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University "Ss. Cyril and Methodius" Skopje,
Faculty of Dental Medicine, Republic of Macedonia
Department of Restorative Dentistry and Endodontics[1]
Department of Pediatric and Preventive Dentistry[2],
University of Belgrade, School of Dental Medicine, Republic of Serbia, Department of Prosthodontics[3]

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ADAPTABILITY OF DIFFERENT CANAL SEALERS TO THE ROOT CANAL DENTIN – SCANNING ELECTRON MICROSCOPY ANALYSIS

ADAPTABILNOST RAZLIČITIH KANALNIH PUNJENJA ZA DENTIN KORENSKOG KANALA – ANALIZA ELEKTRONSKI SKENIRANIH MIKROFOTOGRAFIJA

Sonja APOSTOLSKA[1], Elizabeta GJORGIEVSKA[2], Vasilka RENDŽOVA[1], Marina EFTIMOSKA[1], Rade ŽIVKOVIĆ[3] and Ivica STANČIĆ[3]

Summary

Introduction. The aim of this in vitro study was to test and analyze the sealing ability of three endodontic materials used for permanent obturation, in between the dentin walls and the gutta-percha points, using a scanning electron microscope. **Material and Methods.** Forty-five recently extracted single-root teeth, treated by a step-back technique, were divided into three groups (15 teeth in each); the canals were filled with three different permanent obturation materials: N2 - zinc oxide root canal cement, Gutta Flow (Coltene), and Endomethasone N (Septodont). Their sealing ability and adhesive properties were analyzed using field emission gun scanning electron microscope, at the time when they were applied between the dentin walls of the canal and the gutta-percha. **Results.** The results of the scanning electron microscope analysis have shown that all the three sealers have good adhesion properties when used over the root canal walls in the apical third. Good adaptation of the filling used for the root canal walls in the middle and the cervical third was found only in teeth obturated using Gutta Flow, while samples obturated by N2 - zinc oxide root canal cement and Endomethasone showed the weakest adhesion, and greatest number of cracks between the sealer and the canal wall. **Conclusion.** When using a single-cone obturation technique, compared to other obturation materials, Gutta Flow shows considerably better adaptation to the root canal wall and the gutta-percha points in the apical, middle, and the cervical third of the root.

Key words: Root Canal Filling Materials; Root Canal Preparation; Root Canal Obturation; Dentin; Microscopy, Electron, Scanning; Gutta-Percha

Sažetak

Uvod. Cilj ove *in vitro* studije je testiranje i analiziranje sposobnosti zaptivanja tri različita endodontska materijala koji se upotrebljavaju za definitivno punjenje između dentinskih zidova i gutaperke poena, primenom elektronskog mikroskopa. **Materijal i metode.** Četrdeset pet ekstrahovanih jednokorenih zuba, tretiranih *step-back* tehnikom bili su podeljeni u tri grupe (po 15 zuba u svakoj od njih), kanali su bili ispunjeni trima različitim materijalima za definitivnu opturaciju kanala: cink-oksid eugenolom, *Gutta Flow (Coltene)* i *Endomethasone N (Septodont)*. Elektronskim mikroiskopom sa emisijom polja analizirani su adhezivna sposobnost i zaptivanje materijala za punjenje između dentinskih zidova korencskog kanala i gutaperke. **Rezultati.** Analiza elektronski skeniranih mikrofotografija pokazala je da sva tri materijala imaju dobru adheziju karakterističnu za njihovu primenu na zidovima kanala korena u apikalnoj trećini. Dobra adaptacija punjenja za zidove kanala korena u srednje i cervikalne trećine pronađena je samo na uzorke opturisanih metodom *Gutta Flow*, a uzorci koji su bili opturisani sa cink-oksid eugenolom, i *Endomethason*-om N imali su najslabiju adheziju i najveće prisustvo pukotina između silera i zida kanala. Kada se primenjuje *single-cone* tehnika za opturaciju kanala, *Gutta Flow* pokazuje znatno bolju adaptaciju za zid korenskog kanala i gutaperke u apikalni deo kao i u srednjoj i cervikalnoj trećini korena u poređenju sa drugim materijalima za opturaciju kanala.

