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PRODUCT OVERVIEW

with a Scientific Foundation

MARUCHI

Product Description

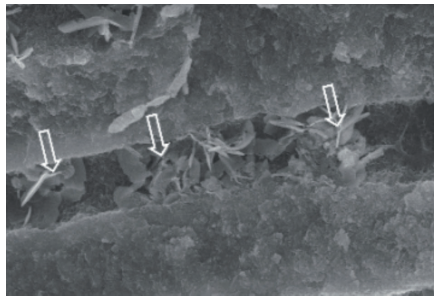
Endocem MTA® premixed Regular is the latest MTA product in the MARUCHI company.
It is a newly developed calcium silicate-based premixed bioceramic root-end filling material with Dimethyl sulfoxide (DMSO) vehicle to produce an injectable and ready-to-use form was developed, confined into an air-tight syringe that permits its direct application into the root canals. During injection, Endocem MTA® premixed Regular absorbs the environmental moisture as basis for the hydration reaction and sets without the need of previous powder/liquid or base/catalyst mixing.

Endocem MTA® premixed Regular is a highly effective material for vital pulp treatment due to its exceptional physical and biological properties.

Its biocompatibility, bioactivity, and sealing capabilities make it an optimal choice for this type of treatment. The material's quick setting time and minimal solubility further enhance its attributes, ensuring a successful outcome for patients.

Endocem MTA® premixed Regular sealing efficacy is primarily due to its inherent bioactivity, which enables the release of calcium ions and the formation of an apatite layer in the presence of phosphate-containing physiological fluids.

These properties make it an outstanding choice for vital pulp treatment, providing excellent biocompatibility, sealing ability, and antibacterial properties.



Representative scanning electron microscopy images of intratubular biomineralization. Arrows indicate the flake-shaped intratubular precipitates.

Endocem MTA® premixed Regular has a Sub micron particle size and a uniform surface roughness that allows for effective sealing of dentinal tubules.

Endocem MTA® premixed Regular Contains;

- Core material : 40-50% Tricalcium Silicate
- Radiopacifier : Zirconium Dioxide
- Vehicle : Dimethyl Sulfoxide (DMSO) is included as a non-reactive diluent to ensure the paste has appropriate flow properties.
  ★ European Patent Nos 3542778
- Setting Support : Lithium Carbonate
- Expansion : Bentonite clay
- Thickening agents : Included to enhance the paste's viscosity and consistency.

Calcium Hydroxide increases the pH, which induces the formation of hydroxyapatite (HA) Its basic physico-chemical properties are summarized in Table 1, in comparison with Endocem MTA® premixed Regular and ProRoot MTA (Dentsply).

Table 1

Material Components of Endocem MTA® Premixed Regular		
Role	Ingredient	Endocem MTA Premixed Regular
Main	Tricalcium silicate	40-60
	Calcium aluminate	< 1
	Calcium sulfate	< 1
	Lithium Carbonate	< 0.5
Radiopacity	Zirconium dioxide	40-60
Thickening agent	HPMC	< 3
	Bentonite	
Solvent	DMSO	10~20
	Water	
	Ethyl alcohol	

1. Physico-chemical Properties

1-1

Yuji Jang, Yujin Kim, Junghwan Lee, Jongsoo Kim, Joonhaeng Lee, Mi Ran Han, Jongbin Kim, Jisun Shin. Evaluation of Setting Time, Solubility, and Compressive Strength of Four Calcium Silicate-Based Cements, JKAPD.2023.50.2.217

Comparing the physical properties of 4 kinds of calcium Silicate-based cements (CSCs): 2 kinds of powder-liquid mix type (RetroMTA® and Endocem® MTA Zr) and 2 kinds of premixed type (Well-Root™PT and Endocem® MTA premixed).

The setting time is a crucial factor in endodontic treatment procedures because prolonged setting time can result in material washout[1,2].

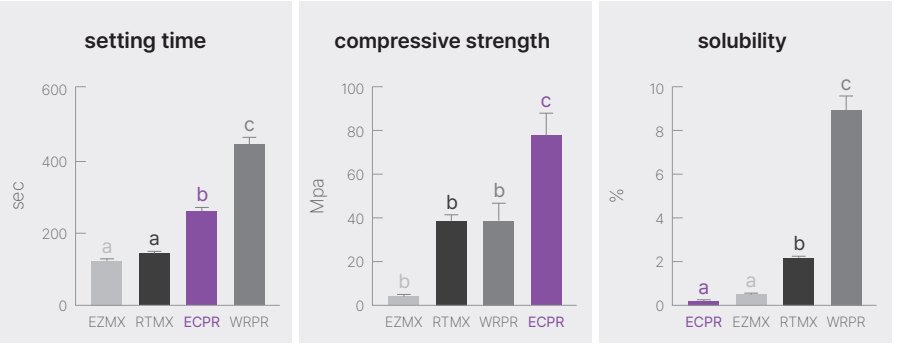
In addition, materials with high solubility are easy to wash out, can aggravate pulp inflammation caused by bacterial infection, and can affect pulp response[3]. Compressive strength is essential to withstand high masticatory forces. This property is highly requested, especially in the molar region[4]. Therefore, the present study aimed to compare the setting time, solubility, and compressive strength of four different CSCs.

Materials	Setting Time (seconds)	Solubility(%)	Compressive Strength (Mpa)
RetroMTA®	146.67 ± 5.77	2.17 ± 0.07	38.17 ± 2.50
Endocem Zr®	123.33 ± 5.77	9.01 ± 0.55	4.07 ± 0.60
Well-Root™ PT	460.00 ± 17.32	9.01 ± 0.55	38.39 ± 7.25
Endocem® MTA premixed	260.00 ± 17.32	0.17 ± 0.03	76.67 ± 25.67

All data from the repeated tests were presented as mean ± standard deviation and analyzed using the Kruskal-Wallis test, followed by the Mann-Whitney U test with Bonferroni correction, using the Statistical Package for Social Sciences software version 21.0 (SPSS Inc.,Chicago, IL, USA). A p-value of < 0.0083.

The outcomes are the following

- All evaluated CSCs complied with ISO 6876 and ISO 9917-1 regarding their setting time, solubility, and compressive strength evaluation.
- Endocem® MTA premixed exhibited the lowest solubility and the highest compressive strength.
  - High solubility and low compressive strength can lead to treatment failure, so this should be taken into consideration when selecting materials based on the specific clinical situation. Endocem® MTA premixed is a promising material in that it has improved solubility and compressive strength, and the working time can be shortened due to the characteristics of premixed CSC.
- Endocem® MTA premixed exhibits a rapid setting time of within 5 minutes.
  - The ideal setting time for pulp capping materials can vary depending on the specific material and clinical application. However, a setting time of around 10-15 minutes is often considered desirable for pulp capping procedures[5].



1-2

Jang, Y.-J.; Kim, Y.-J.; Vu, H.T.; Park, J.-H.; Shin, S.-J.; Dashnyam, K.; Knowles, J.C.; Lee, H.-H.; Jun, S.-K.; Han, M.-R.; et al. Physicochemical, Biological, and Antibacterial Properties of Four Bioactive Calcium Silicate-Based Cements. Pharmaceutics 2023, 15, 1701.

Physical properties, such as film thickness and flow, strongly affect the material's clinical performance, thus affecting their sealing ability [6]. In this study, premixed-type CSCs showed higher flow and lower film thicknesses than powder–liquid-type CSCs ($p < 0.05$).

