# A Comparative Study of Gap Volume after Retro−filling Using 4 Different Filling Materials: Evaluation by Micro−computed Tomography

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# A Comparative Study of Gap Volume after Retro−filling Using 4 Different Filling Materials: Evaluation by Micro−computed Tomography

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# 감사의 글

2011 년 9 월, 연세대학교 치과대학원에 긴장과 기대감으로 입학하였을 때부터, 부족한 저에게 항상 격려와 지도를 해주신 김의성 교수님께 감사드립니다. 그리고 특별한 관심으로 깊은 조언을 해주신 이승종 교수님과 신수정 교수님께도 감사드립니다.  또한 보존과에서 공부할 수 있는 기회를 주시고 많은 가르침을 주신 이찬영 교수님, 노병덕교수님, 박성호 교수님, 신유석 교수님, 송민주 교수님께도 감사 드립니다.

보존과에 처음 들어와 아무것도 모르는 저를 따뜻하고 친절하게 설명해주고 도와주었던 동기들과 의국원들, 특히 권희준 선생님, 강민지 선생님, 김건태 선생님께 고마운 마음 전합니다.

마지막으로 한없이 큰 사랑과 기도 해주시는 가족에게 감사한 마음 전하고 싶습니다. 항상 저를 믿고 응원해주시는 아버지, 제 인생의 멘토이시자 버팀목이신 어머니, 착하고 예쁜 동생 수민이 사랑합니다.

2013 년 12 월

김수연

# Table of Contents

# List of Figure

# List of Table

Abstract

# A Comparative Study of Gap Volume after Retro−filling Using 4 Different Filling Materials: Evaluation by Micro−computed Tomography

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(Directed by Prof. Euiseong Kim, D.D.S., M.S.D., Ph.D.)

**1. Objective**

New materials namely, Endocem®(Maruchi, Wonju, Republic of Korea) and RetroMTA® (BioMTA, Seoul, Republic of Korea) were introduced in the market to overcome shortcomings of Mineral Trioxide Aggregate such as long setting time and wash out. The purpose of this study is to evaluate and compare the volume between the dentin and the root end filling materials which are ProRoot MTA® (Dentsply Tulsa Dental, Tulsa, OK, USA), MTA−Angelus® (Angelus, Londrina, PR, Brazil), Endocem MTA® and RetroMTA® by micro−computed tomography analysis.

2. Materials and methods

Four root-end filling materials were used in the present study: ProRoot® MTA (Dentsply Tulsa Dental, Tulsa, USA), MTA Angelus® (Angelus, Londrina, Brazil), RetroMTA® (BioMTA, Seoul, Korea), EndoCem® (Maruchi, Wonju, Korea). Forty eight single rooted, extracted human teeth were instrumented with ProFile® NiTi system, oburated with gutta percha, resected their 3mm of apex, retro-prepared with a diamond bur, and retro-filled with the experimental root-end filling materials. Then, the samples were scanned with a micro-computed tomography (Skyscan 1076, SkyScan, Konitch, Belgium). Two softwares called NRecon (NRecon v1.6.3.2, SkyScan, Konitch, Belgium) and ct_An (SkyScan, Konitch, Belgium) were used to reconstruct three dimensional images of the samples and to measure the volume of the gap between tooth surface and the root-end filling materials.

3. Result

Median $V_G$% for ProRoot, Angelus, Endocem, and RetroMTA groups were 4.72 E-03, 1.34E-03, 0.14E-03, and 0.71E-03 respectively. Kruskal-Wallis one-way analysis of variance showed that ProRoot group had the greatest gap volume percentage among the experimental groups with a significant statistical difference ($p<0.05$). Mann-Whitney test showed that ProRoot had greater gap volume percentage than Angelus and Endocem groups with a significant difference ($p<0.05$). Other comparisons showed no significant statistical difference.

4. Conclusion

From the micro-CT analysis, ProRoot had greater gap volume percentage than Angelus and Endocem with $p<0.05$.

Key words : root-end filling, MTA, Endocem, micro-CT

# A Comparative Study of Gap Volume after Retro−filling Using 4 Different Filling Materials: Evaluation by Micro−computed Tomography

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Department of Dental Science

