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Comparative Evaluation Of The Effect Of Different Chelating Agents On The Push-Out Bond Strength Of A Bioceramic Sealer: An In-Vitro Study

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Abstract
Aim: *This study aimed to assess how the push out bond strength of a bioceramic sealer (Meta CeraSeal) is affected by three different chelating agents: 17% EDTA, 7% Maleic acid, and 5% Pentetic acid.*
Methodology*: 60 mandibular premolars were shaped using Pro Taper Gold rotary file upto size F2. The canals were irrigated with 2ml of 5.25% sodium hypochlorite (NaOCl) between instrumentation and then the NaOCl was removed by rinsing with five milliliters of distilled water.. The 60 specimens were divided into 4 groups of 15 each, in a random manner, depending on the final irrigating solution: Group 1 (n=15): 17% EDTA,Group 2 (n=15): 7% Maleic acid,Group 3 (n=15): 5% Pentetic acid and Group 4 (n=15): 0.9% Saline. The canals were obturated with Meta CeraSeal coated gutta percha using single cone technique. Access to cavities were sealed and the specimens were sectioned to obtain three horizontal sections at distances of 12, 6, and 2 mm from the apex (coronal, middle, and apical root sections, respectively). A universal testing machine was used to apply the push-out test.*
Results*: The push out bond strength was significantly higher for 5% Pentetic acid as compared to 17% EDTA and 7% Maleic acid (p<0.05). Also, the apical third exhibited the lowest push out bond strength value in all the groups.*
Conclusion*: Within the limitations of the study, it can be concluded that, in comparison to the other tested groups, 5% pentetic acid has higher potential to facilitate the bonding of the bioceramic sealer Meta CeraSeal to root dentin.*
Keywords: *bioceramic sealer, chelating agent, Meta CeraSeal, push out bond strength, pentetic acid*

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I. Introduction

Successful root canal therapy depends on thorough chemomechanical debridement of pulpal tissue, dentin debris, and infective microorganisms. Irrigants augment mechanical debridement by flushing out debris,dissolving tissue, and disinfecting the root canal system [1]. Even though sodium hypochlorite (NaOCl) is widely used as an irrigant in endodontic treatment, it cannot dissolve inorganic substances and therefore does not effectively remove the smear layer [2,3].

Smear layer plays an important role in the bond strength of sealers to the root canal walls.

Studies have shown a significant increase in adhesive strength and resistance to microleakage of sealers when the smear layer is removed [4]. Hence, the use of chelating agents is recommended in conjunction with NaOCl to facilitate smear layer removal.

EDTA is the most commonly used chelating agent. Whenever NaOCl is used in combination with EDTA, the interaction between the two solutions lead to early inactivation of NaOCl. The use of EDTA for over 1 minute could lead to unintended erosion of peritubular and intratubular dentin [5]. Therefore, the search for alternative chelating agents that facilitate smear layer removal without being aggressive on root dentin is still ongoing. Ballal et al suggested 7% maleic acid, a mild organic acid as a chelating agent and has shown that it is more effective than EDTA in smear layer removal, especially at the apical third of the root canal.10 It was also found to be less cytotoxic than EDTA [6]. Another chelating agent, diethylene triamine penta acetic acid (DTPA), commonly known as pentetic acid, has a chemical structure that is an extended form of EDTA [7].

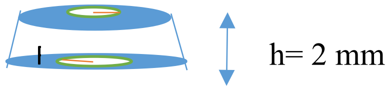
Lately, the use of bioceramic sealers has been on the rise. Meta CeraSeal is a premixed calcium silicate - based bioceramic sealer which includes tricalcium silicate (20–30%) and dicalcium silicate (1–10%) as bioactive components and zirconium dioxide as the radiopacifier (45–50%)[6]. It has been claimed to possess antibacterial property, unique stability and excellent sealing ability [8].

The goal of this study was to evaluate and compare how three chelating agents—17% EDTA, 7% maleic acid, and 5% pentetic acid—affect the push-out bond strength of Meta CeraSeal, a bioceramic sealer. This consisted of in vitro evaluation of the push out bond strength of Meta CeraSeal using Universal Testing Machine (UTM).