Additional components, such as polyethylene glycol in Well-Root™ PT and hydroxypropyl methylcellulose in Endocem® MTA premixed, of premixed CSCs could increase the flowability [7]. This could contribute to better adaptation to various irregularities present in the root canal system and improve the material's ability to seep into the canal or perforation areas [8,9]. According to ISO 6876 [10] standards for root canal sealers, a film thickness of less than 50 μm and a flowability of more than 17 mm are needed. Only Endocem® MTA premixed satisfies these conditions. This indicates that Endocem® MTA premixed can be considered a root canal sealer as well as a pulp capping material.

The results of flow and film thickness (mean ± SD).

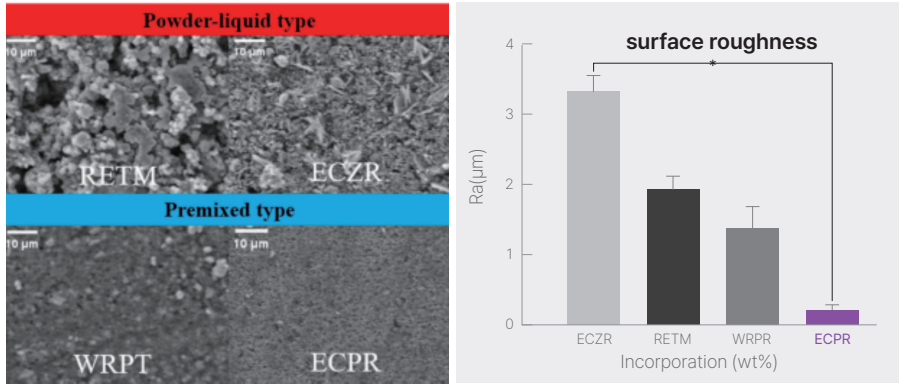
Materials	Film Thickness (μm)	Flow (mm)
RetroMTA®	233.33 ± 47.25^{c}	7.06 ± 0.55^{a}
Endocem Zr®	246.66 ± 41.63^{c}	7.03 ± 0.27^{a}
Well-Root™ PT	143.00 ± 13.00^{b}	13.83 ± 0.35^{b}
Endocem® MTA premixed	30.00 ± 5.00^{a}	20.18 ± 1.16^{c}

Within each column, the significant differences between groups are indicated by different superscript letters.

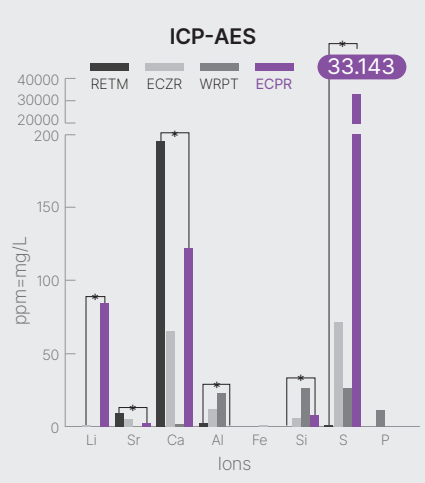
The outcomes are the following

- Endocem® MTA premixed showed the higher the flowability, the lower the film thickness.

[Surface Analysis]



- During surface observation, the premixed type exhibited a more uniform and less rough surface. Material uniformity can reduce the influence of operator skill [11]. This is attributed to the different composition and filler sizes of the products.



• **Elemental Analysis and Ion Release,**

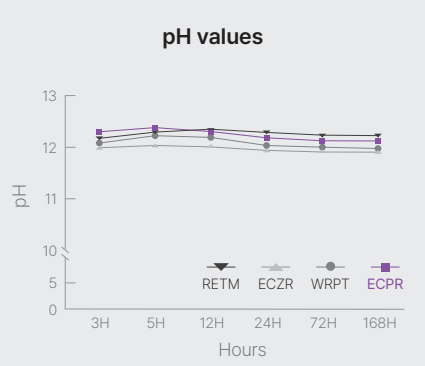
- The release of calcium ions from materials is important for the differentiation of pulp cells and maintaining dentin mineralization and the formation of a dentin bridge through the enhancement of pyrophosphatase activity. Therefore, the ability to release calcium ions is a key factor for successful pulp therapy due to the role of calcium in pulp cell differentiation and hard tissue mineralization [12–14].

- Ca ions are produced in high quantities from calcium hydroxide and through the decomposition of calcium silicate hydroxide, which leads to an alkaline pH[15]. Strong alkalinity is believed to be crucial in biological activity, to be related to the antibacterial effect against E. faecalis and to have mineralization effects[8,16,17]. McHugh[18-21] stated that a high alkaline pH of more than 11.5 is bactericidal to E. faecalis.

- The highest release of Li ions was observed for Endocem® MTA premixed due to the presence of lithium carbonate, which can help reduce the setting time of the material through promoting the hydration of calcium aluminate. Additionally, the release of Li ions can increase the pH of the material, resulting in a more alkaline environment[22,23].

- The highest release of Sulfide ions was observed for Endocem® MTA premixed, which is composed of calcium sulfate and DMSO. DMSO has a high dielectric constant and the ability to solvate polymers and adhesives due to its low surface energy; it is an aprotic solvent that possesses the necessary polarity to disrupt the self-associative tendencies of water and form stable complexes with it and can help improve dentin wettability [22,24]. DMSO has intrinsic antimicrobial properties and has been reported to have antibacterial effects against Gram-positive bacteria[25]. Thus, the release of high concentrations of S ions could have an antibacterial effect on E. faecalis in our study[3,26].

• **PH values**



The pH values are shown in the table above. The results indicated that all four materials had highly alkaline pH values of approximately 12.

1-3

Seolah Back, YuJi Jang, Junghwan Lee, Joonhaeng Lee, Jisun Shin, Jongbin Kim, Miran Han, JongSoo Kim pH, Ion Release Capability, and Solubility Value of Premixed Mineral Trioxide Aggregates, JKAPD.2022.49.4.379

Comparing the pH, solubility value, and ion release capability of premixed mineral trioxide aggregates (MTAs) versus conventional pulp capping materials before and after setting.
The following materials were used: resin-modified calcium silicate cement (TheraCal LC®, TLC), resin-modified calcium hydroxide cement (Ultra-BlendTM plus, UBP), and 2 kinds of premixed MTA (Endocem MTA® premixed regular [EMPR] and Well-RootTM PT [WRP]).

