

Investigation of surface topography of different root-end filling materials: An in vitro study

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Abstract

Aim: Although there are many materials that can be used for retrograde filling in surgical endodontics, none of them can be regarded as an ideal material yet. The purpose of this study was to compare the surface topography of three different root-end filling materials. **Methods:** 36 extracted single rooted human incisor teeth were cleaned and decoronated to standardized 10 mm root lengths. The root segments were prepared and 2 mm apical resection were performed. The samples were randomly separated to three groups (Group A: Ca(OH)₂, Group B: MTA Angelus, Group C: ProRoot MTA), each one of them was comprised of 12 roots. Materials were placed as 2 mm apical barriers and obturated with guttapercha and AH-Plus sealer. Each group was divided into two subgroups (A1,A2,B1,B2,C1,C2). Groups A1,B1,C1 were stored in normal saline (NS), groups A2,B2,C2 were stored in neutral phosphate buffer saline (NPBS) solution and samples were incubated at 37°C for 2 weeks. Stereomicroscope (32X) was used to photograph the root-end filling. **Results:** All specimens demonstrated white crystals formation and sediment over the root-end filling materials and on the superficial border of the root-end cavities' wall as a white plaque. A2,B2,C2 samples had more crystal sediment on root-end fillings than samples A1,B1,C1. Dissolution and corrosion were observed in groups A1, A2. **Conclusions:** The results of this study revealed that calcium hydroxide is more resorbable than MTA Angelus and ProRoot MTA. The crystals formation and precipitation were observed in neutral phosphate buffer saline solution which were more than normal saline solution for all groups as a hydroxiapatite crystals.

Key words: Root canal filling materials, root canal medicaments, Mineral trioxide aggregate

Citation: Kuruyucu M, et al. (2019) Investigation of surface topography of different root-end filling materials: An in vitro study. Dentistry 3000. 1:a001 doi:10.5195/d3000.2019.89

Received: August 7, 2018

Accepted: September 18, 2018

Published: July 25, 2019

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Introduction

Endodontic surgery is performed in cases when treatment with orthograde root canal is treatment-resistant to periradicular inflammation or non-surgical root canal treatment is unsuccessful [1,2]. In periradicular surgery, a root-end cavity preparation is performed then a retrograde filling material is used

for filling. The periradicular surgery aims to block the ways in which transmission can occur between the root canal system and surrounding tissues [3]. Surgical endodontic treatment technique is a feasible treatment option, and the type of root-end filling material can affect the end result [4]. Root-end filling materials get in touch with periapical bone tissue after apex resection surgery.

Various materials are invariably used for instance amalgam, bonding systems, zinc oxide eugenol cements, glass ionomer cements, and calcium-silicate cements, all of which are commonly named as mineral trioxide aggregate based cements [5,6].

An ideal root-end filling material should demonstrate particular characteristics. The material

should adjust to the living tissue with its biocompatibility and therefore be able to start tissue repairing of periodontal ligament complex and most importantly its own cementogenesis. It should also be radiopaque like a natural tooth while being antibacterial, non-corrosive, non-resorbable and moisture indifferent. While being easy to handle and able to adapt to the dentinal walls, they should still be dimensionally stable and cost effective as well as safe to use with its non-toxic characteristics [7].

The problems encountered during pulpal healing have been treated with calcium hydroxide for many decades. Calcium hydroxide does not lead to periapical reactions, it has predictable results. Another advantage of calcium hydroxide is its mixability with certain liquids. However, calcium hydroxide may have got some disadvantages. These are resorption, variable treatment time, unpredictable treatment period, apexification situation, increased risk of tooth fracture, and poor patient compliance due to the long treatment time. Disadvantages of calcium hydroxide can affect treatment results [8,9].

Calcium silicate based materials have received great interest due to their high sealing ability, biocompatibility, regenerative capacity, and antibacterial properties. There are calcium silicate-based root repair materials developed, such as; ProRoot Mineral Trioxide Aggregate

(MTA), MTA Plus and MTA Angelus [7,10]. Due to their excellent biocompatibility, low solubility and impermeability, these materials are widely used to repair perforations in root canals and to form apical barriers [11]. These are hydraulic materials that provide better clinical results when compared to other root filler materials [7,10].