The Graduate School, Yonsei University

Sue Youn Kim

## I. Introduction

Since its introduction in 1990s, a vast amount of studies were done to evaluate and investigate characteristics of mineral trioxide aggregate. Because of its superior results of sealing ability (Torabinejad, Rastegar et al. 1995, Wu, Kontakiotis et al. 1998) and biocompatibility (Torabinejad, Pitt Ford et al. 1997, Camilleri, Montesin et al. 2004), MTA has been especially popular. Nonetheless, there are some commonly found drawbacks of MTA namely, its slow setting time and difficulties in handling and manipulation of the materials. In 1995, Torabinejad et al found that MTA had the setting time of 2 hours and 45 minutes which was very long when compared to amalgam which has the setting time of 4 minutes and Super−EBA which has the setting time of 9 minutes (Torabinejad, Hong et al. 1995). The slow setting time of MTA can lead to the questionable integrity and possible wash out of MTA when it is used in the clinical microsurgery settings as a root−end filling material (Kogan, He et al. 2006). In addition, handling and manipulation of MTA often causes difficulties and troubles to clinicians because of its granular consistency (Kogan, He et al. 2006), looseness (Fridland and Rosado 2003, Coomaraswamy, Lumley et al. 2007)and inability to be easily carried and delivered (Lee 2000). To overcome shortcomings of MTA, many attempts were made by numerous scholars: addition of various accelerants(Fridland and Rosado 2003, Wiltbank, Schwartz et al. 2007, Ding, Kao et al. 2008), modification in the formula(Fridland and Rosado 2003, Ber, Hatton et al. 2007), usage of anti−wash gel(Formosa, Mallia et al. 2013), and invention of the delivery system (Lee 2000).

Recently, new types of materials for root end filling became available to overcome the shortcomings of MTA. A pozzolan cement, EndoCem® (Maruchi, Wonju, Korea) was introduced in the market, endorsing as a fast setting cement which is similar to MTA but has small particles of pozzolan cement(Choi, Park et al. 2013). Another newly developed type of material is a bioceramic based material called RetroMTA® (BioMTA, Seoul, Korea). It is endorsed to be similar to MTA but has an addition of hydraulic calcium zirconia complex to enhance the properties and a rapid setting time of 150 seconds, according to its manufacturer. Since both of them are fairly new products in the dental market, to date, not many studies were followed about the properties of these products.

There have been many studies evaluated the ability for sealing and marginal adaptation of the root end filling materials by tests such as dye or protein penetration or bacterial leakage methods. Those methods often have some drawbacks. The dye penetration method was influenced by the type of dye used, pH of dye (Camilleri and Pitt Ford 2008) and formalin which was a storage medium of the teeth specimens(Pichardo, George et al. 2006). Also, various studies that used the dye penetration method produced inconsistent and contradicting results; some studies showed that MTA had less leakage(Gondim Jr, Kim et al. 2005) and some studies showed that MTA had more leakage(Pichardo, George et al. 2006, Tobón−Arroyave, Restrepo−Pérez et al. 2007).

Another commonly used methodology is a bacterial leakage test which is more clinically relevant and significant. Its drawback is that the bacterial leakage test usually takes relatively long time. Many studies that used this method performed the experiment for varying time periods of 30 to 120 days(Torabinejad, Rastegar et al. 1995, Fischer, Arens et al. 1998, Adamo, Buruiana et al. 1999, Scheerer, Steiman et al. 2001, Maltezos, Glickman et al. 2006, Montellano, Schwartz et al. 2006, Ferk Luketić, Malčić et al. 2008). Scheerer et al. carried out the experiment to compare Super EBA and ProRoot for 47 days and ProRoot group did not show any bacterial leakage during that time period(Scheerer, Steiman et al. 2001).

Recently the use of micro-computed tomography has been increased as a new promising tool in the endodontic dentistry field. Overall, the micro-CT analysis is fast, repeatable, conservative and non-destructive of the study specimens (Jung, Lommel et al. 2005). The micro-CT is convenient to see root canal anatomy and morphology and quality of the root canal filling. Furthermore, 3-dimensional reconstruction of root canal which is attainable from the micro-CT, is useful and valuable to visualize the canal anatomy or quality of the obturation(El-Ma'aita, Qualtrough et al. 2012). Also, from the 3-D reconstruction data, volume of filling material, void or space can be numerically measured and percentage volume can be calculated(Hammad, Qualtrough et al. 2009).

The purpose of this study is to evaluate and compare the volume between the dentin and the root end filling materials which are ProRoot MTA® (Dentsply Tulsa Dental, Tulsa, OK, USA ), MTA-Angelus® (Angelus, Londrina, PR, Brazil), Endocem MTA® (Maruchi, Wonju, Republic of Korea) and RetroMTA® (BioMTA, Seoul, Republic of Korea) by micro-computed tomography analysis.

# II. Materials and Methods

## 1. Sample Preparation

Four experimental root-end filling materials were used: ProRoot® MTA (Dentsply Tulsa Dental, Tulsa, USA), MTA Angelus® (Angelus, Londrina, Brazil), RetroMTA® (BioMTA, Seoul, Korea), EndoCem® (Maruchi, Wonju, Korea). Forty eight single rooted, extracted human teeth were collected and stored in $H_2O$ until use. Any teeth with previous root canal treatments, cracks, or perforations were excluded from the experiment.