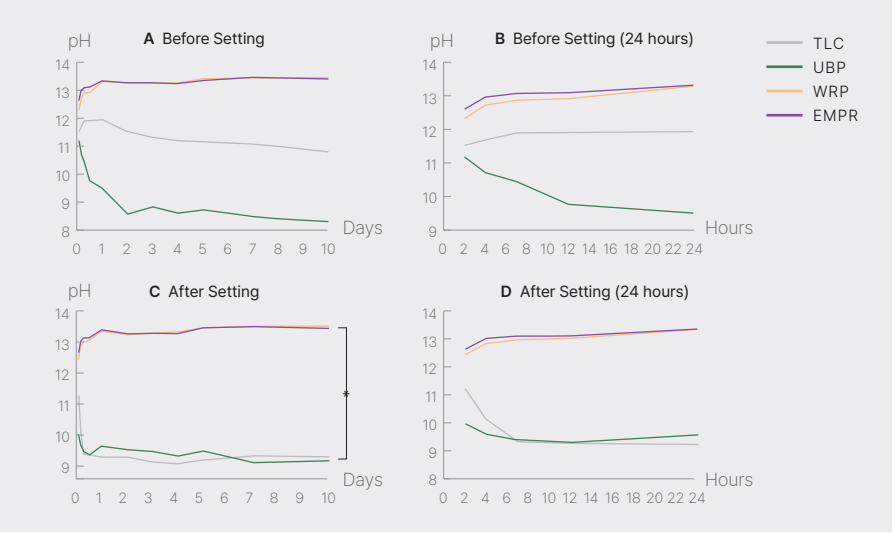
The physicochemical properties of pulp capping materials, such as pH, solubility value, and ion release capability, can affect pulpal response[27,28]. An acidic pH disrupts protein synthesis and proliferation of pulp cells[28,29]. Additionally, calcium ions play an important role in the differentiation of pulp cells into mineralized tissue forming cells[30,31]. Therefore, a high solubility can exacerbate pulp inflammation due to bacterial infection[32,33,34]. The current study aimed to compare the pH, solubility, and ion release capability of WRP and EMPR versus TLC and UBP before and after setting.

• PH

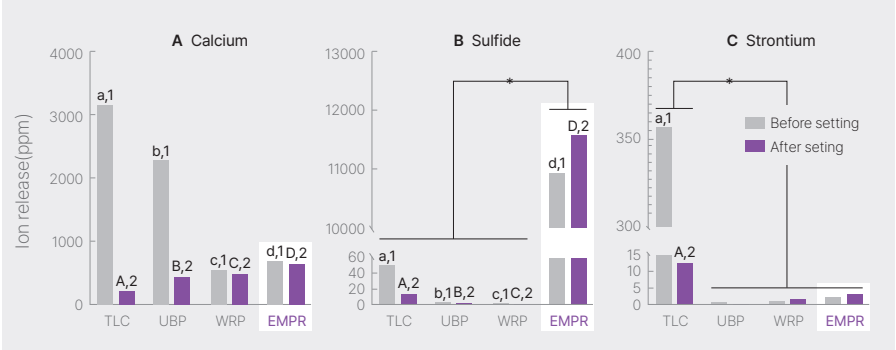
WRP and EMPR had significantly higher pH values than TLC and UBP in all measurement periods ($p < 0.05$).
In the after-setting group, the pH of WRP and EMPR significantly increased over time until after 1 day and then became constant. Moreover, the pH of TLC and UBP significantly decreased over time until 12 hours and became constant ($p < 0.05$).

Pulp capping materials play an essential role in successfully regenerating the dentin-pulp complex[33,34].

For a successful vital pulp treatment, these materials should have the following properties: (1) antibacterial activity (2) good biocompatibility (3) calcium ion releasing ability and (4) pulp cell damage to initiate immune process[36-38]. Alkaline pH has antibacterial activities and mineralization effects[28,37-40]. The pH of Endocem MTA® premixed regular and Well-Root™ PT increased over time before and after setting. In particular, the pH increased evidently after 24 hours.



• Ion release

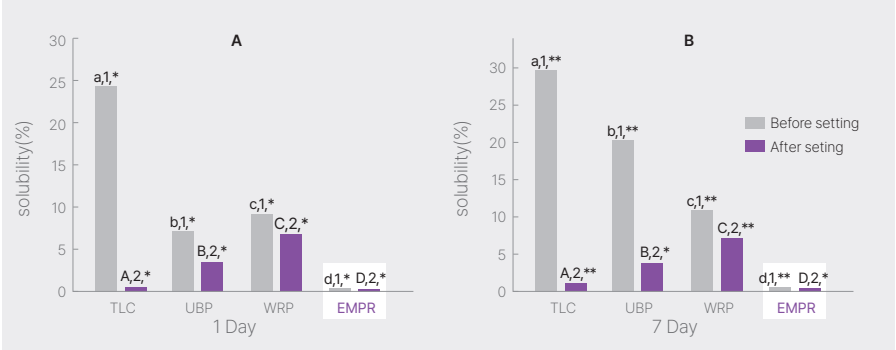


Results showed that in the after setting group, WRP and EMPR released a significantly higher concentration of calcium ions compared with TLC and UBP ($p < 0.05$). Endocem MTA® premixed regular released the highest concentration of sulfide ions before and after setting ($p < 0.05$). Small concentrations of strontium ions were detected in all materials except TLC.

Calcium, sulfide, and strontium ions at appropriate concentrations have antibacterial effects and can promote cell differentiation[41-44]. In particular, calcium ions are essential for the differentiation and mineralization of pulp cells and for the regulation of pulp calcification[31,37,45]. These ions are more likely to be detected in premixed MTAs after setting.

This outcome is expected because calcium ions are released via the hydration of calcium silicate particles such as hydroxide ions[12,37]. Endocem MTA® premixed regular contains calcium sulfate and dimethyl sulfoxide. Hence, it releases a high concentration of sulfide ion before and after setting. Moreover, it can have a high antibacterial effect.

• Solubility



It shows the solubility test results after 24 hours and 1 week.
TLC=TheraCal LC®, UBP=Ultra-BlendTM plus, WRP=Well-RootTM PT,
EMPR=Endocem MTA® premixed regular, n= number of measurements.

Before and after setting, Endocem MTA® premixed regular had the lowest mean solubility value after 1 and 7 days ($p < 0.05$). The solubility value was significantly higher before setting than after setting in all groups ($p < 0.05$).

. Low solubility is essential for pulp capping materials[46,47]. Endocem MTA® premixed regular has a high washout resistance and high mechanical strength because of its anti-washout ingredients such as hydroxypropyl methylcellulose and dimethyl sulfoxide [48-50]. Based on the study results, Well-Root™ PT and Endocem MTA® premixed regular are suitable pulp capping materials.

1-4

Ju-Ha Park, Hee-Jin Kim, Kwang-Won Lee, Mi-Kyung Yu, Kyung-San Min. Push-out bond strength and intratubular biomineralization of a hydraulic root-end filling material premixed with dimethyl sulfoxide as a vehicle. Restor Dent Endod. 2023 Feb;48(1):e8

The purpose of a root-end filling is to establish a seal between the root canal space and the periradicular tissues[51]. Hydraulic bioceramic cements have been used successfully in root-end fillings due to their favorable sealing ability[52]. In the present study, we aimed to evaluate the bonding ability to root canal dentin of the DMSO-containing root-end filling material in comparison to a widely used conventional powder-liquid cement (ProRoot MTA).