In terms of sealing ability and biocompatibility, MTA cements are better than amalgam, Superseal, Intermediate restorative materials (IRM), and glass ionomer cement (GIC), which are all conventional root materials. Studies demonstrate that MTA induce the proliferation of periodontal fibroblasts, dental pulp cells, osteoblasts and osteoblast-like cells, and mesenchymal stem cells [10,12].

There are different root-end filling materials that can be used for endodontic surgery, however they all lack some characteristics to be the ideal material yet [13].

The purpose of this study was to compare the surface topography of three materials: Calcium Hydroxide (Sultan Chemists Inc., Englewood, NJ, USA), MTA Angelus (Angelus Soluções Odontológicas, Londrina, Brazil) and ProRoot MTA (Dentsply Endodontics, Tulsa, OK, USA).

Material and Methods

Ethical approval of the study was obtained from Istanbul University Faculty of Dentistry Clinical Research Ethics Committee (No: 2012/1738-1298).

In this study, three commercial root end filling materials were tested. These were Calcium Hydroxide (Sultan Chemists Inc.,

Table 1: Contents of materials		
	Composition	liquid
Calcium hydroxide	Calcium Hydroxide Powder	Sterile water
MTA Angelus	Tricalcium silicate, dicalcium silicate, bismuth oxide, tricalcium aluminate, calcium oxide, aluminium oxide, silicon dioxide	Distilled water
ProRoot MTA	Tricalcium silicate, dicalcium silicate, bismuth oxide, tricalcium aluminate, calcium sulphate dihydrate or gypsum	Distilled water

Englewood, NJ, USA), MTA Angelus (Angelus Soluções Odontológicas, Londrina, Brazil) and ProRoot MTA (Dentsply Endodontics, Tulsa, OK, USA). (Table 1)

Thirty-six extracted single-rooted human incisor teeth were used in this study. The teeth with caries, resorption or root fracture were eliminated from study. Teeth were cleaned from soft issues, bone residues and debris, and kept in 5.25% sodium hypochlorite for one week and then placed in normal saline solution until to be used in the current study.

Teeth were decoronated from the cement enamel junction using micromotor handpiece (W&H Dentalwerk Bürmoos GmbH, Austria) and diamond discs (Diamant 0.15mm, Dentaurum, Germany) for standardized 10 mm root lengths.

The root segments were prepared with ultrasonic tips and 2 mm apical resection were performed from vertical to the long axis of the root for each tooth, using a cylindrical carbide bur under water cooling in a high-speed cycle.

The canal length was measured by #15 K-file. K-file were used for canal preparation with step-back technique. Apical widening was performed up to #40 K-file. The preparing root canal method was completed with 1,2 and 3 Gates-Glidden drills for the coronal shaping. Irrigation was made with 2 ml of 2.5% sodium hypochlorite. 2 ml of 17% EDTA was applied for three minutes to remove smear

layer, then 2 ml distilled water was used as the last irrigation. The prepared canals were dried up with paper points.

The samples were randomly divided into three groups (Group A: Ca(OH)₂, Group B: MTA Angelus, Group C: ProRoot MTA), each one of them comprised of 12 roots. Ca(OH)₂, MTA Angelus and Pro

Root MTA were prepared according to the manufacturer's instructions. Materials were placed as 2 mm apical barriers and obturated with guttapercha and AH-Plus sealer. Each group was dimidiated into two subgroups (A1, A2, B1, B2, C1, C2) (Table2). Groups A1, B1, C1 were stored in normal saline (NS), groups (A2, B2, C2) were stored in neutral phosphate buffer saline (NPBS) solution and samples were incubated at 37°C for 2 weeks. A stereomicroscope (Leica MZ 7.5) at x32 magnification was used to photograph the root-end filling

both before placing the samples in their solutions and afterwards.