II. Methodology

After ethical committee approval (Ref: No. IEC/04/CONS-C/MDC/2021), 60 single rooted, single canal mandibular premolars with fully matured apices extracted for orthodontic reasons and untraceable to a contributor were collected. Teeth with fractures, cracks, dental caries, root resorption, severely angulated roots and calcified root canals were excluded. Specimens were decoronated with a diamond disc (Kerr dental, USA) under copious water cooling, so that the coronal surface was perpendicular to the long axis of the root and the remaining root length was 14 ± 2 mm from the apex. Working length determination was done using an ISO size 10 K file. Pro Taper Gold (Dentsply Sirona, Baillagues, Switzerland) rotary files were used to prepare the roots and the canals were enlarged up to F2 (size 25,0.08 apical taper) files. The canals were irrigated with 2ml of 5.25% sodium hypochlorite (TRU LON Jayna industries, Uttar Pradesh, India) between each instrumentation. All canals were rinsed with five milliliters of distilled water (IDS Denmed Water Distiller, India) to eliminate the hypochlorite. The specimens were then randomly divided into 4 groups of 15 each, based on the final irrigation solution. The groups were as follows: Group 1 (n=15): Final irrigation with 17% EDTA, Group 2 (n=15): Final irrigation with 7% Maleic acid, Group 3 (n=15): Final irrigation with 5% Pentetic acid and Group 4 (n=15): Final irrigation with 0.9% Saline. The canal was filled with 5 ml of the final irrigation solution, and passive ultrasonic agitation (Woodpecker, Guilin, Guangxi, China) was done for 1 minute while the solution remained in the canal. The root canals were flushed with 5 millilitres of distilled water and then dried using paper points.The canals were obturated with F2 gutta percha cones (Dentsply, Maillefer, Baillagues, Switzerland) coated with Meta CeraSeal sealer (Meta Biomed Co., Cheongju, Korea) by single cone technique. Access to cavities were temporarily sealed using a temporary restorative material (Waldent DenTemp, Vasa Denticity Pvt. Ltd, Gurgaon). The specimens were then subjected to a 3-week incubation period at 37°C in an environment with 100% humidity.

The samples were sectioned horizontally with a slow-speed saw (Chennai Metco Pvt. Ltd., Chennai). The coronal, middle and apical sections of 2 mm were obtained at distances of 12, 6, and 2 mm from the apex respectively. The push-out test was conducted using a universal testing machine (Instron E3000 V1.4, England) at a cross-head speed of 0.5 mm/min. The maximum load at failure (in Newtons) obtained was utilized to compute debonding values in Megapascals. This computation involved dividing the Newtons by the bonding area of the root canal filling. The bonding area was obtained using the following formula: $\pi(R + r)[(h)2+ (R – r)2]0.5$ where $h = 2$ mm, $\pi = 3.14$, R is the coronal radius, and r is the apical radius in mm.



Data was analysed using the statistical package SPSS 26.0 (SPSS Inc., Chicago, IL) and level of significance was set at $p<0.05$. Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Since the data was seen to follow normal distribution, the parametric tests, One Way ANOVA and Bonferroni Posthoc were performed.