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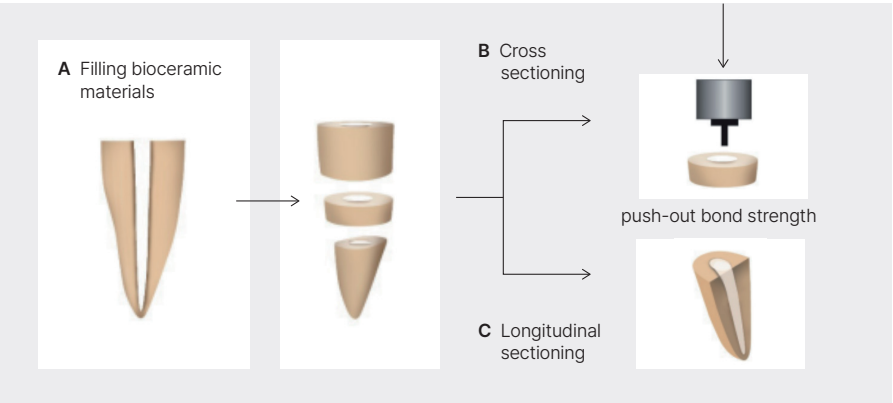
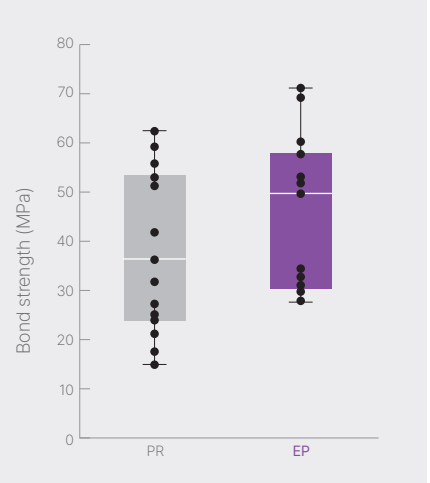


Illustration of the experimental procedure.

(A) The tooth filled with the tested materials was sectioned horizontally to obtain a sliced specimen and an apical segment.

(B) Push-out bond strength was measured with the sliced specimen using a universal testing machine.

(C) The apical segment was sectioned longitudinally, and the intratubular biomineralization was observed under scanning electron microscopy.



Push-out bond strength and the failure patterns of the tested materials.
Bar chart showing the mean bond strength of the 2 tested material groups.

The push-out bond strength to quantify the interfacial adaptation values of the cements to the root canal dentin. Endocem MTA Premixed was found to have a similar value to ProRoot MTA. Notably, ProRoot MTA has been considered a gold standard for root-end filling and is usually adopted as the control material when interfacial adaptation is evaluated [53-55]. Furthermore, push-out bond strength is a widely used methodology to evaluate the adaptation of root-end filling material [56,57]. Therefore, this result suggests that Endocem MTA® premixed regular is comparable to ProRoot MTA regarding interfacial adaptation and can be considered to show adequate performance in root-end filling.

Endocem MTA® premixed regular is also mixed with a nonaqueous vehicle, DMSO, which has been demonstrated to improve the adhesive bonding to coronal dentin and to decrease leakage by increasing dentin wettability[58,59].

Endocem MTA® premixed regular, a newly developed premixed bioceramic root-end filling material, showed similar push-out bond strength to the widely used material ProRoot MTA.

1-5

Min-Yong LEE, Hi-Won YOON, Min-Jae LEE, Kwang-Mahn KIM and Jae-Sung KWON. Thermophysical properties and bonding with composite resin of premixed mineral trioxide aggregate for use as base material. Dental Materials Journal

Dental bases require low thermal conductivity and good mechanical properties, such as bonding with composite resins. This study aims to elucidate the physicochemical properties of premixed mineral trioxide aggregate (MTA) for its suitability as a dental base and to explore the optimal adhesive strategy with composite resin.

A dental base with a thickness of 1–2 mm is to replace the removed dentin and provide insulation and support for the final restoration [68]. Materials used as dental bases should have low thermal conductivity, good physical properties, and high bonding strengths with the final composite resin [69]. Glass ionomer, zinc phosphate, and flowable resin have conventionally been considered high strength dental base materials [70], with thermal conductivities of approximately 0.4–2.0 $Wm^{-1}K^{-1}$ [71,72]. The thermal conductivities of enamel and dentin are approximately 0.9 $Wm^{-1}K^{-1}$and 0.6 $Wm^{-1}K^{-1}$, respectively; therefore, materials with appropriate thermal conductivities have traditionally been used as dental base materials [73].

Premixed MTA enables a uniform composition and possesses uniform thermal and physical properties [74]. Furthermore, because premixed MTA is based on a pozzolanic reaction, the silica and alumina eluted during the hydration process react with calcium hydroxide to enable rapid setting [75,76].
The main component of premixed MTA, calcium silicate, has a sufficiently low thermal conductivity for use as an insulator in the building and construction fields [77]. Additionally, when premixed MTA was mixed with tertiary distilled water, it exhibited a compressive strength of 100 MPa after 1 day [78]. Based on these results, the premixed MTA is expected to be a suitable dental base.

The premixed MTA had a large number of micropores. Because of these micropores, the actual distance through which the input heat passes was shortened, likely leading to high thermal diffusivity and conductivity in the premixed MTA group [79]. The thermal conductivity of premixed MTA, which ranges from 1.187-1.224 $Wm^{-1}K^{-1}$, is higher those that of enamel (0.9 $Wm^{-1}K^{-1}$) and dentin (0.6 $Wm^{-1}K^{-1}$) [73].

Although premixed MTA has a relatively high thermal conductivity, considering its potential for reparative dentin formation, antibacterial properties, microleakage resistance, and high compressive strength, it could be a suitable dental base material [80-82]. However, for premixed MTA, there was a significant difference in the compressive strength between the initial setting (5 min) and final setting (1 day). Therefore, patients should be advised to refrain from chewing teeth restored with premixed MTA on the first day of placement.

Material		Thermal Conductivity [W/(m•K)]		Compressive strength (MPa)	Surface roughness increments (μm)
		37°C	55°C		
Endocem MTA premixed (Maruchi)	**MTA**	**1.187**	**1.224**	**92.28±9.98^{A}**	**(0.457±0.163)^{A}**
Fuji 1 (GC)	Glass Ionomer	0.513	0.632	99.97±13.53^{A}	(0.228±0.084)^{B}
Elite cement 100 (GC)	Zinc phosphate	1.581	1.728	95.35±13.45^{A}	(1.285±0.161)^{C}
Denfil Flow A2 shade (Vericom)	Flowable resin	0.404	0.416	368.48±39.74^{A}	(0.008±0.004)^{D}

Clearfil SE bond is considered the gold standard bonding agent for composite resin–tooth bonding in many previous studies [83-86]. Because the premixed MTA has hydrophilic properties, the Clearfil SE bond was selected for this study. As shown in Fig. 1, most failure modes were cohesive failures of the premixed MTA, indicating that the bonding strength between the Clearfil SE bond and premixed MTA was greater than the strength of the premixed MTA. Although the compressive strength of the FR was four times that of the premixed MTA, cohesive fracture in the composite resin did not occur because of the high bonding strength between the Clearfil SE bond and premixed MTA. Furthermore, it was difficult for adhesive failure to occur because of the high adhesion strength of the Clearfil SE bond and the premixed MTA.

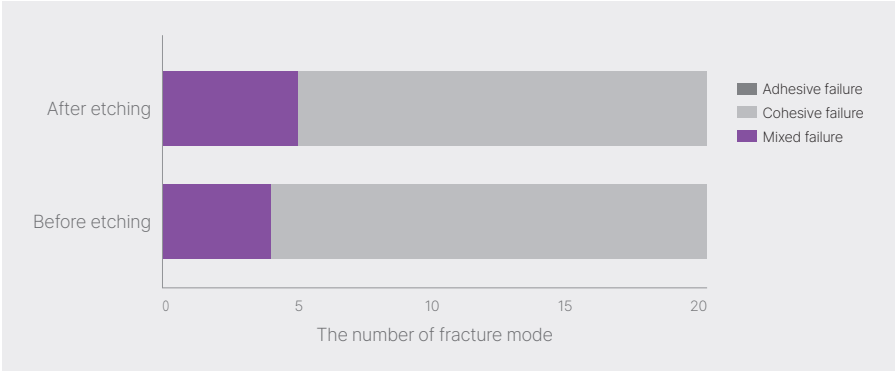


Fig. 1 Observation of fractured surfaces of specimens after completion of bonding strength test for comparison of number of fracture mode distributions before and after etching.