Results

All specimens demonstrated white crystals formation and sediment over the root-end filling materials and a white plaque was seen on the superficial border of the root-end cavities' wall. The crystal sediments on root-end fillings in the samples of Calcium Hydroxide, MTA Angelus and ProRoot MTA which were stored in normal saline solution (A1, B1, C1) were less than Calcium Hydroxide, MTA Angelus and ProRoot MTA which were stored in neutral phosphate buffer saline solution (A2, B2, C2). White crystal formation were observed the same in both ProRoot MTA groups (C1, C2). White crystal formation were observed in NPBS group (B2) was more than NS group (B1) in MTA Angelus group. White crystal

Table 2: Subgroups of the study

	Calcium hydroxide	MTA Angelus	ProRoot MTA
Normal Saline	A1	B1	C1
Neutral Phosphate Buffer Saline	A2	B2	C2

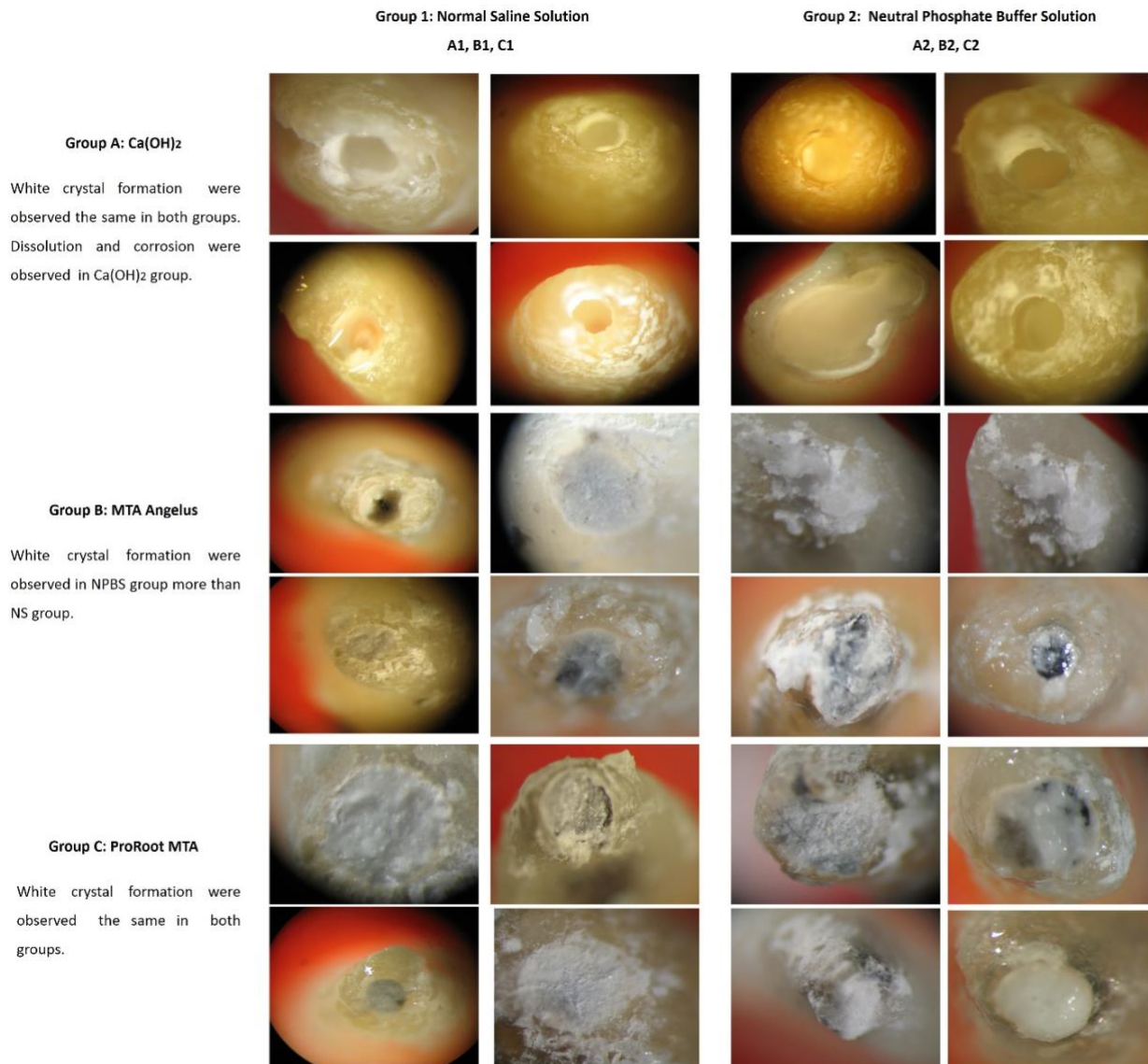


Figure 1. Stereo-microscope images

formation were observed the same in both Ca(OH)₂ groups. Dissolution and corrosion were observed in groups A1, A2 (Ca(OH)₂) (Figure 1).