The canals were instrumented with ProFile® NiTi system(Dentsply Maillefer, Ballaigues, Switzerland) to a master apical size of #40 in a crown down fashion and to 0.5-1mm short of the apex. They were obturated with gutta percha (Obtura III Max System®, Obtura Spartan, Fenton, MI, USA). Then, the root tips (3mm from the apex) were resected at 90° to the axis of the teeth with a tapered diamond bur, ISO 173/016 Fine. We retro-prepared 3mm from the apical end with another tapered diamond bur namely, ISO 160/014 Extra Fine. To standardize for uniformity of the length and size of the retro-preparations, efforts were made to insert the burs about 3mm into the canals and to keep the size of the preparation same as the size of straight apical pluggers which are commonly used in the endodontic microsurgeries.

The retro-filling materials were mixed and applied according to manufacturer's instructions. All apicoectomy procedures were performed under a dental microscope (OPMI PICO; Carl Zeiss, Göttingen, Germany) at 10x magnification. After root−end fillings were done, x−rays were taken for all samples to ensure the density and quality of filling. The retro−filled samples were allowed to set and stored at 100% humidity and room temperature for 7 days. All specimens were prepared by one operator.

## 2. Micro−CT Evaluation

To evaluate sealing ability of the root−end filling materials, a gap between a tooth surface and a root−end filling material was examined to compare among the four different materials. Micro−Computed Tomography (Skyscan 1076, SkyScan, Konitch, Belgium) was used to measure the gap between the tooth surface and the retro−filling materials at x−ray source voltage 100kV; beam current 100μA; filter Al 0.5mm thick; rotation step 0.5 ° step; pixel size 9μm; exposure time 4712ms. After micro−CT images were taken, two softwares called NRecon (NRecon v1.6.3.2; SkyScan, Konitch, Belgium) and ct_An (SkyScan, Konitch, Belgium) were used to reconstruct three dimensional images of the samples and to measure the volume of the gap between tooth surface and the root−end filling materials.

## 3. Statistical Analysis

A Kruskal−Wallis one−way analysis of variance and Mann−Whitney test were used to determine the statistical differences between the experimental groups by using SPSS software version 20 (SPSS Inc, Chicago, IL, USA) with $p<0.05$.

# III. Results

Micro− CT scanning and 3D image reconstruction analysis were done by one technician. After micro−CT scanning, a range of measurement was set to be 2mm coronal from the resected apex for measuring the volume of a gap between the tooth surface and the root−end filling materials. Within that range, a density between 80 and 255 was assigned to be the volume of root−end filling material ($V_M$) and a density between 0 and 23 was assigned to be the volume of the gap ($V_G$). Micro CT scans were reconstructed to 3−dimensional images (Figure 1) by NRecon. The grey portion is the root−end filling material and the blue dots represent the gap between the root−end filling and the tooth structures.