Ključne reči: materijali za punjenje kanala korena zuba; preparacija kanala korena zuba; opturacija kanala korena zuba; dentin; skenirajuća elektronska mikroskopija; gutaperka

Introduction

The endodontic treatment is a complex procedure which includes preparation, instrumentation, and root canal obturation.

A successful outcome of endodontic therapy depends on numerous factors, including appropriate canal instrumentation, successful irrigation and decontamination of the whole root canal system, as well

Corresponding Author: Prof. dr Sonja Apostolska, Univerzitet "Sv. Ćiril i Metodije", Stomatološki fakultet, 1000 Skopje, Majke Tereze 43, Republic of Macedonia, E-mail: sapostolska@stomfak.ukim.edu.mk

Abbreviations

SEM	– scanning electron microscope
NiTi	– nickel titanium
EDTA	– ethylenediaminetetraacetic acid
FEG-SEM	– field emission gun - scanning electron microscope
N2	– zinc oxide root canal cement
NaOCl	– sodium hypochlorite
AHplus	– epoxy-amine resin

as complete obturation, using biocompatible materials [1, 2].

One of the main purposes of the root canal filling materials is to prevent penetration of microorganisms and their products, in order to prevent reinfection of the root canal system. That is why the biocompatibility of the obturation material, the antimicrobial effect, as well as the sealing and adaptation ability of the material used over dentin walls, are important preconditions for achieving that goal [3].

For years, gutta-percha has been the most commonly used material for permanent obturation of root canals. As it does not have the ability to bond to dentin, it is mostly used in combination with sealers or cements that fill the space gap between the gutta-percha and the root canal wall, and between the gutta-percha and the dentin walls [4].

In order to achieve quality permanent sealing, as well as complete obturation of the whole canal space, it is necessary to prevent micro crack formation, which in turn prevents micro leakage that occurs between the canal walls, the filing material, and the gutta-percha points after certain period of time [5].

One of the most important properties that permanent obturation cements must possess is viscosity (the fluidity) of the material, in order to fill in the space between the gutta-percha and the dentin walls better, and be able to reach and fill in all the irregularities of the canal space and to obturate the holes of the lateral and the accessory canals [6].

Gutta Flow (Coltene/Whaledent, Altstatten, Switzerland) is a a cold liquid self-bonding cement composed of powdered gutta-percha, polydimethylsiloxane and nanosilver particles. The structure and the size of the particles enable good adaptability because of its leakage ability and expansion of 0.2% when bonding [7].

The solubility of Gutta Flow is virtually equal to zero, which should ensure good sealing for a longer period of time.

The sealing ability is the main characteristic that needs to be tested for every material or technique that is used for permanent obturation of the root canal system. Nowadays, many techniques are used for evaluation of the adhesion level of the root canal filling materials. These methods include penetration of ink, the fluid filtration method, the radioactive isotopes method, penetration of bacteria and scanning electron microscope (SEM) analysis [8, 9].

The SEM analysis enables evaluation of the sealing and the adhesion properties of the sealer to the root canal wall, as well as to the gutta-percha point, at various levels of sectioning [10].

The purpose of this in vitro study was to test and analyze the sealing ability of three endodontic materials used for permanent obturation, applied between the dental walls and the gutta-percha points, using SEM.

Material and Methods

This in vitro study examined forty-five single-root upper anterior intact teeth (incisors) recently extracted due to periodontal reasons. The teeth were cut transversely, down to the level of the enamel-cement junction, using a high speed diamond burr, under water coolant and the crowns were removed from the root part of the teeth. The working length of the canals was established 0.5 mm short of the apex, using K-file # 10. The instrumentation was performed using nickel titanium (NiTi) hand files size #40, by a step-back technique. During the canal preparation, 5 ml 3% sodium hypochlorite was used as an irrigant. Towards the end of canal preparation, root canals were irrigated with 1 ml 15% ethylenediaminetetraacetic acid (EDTA) followed by 2 ml 3% sodium hypochlorite to remove the smear layer. Finally, the root canals were rinsed with 2 ml deionized water and dried with paper points. The roots were divided into three groups (15 in each) and the canals were filled with three different permanent obturation materials: the first group was obturated with Endomethasone N (Septodont) and gutta-percha point, the second with Gutta Flow system (Coltene), and the third group with zinc oxide root canal cement (N2) (Hager&Werken) and gutta-percha point. The root canal sealer was applied using a #25 lentulo spiral. Then, a single Master gutta-percha point #35 was inserted in each of the canals down to the previously determined length. The excessive gutta-percha cones were removed and the cervical part of the root samples were obturated using glass-ionomer cement (Fuji IX GP, GC Japan).