Discussion

This study intended to evaluate the surface topography of three retrograde filling materials;

calcium hydroxide, MTA Angelus and ProRoot MTA in different solutions.

Healthy periradicular complex includes multiple tissues like cementum, periodontal ligament and bone. The ability to increase the regeneration of the functional periradicular complex is a feature on demand for root-end filling

materials [15]. MTA has ability of promoting hard tissue accumulation, especially cement formation [2]. The ability of hydroxyapatite formation on its interfaces when in contact with physiological or simulated body fluids such as phosphate buffer saline indicates that this material is bioactive. The fact that a material is bioactive makes it more

preferable in use. The surface topography of the materials which used in this study was examined thus their bioactivity was also identified [3].

Sarkar et al. [15] suggest that the physico-chemical reactions of the MTA changes according to root-end filling material's ability of good sealing and bio-compatibility. Samples which stored in phosphate buffered saline (PBS) solution were photographed with scanning electron microscopy (SEM), examined energy dispersive X-ray analysis (EDXA), and X-ray diffraction (XRD) techniques after 2 weeks. SEM examination of the surface of MTA which were predisposed to the STF showed to be covered with sediments of similar morphology and chemical composition. [15] Asgary et al. [3] used extracted teeth. Samples prepared with MTA or new experimental cement (NEC) and subgroups were stored in normal saline solution or neutral phosphate buffered solution. Samples were photographed with SEM before and after placement in solution. The samples which prepared with MTA and stored with normal saline did not show any change but other samples showed white crystal formation and sedimentation over the retrograde filling materials, the edges of the materials and root-end cavities', and around the dentin surfaces as a white plaque. This situation is similar to our study. [3].

Saghiri et al. [16] studied how storage medium affects MTA and Biodentine cement in terms of their surface porosity. The specimens were utilized under SEM X1000 magnifications. They concluded the least surface crystallization surveyed in MTA samples were stored in STF. The most surface crystallization surveyed in Biodentine samples were stored in distilled water (DW). Biodentine samples demonstrated higher surface porosities when compared to the MTA samples which were stored in DW and STF with significantly lower surface porosities [16].

Endosequence Root Repair Material (ERRM) Putty and Paste were evaluated in terms of biocompatibility and compared to gray MTA by Ma et al. [17] Each material evaluated by SEM. IRM and Cavit G showed inadequate crystallized superficial structure. ERRM Putty, ERRM Paste, and MTA displayed similar crystalline surface structures. These crystals contained calcium, carbon, and oxygen and low level of phosphorus [17].

Vajja et al. [18] investigated in a vitro study that whether the thickness of three root-end filling materials have an effect on sealing ability. Cavities were filled with MTA, RMGIC and IRM. Teeth were examined under stereomicroscope at 30X magnification. The MTA had better sealing properties in proportion to other materials at periapical area [18].

Gandolfi et al.[19] tested apatite-forming ability on ProRoot MTA cement after placement in PBS. Samples were photographed with an ESEM-EDX analysis and the analysis showed different surface morphologies related on the absorbing time. Result of this study proved that ProRoot MTA surface morphology is rapidly modified by the phosphate solution. Similar results were obtained in our study [19].

Asgary et al. [20] compared the properties of NEC and mineral trioxide aggregate (MTA). All specimens were photographed and analyzed with scanning electron microscope and electron probe microanalysis (EPMA). White MTA and NEC specimens both showed the existence of crystalline particles [20].

All these studies demonstrated that MTA specimens' surface shows crystalline particles under SEM examination. These results are similar to properties of our study. In the present study, higher crystallization and porosities occurred in ProRoot MTA, MTA Angelus than Calcium Hydroxide, which is in agreement with previous studies.

This study was performed in vitro conditions; which may not imitate the exact situation of the oral cavity as blood or moisture contamination may affect the properties of sealant which are sensitive to moisture. Longitudinal in vivo studies are required to

check the surface topography and crystal precipitation for establishment of protocols for routine clinical usage.

Conclusion

The consequences of this study revealed that Ca(OH)₂ is more resorbable than MTA Angelus and ProRoot MTA as expected. The crystals formation and precipitation observed in NPBS solution was more than NS solution for all groups as hydroxiapatite crystals.

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