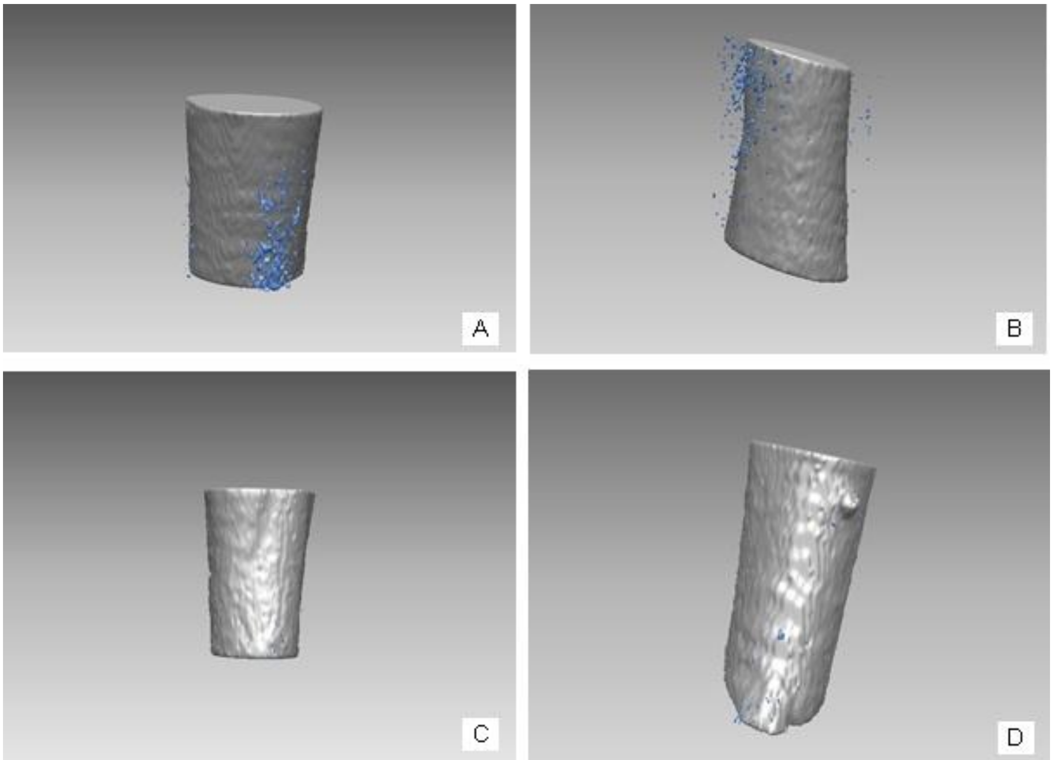


**Figure 1. Micro−CT scans were reconstructed to 3D images: (A) ProRoot, (B) Angelus MTA, (C) Endocem, and (D) RetroMTA groups.** These images were produced by discarding the dentin portions of the samples so that only the retro−filling materials were left. Grey cylinder shapes represent the filling materials and blue dots represent the gap around the root−end fillings. In (A) and (B), relatively large clusters of blue dots are found which indicate greater gap than others. In (C) and (D) fewer and single blue dots are shown which mean less gap volume than others.