2. Biological Properties

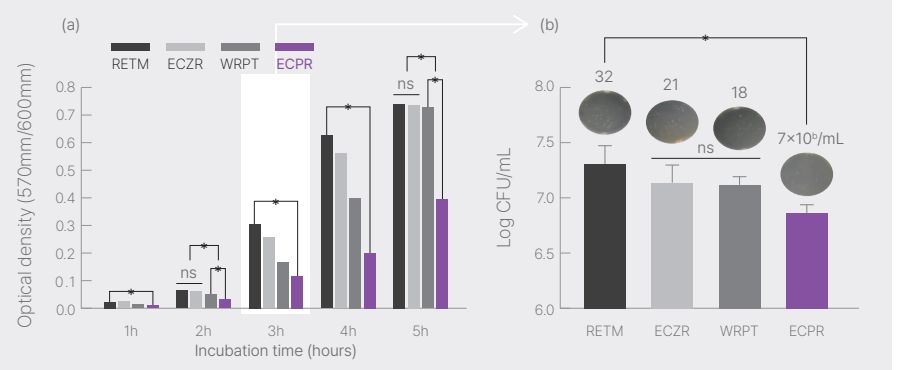
2-1

Jang, Y.-J.; Kim, Y.-J.; Vu, H.T.; Park, J.-H.; Shin, S.-J.; Dashnyam, K.; Knowles, J.C.; Lee, H.-H.; Jun, S.-K.; Han, M.-R.; et al. Physicochemical, Biological, and Antibacterial Properties of Four Bioactive Calcium Silicate-Based Cements. Pharmaceutics 2023, 15, 1701.

Calcium silicate-based cement (CSC) is a pharmaceutical agent widely used in dentistry. It is similar to mineral trioxide aggregate (MTA) in composition, containing calcium and silicate, and is also considered a bioactive material. This bioactive material is used for vital pulp treatment due to its excellent biocompatibility, sealing ability, and antibacterial activity. The purpose of this study is to compare the physicochemical, biological, and antibacterial properties of four commercial CSCs.

The effect of CSCs on the viability of E. faecalis was tested in vitro (Figure 5). The antibacterial activity was significantly different for each material after 3h of incubation time. Endocem MTA® premixed regular exhibited the highest antibacterial activity, (Figure a, $p < 0.05$).

The colony formation units (CFU/log10) after 3h of contact environment were also evaluated using a microplate reader (Figure b). The highest antibacterial activity was observed for Endocem MTA® premixed regular.



Schematic representation of antibacterial effects using four CSCs analyzed with E. faecalis, 106 CFUs/mL. (a) The optical density of E. faecalis using PrestoBlue. E. faecalis cultured with **Endocem MTA® premixed regular exhibited the highest antibacterial activity** relative to that observed in the presence of the other materials. (b) The colony formation units (CFU/log10) after 3h of contact were also evaluated using a microplate reader. The error bars indicate standard deviations. The asterisks indicate significant differences ($p < 0.05$). Represents ns = nonsignificant.

Endocem MTA® premixed regular, which is composed of calcium sulfate and DMSO, had the highest S ion content. In the fields of medicine, pharmacy, chemistry, and synthetic biology, DMSO is recommended as an organic solvent for drug development due to its intrinsic antimicrobial properties. It has also been reported to have antibacterial effects against Gram-positive bacteria such as Mycobacteroides abscessus [3,25,26]. Therefore, the release of high concentrations of S ions from Endocem MTA® premixed regular could have a significant antibacterial effect.

All the materials showed similar levels of cell viability and cell differentiation at low concentrations. In the assessment of antibacterial activity, Endocem MTA® premixed regular showed the highest antibacterial activity.

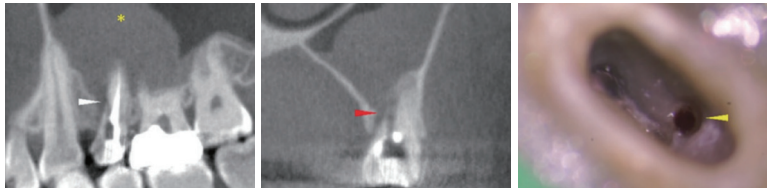
Endocem MTA® premixed regular may be a promising material in that it has improved maneuverability and antibacterial properties.

3. Results of Clinical Aspects

3-1

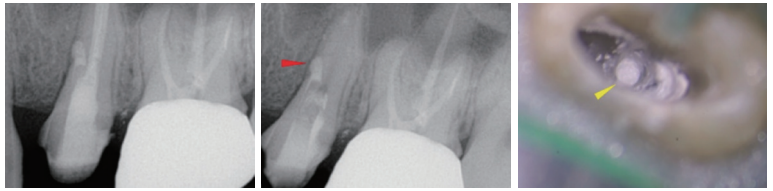
Case Report, Kim and Min: Maxillary sinusitis originated from root perforation, 2022 Saudi Endodontic Journal | Published by Wolters Kluwer - Medknow

Pre -OP



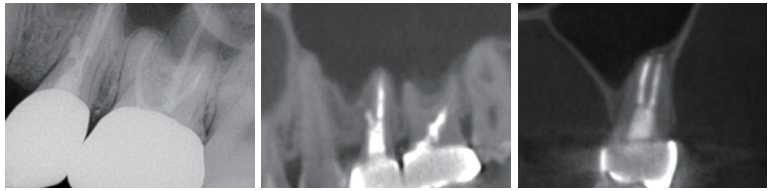
[White triangle] The root perforation in the mesial aspect of the left second premolar
[R e d triangle] The perforation was identifed in the lingual aspect
[Yellow triangle] Clinical features of the perforation site

Post -OP



Periapical X-ray image after canal obturation and core flling
[R e d triangle] Radiographic features of the repaired material
[Yellow triangle] Clinical features of the repaired perforation site with Endocem MTA Premix

F/U 6M



Periapical X-ray image showing normal periapical anatomical features.
Sagittal views of cone-beam computed tomography images showing the absence of mucosal edema on the maxillary sinus floor.

Patient information and diagnostic

A 32-year-old Asian woman who complained of left facial pain, a diagnosis of MSEO with root perforation on #25 was made.

Treatmentselected + Tools used

- Removed using a reciprocating NiTi instrument (Reciproc R25; VDW, Germany)
- Hand instrumentation was done till size #45. (K-fles; Mani, Japan)
- A copious irrigation with 5% NaOCl
- Premixed bioceramic material immediately repaired the perforation site (EndocemMTA Premix). A wet piece of cotton was placed on the material for 3 minutes to facilitate the setting reaction by hydration.

Result

On the next visit, the patient's symptoms disappeared, and the root canals were obturated using gutta-percha and a resin-based endodontic sealer (AH Plus, Dentsply) with continuous wave of condensation technique.

Follow up

A 6-month postoperative periapical radiograph showed normal anatomical features of the maxillary sinus. Furthermore, a CBCT scan showed that the mucosal edema had completely resolved, and the cortical sinus floor had been re-established.