The root samples were placed and kept in a physiological saline for 7 days, at a temperature of 37°C, in order to enable bonding of the material intended to be used for permanent obturation. After this period of time, the teeth were cut transversely on three levels: in the cervical third, in the middle third, and in the apical third, i.e. 10, 5, and 2 mm from the apex.

These surfaces that were previously cut were polished and appropriately prepared for field emission gun scanning electron microscope (FEG-SEM) analysis. The adhesion and the sealing properties of the sealer used between the dental walls of the canal and the gutta-percha were analyzed under different magnifications, ranging from x 100 to x 200. These representative micrographs were taken in order to classify the results, using modified Ray and Seltzer criteria [11] as follows:

- **Grade 1.** Exceptionally good adhesion – flat line of contact at the border between the sealer

and the dentin, without presence of flaws and space gaps, with considerable penetration of the material in the openings of the dental tubules;

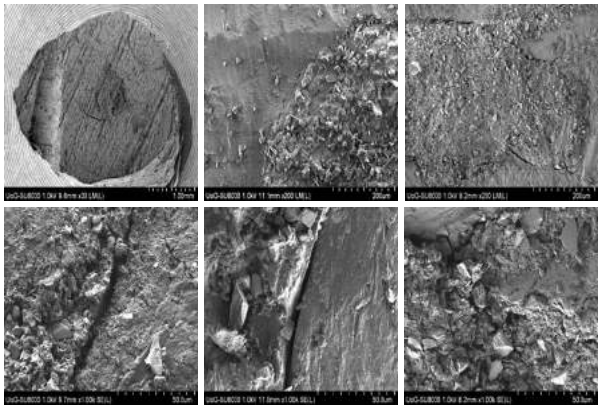
- **Grade 2.** Good adhesion – slightly uneven contact surface on the border between the sealer and the dentin wall, with a few noticeable cracks and space gaps;
- **Grade 3.** Relatively good adhesion – space gaps on the contact surface between the sealer and the dentin of the canal walls was noticed, with unclear and uneven contact surface on the area of bondage.

Results

The micrographs of root samples obturated with N2, Gutta Flow, and Endomethasone cut transversely in the apical third are shown in **Figure 1**. Good adaptation and bondage of sealers with the dentin walls was noticed.

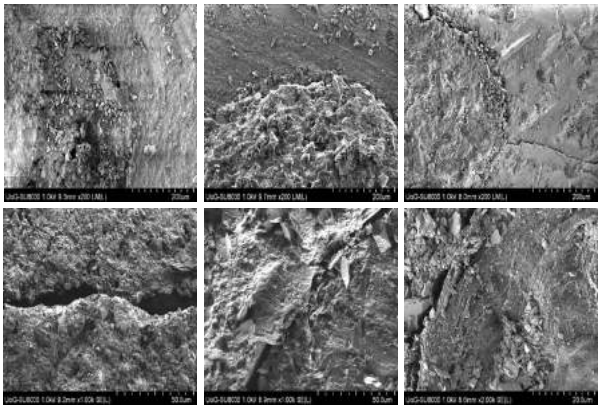
At the contact surface of the gutta-percha and the three types of sealers, presence of a few cracks was evidenced. The adhesion at the apical third of all of tested materials was ranked with grade 2.