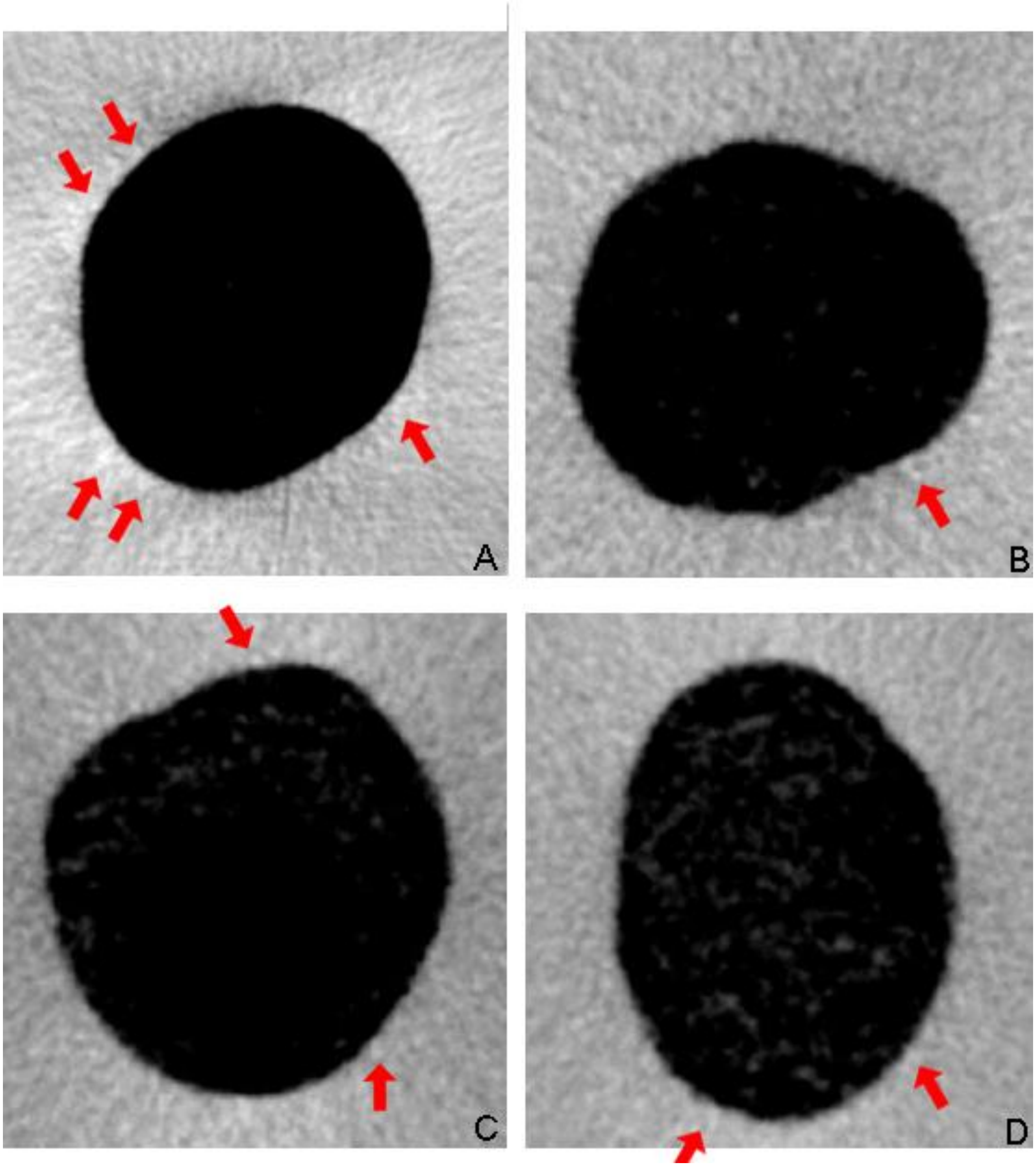


**Figure 2 Micro−CT Cross sections of the samples:(A) ProRoot, (B) Angelus MTA, (C) Endocem, and (D) RetroMTA.** Cross section images are shown above. Black circular areas located in the middle represent the retro−filling materials and the grey areas surrounding the retro−filling materials represent the dentin. Those white spaces were numerically counted by a program called ct_An (SkyScan, Konitch, Belgium) to measure the gap volume.

Volumes of filling materials ($V_M$) and the gap between the filling material and the tooth structure ($V_G$) were acquired by ct_An. Then the percentage volume of the gap between tooth structure and the root−end filling material ($V_G\%$) was calculated as following formula: $V_G\% = V_G/(V_M+V_G)$. The median percentage volumes of the gap between root−end filling materials and tooth structure are shown with the interquartile ranges in Table 1. A box plot of the $V_G\%$s of the experimental groups is shown in Figure 2.

| Groups | Sample Size | Median (%) | Interquartile Range |
|---|---|---|---|
| ProRoot | 12 | 4.72E−03 * | 1.10E−02 |
| Angelus | 12 | 1.34E−03 | 0.49E−02 |
| Endocem | 12 | 0.14E−03 | 0.23E−02 |
| RetroMTA | 12 | 0.71E−03 | 1.59E−02 |

**Table 1. Median $V_G$ % of four root−end filling materials with interquartile ranges.** ProRoot (*) group showed the greatest gap volume percentage with a significant difference. Mann−Whitney test showed that ProRoot group had greater volume percentage than both Angelus group and Endocem group with $p<0.05$.

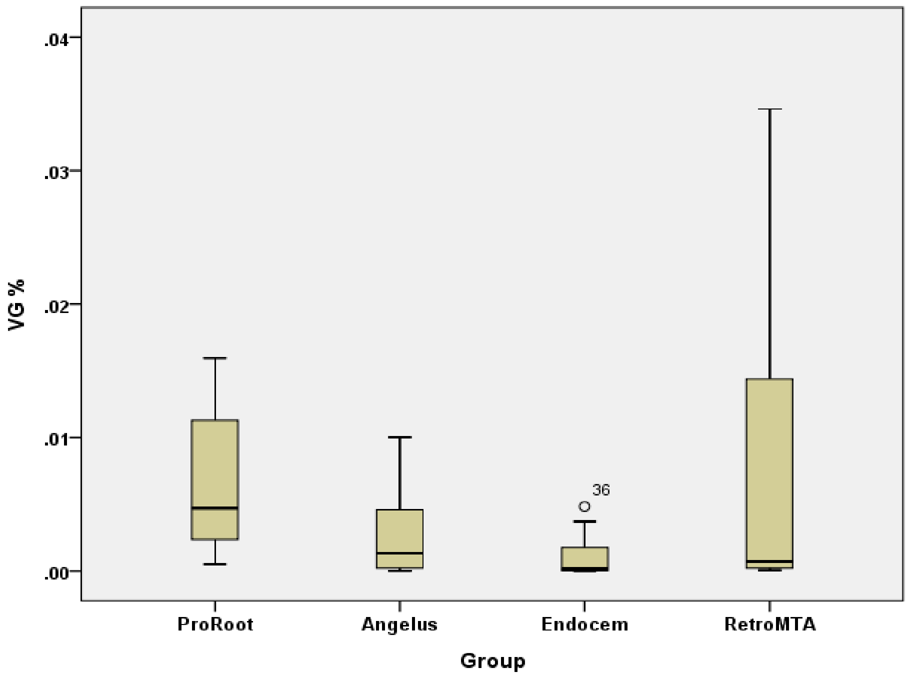


**Figure3. Box Plot of the $V_G$% in ProRoot, Angelus, Endocem and Retro MTA groups.** One outlier from ProRoot group and another outlier from RetroMTA group were excluded.