3-2

Sin-Yeon Cho, Seonghun Park, Yooseok Shin, Il-Young Jung. Clinical outcomes of pulpotomy using a premixed injectable calcium silicate cement on mature permanent teeth with reversible pulpitis. Research Square,doi.org/10.21203/rs.3.rs-3216796/v1

When treating pulp exposure, root canal therapy (RCT) destroys the tooth structure through access opening and canal enlargement. In contrast, vital pulp therapy (VPT) avoids excessive loss of tooth structure and preserves the vital pulp, thereby maintaining the tooth's defensive properties.[60]. Being a more conservative and predictable approach for permanent teeth with carious pulp exposure [61–63], VPT (especially partial and full pulpotomy) should be attempted before proceeding with RCT to preserve tooth structure and extend tooth longevity.[64–67].

Endocem MTA Premixed (Maruchi, Wonju, Korea), a premixed injectable calcium silicate cement with a flowable consistency, has been developed. Owing to its flowability, it can be delivered directly from the syringe to the target area. this study aimed to evaluate the clinical efficacy and outcomes of pulpotomy using Endocem MTA Premixed and compare them with pulpotomy using ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK, USA).

Patients

71 patients / 71 teeth

Treatment procedure

Six dentists, including five postgraduate residents and one faculty member from Yonsei University Dental Hospital, one postgraduate resident, and one faculty member from National Health Insurance Service Ilsan Hospital performed the procedures.

- After pulp exposure, 2–3 mm of the pulp was removed to a depth of 2mm using a sterile high-speed round-tapered diamond bur (Komet Dental, Gebr. Brasseler, Lemgo, Germany) with copious irrigation.
- A randomly selected calcium silicate material was applied and gently placed over the pulp wound and surrounding dentin to a thickness of 3mm. A moist cotton pellet was then placed to ensure the setting of both materials and removed after 5min.
- A thin layer of light-cured glass ionomer composite liner(Ionoseal, VOCO GmbH, Germany) was applied and light-cured for 20s.
- The cavity was restored using composite restoration at the same visit. Immediate postoperative periapical radiographs were obtained.

Postoperative evaluation

Participants were recalled at 3, 6, and 12 months after the pulpotomy, and radiographic and clinical examinations of the treated teeth were performed.

Clearly visible calcific bridge formation on periapical radiographs was considered a successful calcific bridge formation, whereas its absence was considered a failure.

Result

71 teeth, including 37 in the ProRoot MTA group and 34 in the Endocem MTA Premixed group, were clinically and radiographically evaluated at one year.

The study reported an overall success rate of 94.4%, which is considered excellent for pulpotomies, with no statistically significant differences between the success rates of the two materials used.

The results of this study indicate that the Endocem MTA Premixed is a viable alternative to ProRoot MTA for single-visit pulpotomies of permanent premolars and molars. The overall success rates for both materials were high, with no statistically significant differences between the two groups.

Variables		Total N=71	Treatment success			
			Success		Failure	
			N	%	N	%
Overall		71	67	94.4	4	5.6
Material	ProRoot MTA	37	34	93.9	3	6.1
	Endocem MTA Premixed	34	33	97.1	1	2.9

* This table is based on specific data and results selected from the original paper.

References

1. Abdalla MM, Lung CYK, Neelakantan P, Matinlinna JP : A novel, doped calcium silicate bioceramic synthesized by sol-gel method: Investigation of setting time and biological properties. J Biomed Mater Res B Appl Biomater, 108:56-66, 2020.

2. Saghiri MA, Orangi J, Asatourian A, Gutmann JL, Garcia-Godoy F, Lotfi M, Sheibani N : Calcium silicate-based cements and functional impacts of various constituents. Dent Mater J, 36:8-18, 2017.

3. Back S, Jang Y, Lee J, Lee J, Shin J, Kim J, Han M, Kim J : pH, Ion Release Capability, and Solubility Value of Premixed Mineral Trioxide Aggregates. J Korean Acad Pediatr Dent, 49:379-391, 2022.

4. Miled MB, Dakhli R, Maaned M, Hajjami H, Cherif M : Interest of Biodentine as pulp-capping materiel under CAD/CAM Ceramic Inlay. Sch J Med Case Rep, 9:207-210, 2021.

5. Ber BS, Hatton JF, Stewart GP : Chemical modification of ProRoot MTA to improve handling characteristics and decrease setting time. J Endod, 33:1231-1234, 2007.

6. Kang, T.-Y.; Choi, J.-W.; Seo, K.-J.; Kim, K.-M.; Kwon, J.-S. Physical, chemical, mechanical, and biological properties of four different commercial root-end filling materials: A comparative study. Materials 2021, 14, 1693.

7. Baba, T.; Tsujimoto, Y. Examination of calcium silicate cements with low-viscosity methyl cellulose or hydroxypropyl cellulose additive. BioMed Res. Int. 2016, 2016, 4583854.

8. Kwon, Y.; Seok, S.; Lee, S.; Lim, B. Comparison of physical properties between paste type mineral trioxide aggregates (MTA) andpowder-liquid mix type MTA. Korean J. Dent. Mater. 2017, 44, 11–20.

9. Natu, V.P.; Dubey, N.; Loke, G.C.L.; Tan, T.S.; Ng, W.H.; Yong, C.W.; Cao, T.; Rosa, V. Bioactivity, physical and chemical properties of MTA mixed with propylene glycol. J. Appl. Oral Sci. 2015, 23, 405–411.

10. ISO-6876; Dental Root Canal Sealing Materials. ISO: London, UK, 2001.

11. Motwani, N.; Ikhar, A.; Nikhade, P.; Chandak, M.; Rathi, S.; Dugar, M.; Rajnekar, R. Premixed bioceramics: A novel pulp capping agent. J. Conserv. Dent. JCD 2021, 24, 124.

12. Gandolfi, M.G.; Siboni, F.; Botero, T.; Bossù, M.; Riccitiello, F.; Prati, C. Calcium silicate and calcium hydroxide materials for pulp capping: Biointeractivity, porosity, solubility and bioactivity of current formulations. J. Appl. Biomater. Funct. Mater. 2015, 13, 43–60.

13. Camilleri, J.; Montesin, F.E.; Brady, K.; Sweeney, R.; Curtis, R.V.; Ford, T.R.P. The constitution of mineral trioxide aggregate. Dent. Mater. 2005, 21, 297–303.

14. Scarano, A.; Manzon, L.; Di Giorgio, R.; Orsini, G.; Tripodi, D.; Piattelli, A. Direct capping with four different materials in humans: Histological analysis of odontoblast activity. J. Endod. 2003, 29, 729–734.

15. Camilleri, J. Characterization of hydration products of mineral trioxide aggregate. Int. Endod. J. 2008, 41, 408–417.

16. Luczaj-Cepowicz, E.; Marczuk-Kolada, G.; Pawinska, M.; Obidzinska, M.; Holownia, A. Evaluation of cytotoxicity and pH changes generated by various dental pulp capping materials—An in vitro study. Folia Histochem. Cytobiol. 2017, 55, 86–93.

17. Hirose, Y.; Yamaguchi, M.; Kawabata, S.; Murakami, M.; Nakashima, M.; Gotoh, M.; Yamamoto, T. Effects of extracellular pH on dental pulp cells in vitro. J. Endod. 2016, 42, 735–741.