At cross sections of samples made in the middle third **(Figure 2)**, a slightly uneven contact surface on the bondage area of the sealer and the dentin walls was found, as well as presence of a small number of cracks and space gaps in root canals filled with Endomethasone and N2 (relatively good adhesion – grade 3). A bit better edge closure and less number of cracks were evidenced in samples filled with Gutta Flow (good adhesion – grade 2). At the contact area between the Gutta Flow and the gutta-percha points, a continuous contact was evidenced, without presence of cracks or space gaps (grade 1).



Endomethasone | Gutta Flow | N2
Endometazon | *Tečna gutaperka* | *Cink-oksid eugenol*

Figure 1. SE micrographs of permanent obturation of the root canals by Endomethasone, Gutta Flow and N2 (Transverse cross-section in the apical third)
Slika 1. *Elektronski skenirane mikrofotografije permanentno opturiranih zubnih kanala korišćenjem: endometazona, tečne gutaperke i cink-oksid eugenola (transverzalni poprečni presek apikalne trećine korena)*



Endomethasone | Gutta Flow | N2
Endometazon | *Tečna gutaperka* | *Cink-oksid eugenol*

Figure 2. SE micrographs of permanent obturation of the root canal using Endomethasone, Gutta Flow and N2 (Transverse cross-section in the middle third)
Slika 2. *Elektronski skenirane mikrofotografije permanentno opturiranih zubnih kanala korišćenjem: endometazona, tečne gutaperke i cink-oksid eugenola (transverzalni poprečni presek srednjeg dela korena)*

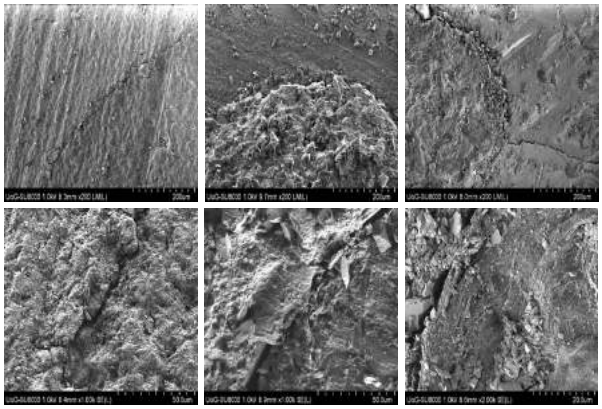
In the cervical third **(Figure 3)**, the adhesion of sealers Endomethasone and Gutta Flow to the dentin was good, with slightly uneven contact surface and small number of cracks (grade 2), while the adhesion in the root canals filled with N2 could be ranked as relatively good, because of the presence of space gaps between the dentin and the sealer (grade 3).

Discussion

Obturation of the root canal is the last phase of the endodontic therapy, which is particularly significant for the long-term success of the endodontic therapy. For many years, gutta-percha is the most commonly used material for permanent obturation of the root canals. Due to its inability to bond to the dentin, it has been used in combination with sealers or cements that fill in the space gap between the gutta-percha and the root canal wall [12].

Based on the previous tests, modern endodontics prefers lesser thickness of the sealer, due to its contraction and dissolution, and occurrence of micro leakage. Of all filling techniques, the largest volume of the sealer compared to the gutta-percha point appears in the single cone technique, which enables occurrence of space gaps in the filling, thus resulting in lower quality. By calibrating the gutta-percha points in the preparatory period, one enables to lower the volume of the sealer even in the single cone technique [13].

Today, there are more techniques that are used for evaluation of the root canal walls filling such as penetration of ink, fluid filtrating method, radioactive isotope method, penetration of bacteria. The SEM analysis allows evaluation of the sealing and adhesion ability of the sealer to the wall of the root



Endomethasone *Endometazon* | Gutta Flow *Tečna gutaperka* | N2 *Cink-oksid eugenol*

Figure 3. SE micrographs of permanent obturation of the root canals using Endomethasone, Gutta Flow and N2. (Transverse cross-section in the cervical third)
Slika 3. *Elektronski skenirane mikrofotografije permanentno opturiranih zubnih kanala korišćenjem: endometazona, tečne gutaperke i cink-oksid eugenola (transverzalni poprečni presek cervikalnog dela korena)*

canal and the gutta-percha point on various levels of sectioning.