Median $V_G$% for ProRoot group, Angelus group, Endocem group, and RetroMTA group were 4.72 E−03, 1.34E−03, 0.14E−03, and 0.71E−03 respectively. Kruskal−Wallis one−way analysis of variance showed that ProRoot group had the greatest gap volume percentage among the experimental groups with a significant statistical difference ($p<0.05$). Mann−Whitney test showed that ProRoot group had greater gap volume percentage than Angelus and Endocem groups with a significant difference ($p<0.05$). Other comparisons showed no significant statistical difference.

## IV. Discussion

The purpose of this study was to evaluate and compare the volume between the root end filling materials (ProRoot®, Angelus®, Endocem® and RetroMTA®) and tooth structure by micro−CT analysis. There were many previous studies to evaluate sealing ability and marginal adaptation of the root−end filling materials by use of the methods such as dye leakage and bacterial leakage were used(Torabinejad, Rastegar et al. 1995, Fischer, Arens et al. 1998, Adamo, Buruiana et al. 1999, Scheerer, Steiman et al. 2001, Gondim Jr, Kim et al. 2005, Maltezos, Glickman et al. 2006, Montellano, Schwartz et al. 2006, Pichardo, George et al. 2006, Tobón−Arroyave, Restrepo−Pérez et al. 2007, Camilleri and Pitt Ford 2008, Ferk Luketić, Malčić et al. 2008). In this study, the micro−CT analysis was used as a main tool to evaluate the volumes of the root−end filling material and gap between the filling material and the tooth structure. The micro−CT has a lot of potentials for various applications in dentistry and especially in the endodontic dentistry. Many studies evaluated anatomy and shapes of the root canals (Dowker, Davis et al. 1997, Gu, Zhang et al. 2013, Li, Li et al. 2013), analyzed the efficacy root canal instrumentation(Roggendorf, Legner et al. 2010, De−Deus, Barino et al. 2012, Rödig, Hausdörfer et al. 2012, Stern, Patel et al. 2012) and the quality of the obturation(Hammad, Qualtrough et al. 2009, Somma, Cretella et al. 2011, El−Ma'aita, Qualtrough et al. 2012), and estimated voids in the canal (Gandolfi, Parrilli et al. 2013). However, not much investigation was done about the quality or sealing ability of the root−end materials by use of the micro−CT.

Obvious advantages of the micro−CT method are its fast speed, reproducibility, and conservation of the specimens. Furthermore, when measuring three−dimensional values such as volume, the micro−CT and its 3−dimensional reconstruction program can be very accurate and useful. On the contrary, its disadvantages are its cost and lack of its applications in long term studies. Also, Zaslansky et al. raised questions about humanly mistakes and difficulties to determine the differences between the filling materials and canal walls by a micro−CT image analyst. The authors said even the best micro CT images can have some misleading differences of the contrast between the two different interfaces (Zaslansky, Fratzl et al. 2011). In this study, to minimize these humanly errors and differences, we assigned the certain density ranges for the root−end filling component and the empty space; the density between 80 and 255 was classified as the root−end filling material and the density between 0 and 23 was classified as the gap between the tooth structure and the root−end filling materials. The density between 24 and 79 was classified as dentin and not counted in the evaluation.

There were many previous studies on comparing sealing ability or marginal adaptation of the root−end filling materials(Torabinejad, Watson et al. 1993, Xavier, Weismann et al. 2005, Bortoluzzi, Broon et al. 2006, Lolayekar, Bhat et al. 2009). Although most of these studies involved MTAs (ProRoot® or Angelus®), not many studies about Endocem® or RetroMTA® were available. Endocem® was introduced in 2011 as an alternative material of choice for root-end filling, apexification, root perforation, internal resorption, pulp capping and pulpotomy. Main difference of Endocem® from MTA is the presence of the pozzolan cement (Choi, Park et al. 2013). The pozzolanic reaction occurs similar to acid-base reaction of lime and alkalies with some oxides ($SiO_2$ + $Al_2O_3$ + $Fe_2O_3$) of the pozzolan(Askarinejad, Pourkhorshidi et al. 2012). This reaction causes a decrease in the amount of free calcium hydroxide $Ca(OH)_2$ which weakens the durability of the material and an increase in the amount of calcium silicate hydrate (CSH) and calcium aluminate hydrate (CAH) which strengthens the material (Askarinejad, Pourkhorshidi et al. 2012). Due to the presence of the pozzolan, the color of Endocem® was gray and the texture was very fine and mud-like consistency. Those characteristics could explain the superior results of Endocem group in this study. Furthermore, Choi et al found that Endocem group set much faster and more resistant to wash out than ProRoot group(Choi, Park et al. 2013) and this finding could also explain the results of our study.

