polymerization, two 1-mm horizontal sections were cut from the apex using a slow-speed, water-cooled rotary diamond blade (Isomet, Buehler Ltd., Lake Bluff, IL, USA). A digital camera (GCX35E, JVC, Yokohama, Japan) attached to a stereomicroscope (Leica MZ 12, Leica Microsystems, Glattbrugg, Switzerland) was used to capture the images of sections under 40× magnification. The digital images were transferred to a personal computer and stored in TIFF format. AutoCad 2012® (AutoDesk Inc., San Rafael, CA, USA) software was used for collecting data and measuring the methylene blue-infiltrated surface. The extent of dye penetration was determined by the ratio of methylene blue-infiltrated surface divided by the total surface area (Figure 2- 4).

Figure 3. The AutoCad view of a root-end cavity filled with MTA

The mean dye penetration (%) for each group was calculated and statistical analysis was performed using nonparametric Kruskal–Wallis H test because the data was not normally disturbed according to Shapiro Wilk's test ($p < 0.05$ for all variables). After Kruskal–Wallis H test, the post-hoc multiple comparison test was employed to determine which groups differed from each

other (PASW Statistics 20; SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at $p < 0.05$.

Figure 4. The AutoCad view of a root-end cavity filled with Biodentine™

RESULTS

Analysis of microleakage values indicated that all positive control specimens showed complete dye penetration, whereas negative control specimens showed no dye penetration. The experimental groups presented different microleakage values varying between 0% and 95.45% (Table 1). MTA and BD showed a statistically significant difference in microleakage compared with GIC ($p < 0.05$), although no significant difference was obtained between MTA and BD ($p > 0.05$) (Table 2).

DISCUSSION

This study compared the sealing ability of three root-end filling materials, including GIC, MTA, and BD. The results revealed that MTA presented the least microleakage value whereas GIC recorded the highest degree of microleakage. Our hypothesis was that BD has the best sealing ability when compared to other tested materials. As a consequence of the current results, the tested hypothesis was rejected.

A periapical surgery involves the elimination of pathological periradicular tissue, root-end resection, preparation of a root-end cavity, and placement of root-end filling to provide an apical seal.[3] However, the clinical significance of microleakage in apical surgery has not been completely clarified in the literature. Nevertheless, retrograde filling materials with good sealing ability may provide lesser leakage at the root apex and avoid the migration of microorganism and their products into periradicular area.[13] Therefore, the success of apical resection mostly relies on the sealing ability of retrograde filling materials.[1, 6, 9]

For the evaluation of apical microleakage and degree of marginal adaptation several methods including dye penetration, radioisotopes, bacterial penetration, scanning electron microscopy, confocal laser scanning microscopy, stereomicroscope and fluid filtration techniques are being used currently.[7] Due to their cost effectiveness and ease of application, dye penetration tests have been frequently preferred in the studies.[6, 8] Various dyes (i.e. methylene blue, rhodamine, acridine orange, fuchsine, silver nitrate, indian ink) with specific chemical and physical proprieties have been suggested with this purpose.[14] In the present study, we combined dye penetration method (with methylene blue) and the use of an AutoCad program for more standardized measurement of the microleakage of retrograde cavities. However, some limitations including discoloration of dye during the process, and difficulty in observing the maximum penetration of dye have been also identified in the dye penetration methods.[6, 7, 10, 11]

		Group					
		n	Mean	Median	Min	Max	SD
Microleakage Value (%)	GIC	18	69.82	73.53	13.68	95.45	21.71
	MTA	18	17.13	8.75	0	86.51	24.01
	Biodentine	18	19.1	15.8	0.84	69.75	16.87
	Total	54	35.35	21.83	0	95.45	32.15

Table 1. Mean microleakage values of three groups

The sealing ability of retrograde filling material, the plane and depth of resection are important determinants in the degree of microleakage. In periapical surgery, a 3-mm root-end resection is recommended by several studies.[1, 6, 9, 15] This resection depth ensures significant reduction of apical ramification and lateral canals. Furthermore, it has been proved that perpendicular sectioning decreases the number of exposed dentin tubules.[1, 6, 16] Ultrasonic retro-tips offer several advantages over conventional burs; they promote more conservative and precise cavities, which prevent the weakening of the apical root structure.[9, 17] Therefore, in this study, 3-mm root-end was sectioned perpendicular to the long axis of the tooth, and a retrograde cavity was prepared using a diamond-coated ultrasonic tip.

Groups	Kruskal–Wallis H Test		
	Sum of Ranks	H	p
GIC	43.39 [a]	28,3	0.001 [a-b; a-c]
MTA	17.28 [b]		
Biodentine	21.83 [c]		

Table 2. Comparison of three groups with respect to microleakage value using the Kruskal–Wallis H Test ($p < 0.05$)

GIC has a wide range of clinical applications in dentistry due to its several unique properties, such as biological compatibility, antibacterial activity via fluoride release, and ability to chemically bind to the tooth structure.[7, 18] It also has a good marginal sealing ability and low cost; however, manipulation difficulty and extreme moisture sensitivity may restrict its use in a root-end cavity.[7, 19]

In 1995, MTA was first developed by Torabinejad et al. [20] The white version of this material was introduced in the market in which the concentrations of iron, aluminum, and arsenic were decreased. Additionally, smaller particle size of white MTA (wMTA) provides a higher specific surface area, which enhances not only wetting volume and water-binding capacity but also its cohesiveness and handling properties.[1, 21, 22] Similar to the current study, in the study of Post et al[6] dye penetration method was combined with a computer image program for comparing the effect of MTA and amalgam in retrofilling on apical sealing. Although no group showed a complete sealing of root-end areas, significantly less apical leakage was reported with MTA.[6]

BD is a relatively new tricalcium silicate-based material which has a short setting time, good handling, and superior mechanical properties compared with other tricalcium silicate-based materials.[7, 23] Some authors reported that BD has lower microleakage values and better marginal adaptation than those of MTA.[7, 24, 25] Parallel to our study, Pradhan et al.[26] found no statistically significant difference between two types of MTA and BD. Mandava et al.[1] compared the microleakage values of MTA, BD, and light cure GIC using different cavity preparation techniques and concluded that MTA with ultrasonic preparation is a better alternative as retrograde filling material to prevent apical leakage.[1] In another study, Soundappan et al.[9] evaluated the marginal adaptation of MTA, IRM, and BD at different levels and found that MTA was superior to both IRM and BD at the 2-mm level.[9] This superiority may be attributed to the formation of hydroxyapatite-like crystals between MTA and the root canal wall, which result in better adhesion and lower apical leakage.[1, 26] In accordance with the previous studies, GIC demonstrated significantly greater microleakage than that by MTA and BD in the present study.[1, 2, 7, 26, 27]

The difference in the results of these studies may be attributed to several factors, including sample size, angle of apicoectomy, depth of root-end cavity, choice of instruments (i.e., slow or high speed handpieces, sonics, or ultrasonics), type of sectioning, and method of evaluation.[1, 9, 10, 15, 28]

CONCLUSION

Taking into account the limitations of this study, MTA exhibited the least degree of microleakage, whereas GIC recorded the highest degree of microleakage. There was no statistically significant difference in microleakage between MTA and BD. However, further clinical investigations should be designed to evaluate the long-term success of these retrograde filling materials.

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Conflicts of interest
There are no conflicts of interest.

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