The adaptation of the sealer to the root canal walls depends of the presence or the absence of a smear layer. Previous tests have shown that the use of sodium hypochlorite (NaOCl) in combination with EDTA as a solution for irrigation of the root canals is exceptionally effective for removal of the smear layer [14]. In the present study, 3% NaOCl in combination with EDTA for root canal irrigation was used.

The results of SEM analysis have shown that all the three sealers have good adhesion to the root canal walls in the apical third. In the middle and the cervical third, there was good adaptation of the sealer only in the samples obturated with Gutta Flow, while the samples obturated with N2 and Endomethasone show weak adhesion of the sealer and noticeable presence of cracks in-between the sealer and the canal wall. Exceptionally good adhesion of the sealer was not found in any of the samples.

In their study, Vujasković et al. came to a conclusion that Gutta Flow shows great adhesion to the root canal wall and the gutta-percha point, without presence of gaps and cracks [15].

El Ayouti found that even with the presence of a small number of gaps in the same material, Gutta Flow shows good adaptability to the wall of the canal. As a sealer based on a resin, Gutta Flow has a homogenous structure with particles of gutta-percha that allow leakage of the sealer in the open dentin tubules and lateral canals, and complete obturation of the space between the canal wall and the gutta-percha point [16].

According to Varun Kapoor, Gutta Flow is a good alternative for thermoplastic gutta-percha, in all of the cases where application of lateral compaction was contraindicated, providing good apical obturation [17].

Better sealing of apical depressions and lateral canals while applying Gutta Flow was evidenced by various authors [18–20].

According to Dhanya Kumar, Gutta Flow enables significantly better sealing in the apical 3 mm of the root canal as a result of a better leakage in the lateral canals and present depressions in the apical third of the tooth. Unlike in the apical third of the tooth, the technique of vertical condensation of gutta-percha has shown better adaptation to the walls of the root canal in the middle third of the tooth compared to Gutta Flow [21, 22]. The research of Upadhay and associates pointed to significantly more superior sealing of the root canal over the whole length when using Gutta Flow, compared to zinc oxide eugenol sealer and lateral condensation of the gutta-percha [10].

Single-cone technique includes application of one gutta-percha point, at a room temperature, and a sealer (of various thickness), depending on the adaptation of the point to the walls of the root canal. Studies show lower effectiveness of the single-cone technique in the sealing of the canal system because of a greater thickness of the sealer, which may be expected in the absence of the gutta-percha's condensation and presence of variability in the shape of the root canals, that aren't always corresponding to the shape of the instruments that are used for this treatment and the master points. Porosities, contraction, cement dissolution and a lower adaptation of the master point in the middle and the cervical third, especially in root canals with irregular shape, are main flaws of this technique [13].

In the present study, Gutta Flow has shown better adaptation to the walls of the root canal in the middle and the cervical third of the tooth, compared to the other two sealers. Along with liquid consistency, the size of the particles (< 0.9 μm), and the ability of Gutta Flow to expand while bonding by 0.2% additionally improving the adaptation, this may be the reason for better adhesion in the middle and the cervical third of the samples obturated with Gutta Flow. To the opposite, another in vitro research shows that Gutta Flow has maximum apical leakage compared to epoxy-amine resin (AH plus) as a sealer, which may be due to the weak chemical bondage between the gutta-percha particles and the master gutta-percha [23].

Savariz et al. have tested the sealing ability of Gutta Flow and AH plus, in combination with various sealing techniques, for a period of 3, 30, and 120 days. Their test results showed that after a certain period of time Gutta Flow shows greater capacity for sealing apically and coronary compared to AH plus, regardless if the single cone technique or lateral condensation was applied. The application of Gutta Flow as the only solution for filling the root canal without application of a master point has resulted in greater coronal and apical leakage [24].

Conclusion

The results of scanning electron microscope analysis have shown that in single cone technique of obturation, Gutta Flow shows better adaptation to the wall of the root canal and the gutta-percha points than Endomethasone and zinc oxide root canal cement, and that it is better in the apical compared to the middle and the cervical third of the root.

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