There is a lack of studies about RetroMTA® because it was newly developed and quite recently introduced to Korean dental materials market. According to the manufacturer, bioMTA, RetroMTA® is unique in having hydraulic calcium zirconia complex as a contrast media and it includes no heavy metals such as Cr, Ni, Bi or Fe. Its composition and ingredients are as following with their percentages: calcium carbonate ($CaCO_3$) (60−80%), silicon dioxide ($SiO_2$) (5−15%), aluminum oxide (5−10%) and calcium zirconia complex (20−30%)(bioMTA). In our study, when mixed with the instructed amount of water, RetroMTA® seemed dry which made quite difficult to condense. The results of RetroMTA group did not show any significant difference when comparing with other experimental groups. More studies about both Endocem® and RetroMTA® are needed.

In our study, ProRoot group had greater gap volume percentage than Angelus group with a statistically significant difference. This result is in agreement with Borotoluzzi et al (Bortoluzzi, Broon et al. 2006) who found that ProRoot group showed greater dye leakage than other materials. However, there were other authors (Lolayekar, Bhat et al. 2009) whose result was different from our results. Lolayekar et al compared sealing ability of ProRoot group and Angelus group and found out that there was not a significant difference. However, in their study, they performed 5mm root−end filling which provided significantly greater micro−hardness (Lolayekar, Bhat et al. 2009) instead of 3mm which was used in our study. We can assume that our result of ProRoot group was related to the characteristics and consistency of the material.

When we manipulated the ProRoot®, it seemed less sticky than Endocem® which made little more difficult to handle and carry.

Although it is beyond the scope of our study whose main purpose of our study was to investigate the gap volume between dentin and retro-filling material, it is noteworthy to see the density of the filling materials shown in Figure 2. The cross section image of ProRoot group showed the densest retro-filling area (shown in the center with black) with almost no porosity within the filling. In 2013, Basturk et al compared the densities of ProRoot group and Angelus MTA group and their micro-CT cross section images seemed very similar to the micro-CT images from our study. The authors said the size and shape of the particles might be the causal factors(Basturk, Nekoofar et al.). Particles of ProRoot group have a less wide size distribution (Komabayashi and Spångberg 2008) and are more homogenous than Angelus group(Song, Mante et al. 2006). On contrary, the cross section images of Endocem group and RetroMTA group showed less dense fillings with some porosities shown in lighter color. It can be speculated that the particles of Endocem® and RetroMTA® are less homogenous than ProRoot® which must be pertained to the results of our experiment.

# V. Conclusion

Based on the results of this study, we can conclude that from the micro-CT analysis, ProRoot had the greatest gap volume percentage among the root-end filling materials (ProRoot®, Angelus®, Endocem®, and RetroMTA®) with a significant difference. It is confirmed with Mann-Whitney test that ProRoot group had greater gap volume percentage than Angelus and Endocem groups with $p<0.05$.

# Raw Data

| Group | No. | $V_{M\ (mm3)}$ | $V_{G\ (mm3)}$ | $V_G$ % |
|---|---|---|---|---|
| ProRoot | 1 | 2.64911 | 0.00134 | 0.000505575 |
| | 2 | 2.6764 | 0.0073 | 0.002720125 |
| | 3 | 1.79703 | 0.13157 | 0.068220471 |
| | 4 | 2.42751 | 0.01786 | 0.007303598 |
| | 5 | 3.35717 | 0.05202 | 0.015258756 |
| | 6 | 2.61521 | 0.0424 | 0.015954184 |
| | 7 | 2.92235 | 0.01983 | 0.0067399 |
| | 8 | 1.99979 | 0.00514 | 0.002563681 |
| | 9 | 2.80256 | 0.01895 | 0.006716262 |
| | 10 | 2.54063 | 0.00694 | 0.002724165 |
| | 11 | 3.19639 | 0.00532 | 0.001661612 |
| | 12 | 3.33598 | 0.00723 | 0.002162592 |
| Angelus | 1 | 2.45905 | 0.00332 | 0.001348295 |
| | 2 | 2.53256 | 0.00029 | 0.000114496 |
| | 3 | 1.69042 | 0.00224 | 0.001323361 |
| | 4 | 3.22112 | 0.00182 | 0.000564702 |
| | 5 | 2.74023 | 0.01542 | 0.005595776 |
| | 6 | 2.43308 | 0.02464 | 0.010025552 |
| | 7 | 3.62338 | 0.00114 | 0.000314524 |
| | 8 | 4.46569 | 0.0161 | 0.003592315 |
| | 9 | 4.10011 | 0.00048 | 0.000117056 |
| | 10 | 1.32338 | 0.0033 | 0.002487412 |
| | 11 | 2.99816 | 0.00002 | 6.67071E-06 |
| | 12 | 3.29725 | 0.0209 | 0.006298691 |