18. Torabinejad, M.; Hong, C.; Ford, T.P.; Kettering, J. Antibacterial effects of some root end filling materials. J. Endod. 1995, 21, 403–406.

19. Nirupama, D.N.; Nainan, M.T.; Ramaswamy, R.; Muralidharan, S.; Usha, H.H.L.; Sharma, R.; Gupta, S. In vitro evaluation of the antimicrobial efficacy of four endodontic biomaterials against Enterococcus faecalis, Candida albicans, and Staphylococcus aureus. Int. J. Biomater. 2014, 2014, 383756.

20. Özcan, E.; Yula, E.; Arslano ˘glu, Z.; ˙Inci, M. Antifungal activity of several root canal sealers against Candida albicans. Acta Odontol. Scand. 2013, 71, 1481–1485.

21. ElReash, A.A.; Hamama, H.; Eldars, W.; Lingwei, G.; Zaen El-Din, A.M.; Xiaoli, X. Antimicrobial activity and pH measurement of calcium silicate cements versus new bioactive resin composite restorative material. BMC Oral Health 2019, 19, 235.

22. Swan, A.E. Effect of Heat on the Setting Reaction and Physical Properties of Endodontic Sealers. Doctoral Dissertation, University of Illinois Chicago, Chicago, IL, USA, 2022.

23. Han, W.; Sun, T.; Li, X.; Shui, Z.; Chen, Y.; Sun, M. Influence of Lithium Carbonate on C3A Hydration. Adv. Mater. Sci. Eng. 2018, 2018, 6120269.

24. Mehtälä, P.; Pashley, D.; Tjäderhane, L. Effect of dimethyl sulfoxide on dentin collagen. Dent. Mater. 2017, 33, 915–922.

25. Kirkwood, Z.I.; Millar, B.C.; Downey, D.G.; Moore, J.E. Antimicrobial effect of dimethyl sulfoxide and N, N-Dimethylformamide on Mycobacterium abscessus: Implications for antimicrobial susceptibility testing. Int. J. Mycobacteriol. 2018, 7, 134–136.

26. Weld, J.T.; Gunther, A. The antibacterial properties of sulfur. J. Exp. Med. 1947, 85, 531–542.

27. Hamdy M, Fayyad DM, Eldaharawy MH, Hegazy E : Physical properties of different Pulp Capping Materials and Histological Analysis of their effect on Dogs' Dental Pulp Tissue Healing. Egypt Dent J, 64:2657-2667, 2018.

28. Hirose Y, Yamaguchi M, Kawabata S, Murakami M, Nakashima M, Gotoh M, Yamamoto T : Effects of extracellular pH on dental pulp cells in vitro. J Endod, 42:735-741, 2016.

29. Lucas CA, Gillies RJ, Olson JE, Giuliano KA, Martinez R, Sneider JM : Intracellular acidification inhibits the proliferative response in BALB/c-3T3 cells. J Cell Physiol, 136:161-167, 1988.

30. Mizuno M, Banzai Y : Calcium ion release from calcium hydroxide stimulated fibronectin gene expression in dental pulp cells and the differentiation of dental pulp cells to mineralized tissue forming cells by fibronectin. Int Endod J, 41:933-938, 2008.

31. Rashid F, Shiba H, Mizuno N, Mouri Y, Fujita T, Shinohara H, Ogawa T, Kawaguchi H, Kurihara H : The effect of extracellular calcium ion on gene expression of bone-related proteins in human pulp cells. J Endod, 29:104-107, 2003.

32. Hørsted-Bindslev P, Løvschall H : Treatment outcome of vital pulp treatment. Endod Topics, 2:24-34, 2002.

33. Desai S, Chandler N : Calcium hydroxide-based root canal sealers: a review. J Endod, 35:475-480, 2009.

34. Poggio C, Lombardini M, Colombo M, Beltrami R, Rindi S : Solubility and pH of direct pulp capping materials: a comparative study. J Appl Biomater Func Mater, 13:E181-E185, 2015.

35. Narita H, Itoh S, Imazato S, Yoshitake F, Ebisu S : An explanation of the mineralization mechanism in osteoblasts induced by calcium hydroxide. Acta Biomater, 6:586-590, 2010.

36. Cooper PR, Takahashi Y, Graham LW, Simon S, Imazato S, Smith AJ : Inflammation-regeneration interplay in the dentine-pulp complex. J Dent, 38:687-697, 2010.

37. Gandolfi MG, Siboni F, Polimeni A, Bossù M, Riccitiello F, Rengo S, Prati C : In vitro screening of the apatite-forming ability, biointeractivity and physical properties of a tricalcium silicate material for endodontics and restorative dentistry. Dent J , 1:41-60, 2013.

38. Mohammadi Z, Dummer PMH : Properties and applications of calcium hydroxide in endodontics and dental traumatology. Int Endod J, 44:697-730, 2011.

39. Estrela C, Sydney GB, Bammann LL, Felippe Júnior O : Mechanism of the action of calcium and hydroxy ions of calcium hydroxide on tissue and bacteria. Braz Dent J, 6:85-90, 1995.

40. Luczaj-Cepowicz E, Marczuk-Kolada G, Pawinska M, Obidzinska M, Holownia A : Evaluation of cytotoxicity and pH changes generated by various dental pulp capping materials - an in vitro study. Folia Histochem Cytobiol, 55:86-93, 2017.

41. Weld JT, Gunther A : The antibacterial properties of sulfur. J Exp Med, 85:531-542, 1947.

42. Choudhury SR, Roy S, Goswami A, Basu S : Polyethylene glycol-stabilized sulphur nanoparticles: an effective antimicrobial agent against multidrug-resistant bacteria. J Antimicrob Chemother, 67:1134-1137,2012.

43. Canalis E, Hott M, Deloffre P, Tsouderos Y, Marie PJ: The divalent strontium salt S12911 enhances bone cell replication and bone formation in vitro. Bone, 18:517-523, 1996.

44. Buehler J, Chappuis P, Saffar JL, Tsouderos Y, Vignery A : Strontium ranelate inhibits bone resorption while maintaining bone formation in alveolar bone in monkeys (Macaca fascicularis). Bone, 29:176-179, 2001.

45. Schröder U : Effects of calcium hydroxide-containing pulp-capping agents on pulp cell migration, proliferation, and differentiation. J Dent Res, 64:541-548, 1985.

46. Dammaschke T, Galler K, Krastl G : Current recommendations for vital pulp treatment. Dtsch Zahnärztl Z Int, 1:43-52, 2019.

47. Poggio C, Lombardini M, Colombo M, Beltrami R, Rindi S : Solubility and pH of direct pulp capping materials: a comparative study. J Appl Biomater Func Mater, 13:E181-E185, 2015.

48. Han L, Kodama S, Okiji T : Evaluation of calcium-releasing and apatite-forming abilities of fast-setting calcium silicate-modified endodontic materials. Int Endod J, 48:124-130, 2015.

49. Kang TY, Choi JW, Kim KM, Kwon JS : Mechanical and physico-chemical properties of premixed-MTA in contact with three different types of solutions. Korean J Dent Mater, 48:281-292, 2021.

50. Choi Y, Park SJ, Lee SH, Hwang YC, Yu MK, Min KS : Biological effects and washout resistance of a newly developed fast-setting pozzolan cement. J Endod, 39: 467-472, 2013.