| | | | | |
|---|---|---|---|---|
| Endocem | 1 | 2.52947 | 0 | 0 |
| | 2 | 2.10476 | 0.00002 | 9.50218E-06 |
| | 3 | 2.43482 | 0.00012 | 4.92825E-05 |
| | 4 | 2.48993 | 0.00929 | 0.00371716 |
| | 5 | 2.82247 | 0.00033 | 0.000116905 |
| | 6 | 1.68937 | 0.00011 | 6.51088E-05 |
| | 7 | 3.37316 | 0.00033 | 9.78215E-05 |
| | 8 | 3.17546 | 0.00052 | 0.000163729 |
| | 9 | 2.30683 | 0.00087 | 0.000376999 |
| | 10 | 2.49365 | 0.00732 | 0.002926864 |
| | 11 | 2.95646 | 0.00184 | 0.000621979 |
| | 12 | 3.13009 | 0.01522 | 0.004838951 |
| RetroMTA | 1 | 3.20516 | 0.11493 | 0.034616531 |
| | 2 | 2.4001 | 0.00032 | 0.00013331 |
| | 3 | 3.00387 | 0.00091 | 0.000302851 |
| | 4 | 3.20956 | 0.00575 | 0.001788319 |
| | 5 | 1.89039 | 0.02096 | 0.010966071 |
| | 6 | 2.44091 | 0.00078 | 0.000319451 |
| | 7 | 2.11523 | 0.03834 | 0.017802997 |
| | 8 | 2.87091 | 0.00314 | 0.001092535 |
| | 9 | 2.22215 | 0.12076 | 0.05154274 |
| | 10 | 2.9306 | 0.00041 | 0.000139884 |
| | 11 | 2.88592 | 0.00023 | 7.96909E-05 |
| | 12 | 1.98007 | 0.00066 | 0.00033321 |

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## 국문 요약

# 수종의 MTA 를 이용한 역충전 후 Gap Volume 비교: Micro-CT 를 이용한 측정

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### 1. 서론

1990 년대에 개발된 Mineral Trioxide Aggregat(MTA) 은 우수한 sealing ability 와 생체적합성 때문에 치과치료의 여러분야에서 널리 사용되고 있다. 하지만, slow setting time 과 다루기 어려움 등의 단점을 보완하기 위해 Endocem® (Maruchi, Wonju, Republic of Korea), RetroMTA® (BioMTA, Seoul, Republic of Korea) 등의 새로운 재료들이 개발되었다. 현재 새로운 재료들에 대한 연구는 아직 많이 없는 상황이다.

이 연구의 목적은 ProRoot MTA® (Dentsply Tulsa Dental, Tulsa, OK, USA), MTA-Angelus® (Angelus, Londrina, PR, Brazil), Endocem MTA®, RetroMTA® 를 이용하여 근관 역충전 후, 치면과 재료 사이에 생기는 gap volume 을 micro-CT 로 측정 및 비교 분석 하는 것 이다.

## 2. 본론

48 개의 human 발치 치아를 ProFile® NiTi system 을 사용하여 근관 성형후, gutta percha 로 근관 충전을 실시하였다. Diamond bur 를 사용하여 근첨의 3mm 절제와 3mm 깊이의 역충전 와동을 형성 후 4 개의 역충전 재료(ProRoot MTA®, Angelus-MTA®, Endocem®, RetroMTA®)로 역충전 하였다.
시편들은 micro-computed tomography (Skyscan 1076, SkyScan, Konitch, Belgium)으로 촬영 후, NRecon (NRecon v1.6.3.2, SkyScan, Konitch, Belgium)와 ct_An (SkyScan, Konitch, Belgium) 프로그램을 이용하여 3 차원 재구성 및 치면과 역충전 재료사이의 gap 을 측정하였다.

## 3.결과

ProRoot 군, Angelus 군, Endocem 군, RetroMTA 군의 gap volume ($V_G$%) 들의 median 은 4.72 E-03, 1.34E-03, 0.14E-03, 0.71E-03 이었다. Kruskal-Wallis one-way analysis 와 Mann-Whitney test 에서 유의차 있게 ProRoot 군이 $V_G$%가 높게 나왔다.

## 4. 결론

본 실험연구의 결과에 의하면, micro-CT 측정에서 ProRoot 군이 Angelus 군과 Endocem 군 보다 치면과 역충전 재료사이의 더 큰 gap 을 보임으로써 ($p<0.05$) 새로 개발된 Endocem 이 치근단 역충전재로서의 사용가능성을 제시하였다.

Keywords: root-end filling, MTA, Endocem, micro-CT