51. Saxena P, Gupta SK, Newaskar V. Biocompatibility of root-end filling materials: recent update. Restor Dent Endod 2013;38:119-127.

52. Bernabé PF, Gomes-Filho JE, Bernabé DG, Nery MJ, Otoboni-Filho JA, Dezan E Jr, Cintra LT. Sealing ability of MTA used as a root end filling material: effect of the sonic and ultrasonic condensation. Braz Dent J 2013;24:107-110.

53. Alsubait SA, Hashem Q, AlHargan N, AlMohimeed K, Alkahtani A. Comparative evaluation of push-out bond strength of ProRoot MTA, bioaggregate and Biodentine. J Contemp Dent Pract 2014;15:336-340.

54. Nagas E, Cehreli ZC, Uyanik MO, Vallittu PK, Lassila LV. Effect of several intracanal medicaments on the push-out bond strength of ProRoot MTA and Biodentine. Int Endod J 2016;49:184-188.

55. Buldur B, Oznurhan F, Kaptan A. The effect of different chelating agents on the push-out bond strength of ProRoot MTA and EndoSequence root repair material. Eur Oral Res 2019;53:88-93.

56. Saghiri MA, Shokouhinejad N, Lotfi M, Aminsobhani M, Saghiri AM. Push-out bond strength of mineral trioxide aggregate in the presence of alkaline pH. J Endod 2010;36:1856-1859.

57. Vivan RR, Guerreiro-Tanomaru JM, Bosso-Martelo R, Costa BC, Duarte MA, Tanomaru-Filho M. Push-out bond strength of root-end filling materials. Braz Dent J 2016;27:332-335.

58. Salim Al-Ani AA, Mutluay M, Stape THS, Tjäderhane L, Tezvergil-Mutluay A. Effect of various dimethyl sulfoxide concentrations on the durability of dentin bonding and hybrid layer quality. Dent Mater J 2018;37:501-505.

59. Tjäderhane L, Mehtälä P, Scaffa P, Vidal C, Pääkkönen V, Breschi L, Hebling J, Tay FR, Nascimento FD, Pashley DH, Carrilho MR. The effect of dimethyl sulfoxide (DMSO) on dentin bonding and nanoleakage of etch-and-rinse adhesives. Dent M3ater 2013;29:1055-1062.

60. Lin, L. M., Ricucci, D., Saoud, T. M., Sigurdsson, A. & Kahler, B. Vital pulp therapy of mature permanent teeth with irreversible pulpitis from the perspective of pulp biology. Aust. Endod J. 46, 154–166, (2020).

61. Leong, D. J. X. & Yap, A. U. Vital pulp therapy in carious pulp-exposed permanent teeth: an umbrella review. Clin Oral Investig 25, 6743–6756, (2021).

62. Eggmann, F. et al. Partial pulpotomy without age restriction: a retrospective assessment of permanent teeth with carious pulp exposure. Clin Oral Investig 26, 365–373, (2022).

63. Ather, A., Patel, B., Gelfond, J. A. L. & Ruparel, N. B. Outcome of pulpotomy in permanent teeth with irreversible pulpitis: a systematic review and meta-analysis. Sci Rep 12, 19664, (2022).

64. Randow, K. & Glantz, P. O. On cantilever loading of vital and non-vital teeth. An experimental clinical study. Acta Odontol. Scand. 44, 271–277, (1986).

65. Caplan, D. J., Cai, J., Yin, G. & White, B. A. Root canal filled versus non-root canal filled teeth: a retrospective comparison of survival times. J. Public Health Dent. 65, 90–96, (2005).

66. Asgary, S. et al. Outcomes of root canal therapy or full pulpotomy using two endodontic biomaterials in mature permanent teeth: a randomized controlled trial. Clin Oral Investig 26, 3287–3297, (2022).

67. Zhang, M. et al. Factors affecting the outcome of full pulpotomy in permanent posterior teeth diagnosed with reversible or irreversible pulpitis. Sci Rep 12, 20280, (2022).

68. Weiner R. Liners and bases in general dentistry. Aust Dent J 2011; 56: 11-22.

69. Widyasrini D. Dental materials foundations and applications.Tekno 2018; 8: 85-88.

70. Arandi NZ. Calcium hydroxide liners: A literature review. Clin Cosmet Investig Dent 2017; 9: 67-72.

71. Civjan S, Barone J, Reinke P, Selting W. Thermal properties of nonmetallic restorative materials. J Dent Res 1972; 51:1030-1037.

72. Saitoh M, Masutani S, Kojima T, Saigoh M, Hirose H, Nishiyama M. Thermal properties of dental materials-cavity liner and pulp capping agent. Dent Mater J 2004; 23: 399-405.

73. Lancaster P, Brettle D, Carmichael F, Clerehugh V. In-vitrothermal maps to characterize human dental enamel and
dentin. Front Physiol 2017; 8: 461.

74. Kang TY, Choi JW, Kim KM, Kwon JS. Mechanical and physico-chemical properties of premixed-MTA in contact with three different types of solutions. Korean J Dent Mater 2021;281-292.

75. Adl A, Sadat Shojaee N, Pourhatami N. Evaluation of the dislodgement resistance of a new pozzolan-based cement (EndoSeal MTA) compared to ProRoot MTA and Biodentine in the presence and absence of blood. Scanning 2019; 2019:3863069.

76. Choi Y, Park SJ, Lee SH, Hwang YC, Yu MK, Min KS. Biological effects and washout resistance of a newly developed fast-setting pozzolan cement. J Endod 2013; 39: 467-472.

77. Zheng Q, Wang W. Calcium silicate based high efficiency thermal insulation. Br Ceram Trans 2000; 99: 187-190.

78. Kang TY, Choi JW, Seo KJ, Kim KM, Kwon JS. Physical, chemical, mechanical, and biological properties of four different commercial root-end filling materials: A comparative study. Materials 2021; 14: 1693.

79. Shinzato K, Baba T. A laser flash apparatus for thermal diffusivity and specific heat capacity measurements. J Therm Anal Calorim 2001; 64: 413-422.

80. Zhang H, Pappen FG, Haapasalo M. Dentin enhances the antibacterial effect of mineral trioxide aggregate and bioaggregate. J Endod 2009; 35: 221-224.

81. Tziafas D, Pantelidou O, Alvanou A, Belibasakis G, Papadimitriou S. The dentinogenic effect of mineral trioxide aggregate (MTA) in short-term capping experiments. Int Endod J 2002; 35: 245-254.

82. Torabinejad M, Parirokh M. Mineral trioxide aggregate: A comprehensive literature review — Part II: Leakage and biocompatibility investigations. J Endod 2010; 36: 190-202.

83. Mine A, De Munck J, Cardoso MV, Van Landuyt KL, Poitevin A, Kuboki T, et al. Bonding effectiveness of two contemporary self-etch adhesives to enamel and dentin. J Dent 2009; 37:872-883.

84. Peumans M, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Five-year clinical effectiveness of a two-step
self-etching adhesive. J Adhes Dent 2007; 9: 7-10.

85. Loguercio AD, Lorini E, Weiss RV, Torri AP, Picinatto CC, Ribeiro NR, et al. A 12-month clinical evaluation of composite resins in class III restorations. J Adhes Dent 2007; 9. 57-64.

86. Yuan Y, Shimada Y, Ichinose S, Tagami J. Effect of dentin depth on hybridization quality using different bonding tactics
in vivo. J Dent 2007; 35: 664-672.