III. Results

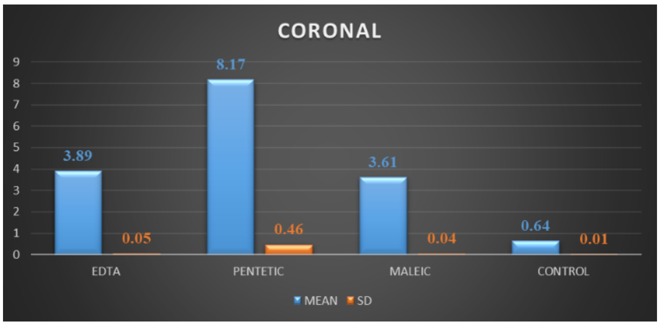
Table 1- Mean Push Out Bond Strength

GROUPS	MEAN
EDTA (1)	**3.42**
MALEIC (2)	**3.41**
PENTETIC (3)	**5.84**
CONTROL (4)	**0.32**

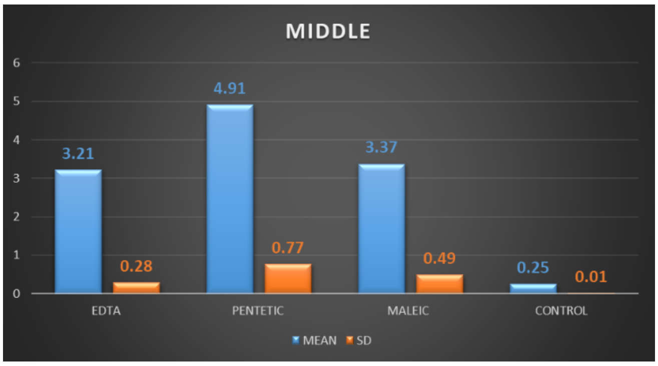
The mean push out bond strength values of the bioceramic sealer are shown in Table 1. The push out bond strength values of Meta CeraSeal on comparing the coronal, middle and apical thirds, after final irrigation with 17% EDTA (Group 1), 7% Maleic acid (Group 2), 5% Pentetic acid (Group 3) and 0.9% Saline (Group 4), are given in Table 2. The same is depicted n graphs 1, 2 and 3. In all the thirds, the highest value for push out bond strength was seen with Group 3 (5% Pentetic acid). In the apical and middle third, the push out bond strength of 7% Maleic acid (Group 2) was higher than that of 17% EDTA (Group 1). Whereas, in the cervical third, the push out bond strength of 17% EDTA was greater than that of 7% Maleic acid. In all the three thirds, the lowest value for push out bond strength was observed in Group 4(0.9% Saline). This was statistically significant ($P<0.05$).

Table 2- Mean Push Out Bond Strength - Coronal, Middle And Apical Thirds

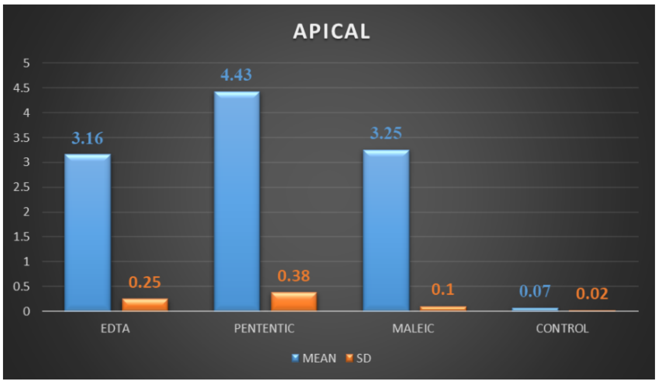
		MEAN	SD
CORONAL	EDTA (1)	3.89	0.05
	MALEIC (2)	3.61	0.04
	PENTETIC (3)	8.17	0.46
	CONTROL (4)	0.64	0.01
MIDDLE	EDTA (1)	3.21	0.28
	MALEIC (2)	3.37	0.49
	PENTETIC (3)	4.91	0.77
	CONTROL (4)	0.25	0.01
APICAL	EDTA (1)	3.16	0.25
	MALEIC (2)	3.25	0.10
	PENTENTIC (3)	4.43	0.38
	CONTROL (4)	0.07	0.02



Graph 1: Graph Showing Push Out Bond Strength Of Bioceramic Sealer In The Coronal Third Of Four Groups



Graph 2: Graph Showing Push Out Bond Strength Of Bioceramic Sealer In The Middle Third Of Four Groups



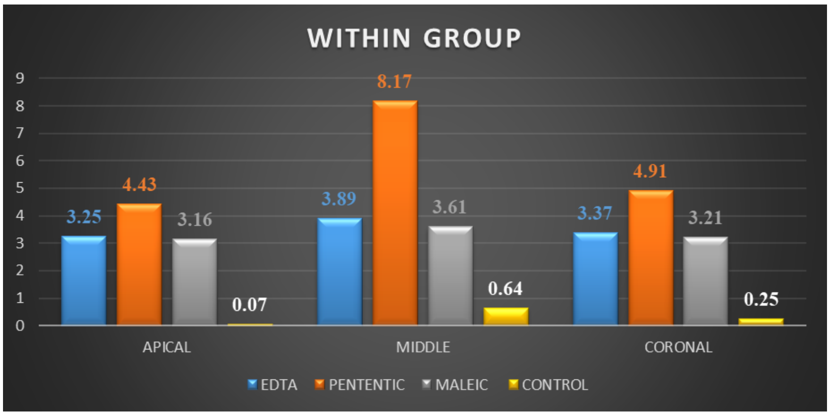
Graph 3: Graph Showing Push Out Bond Strength Of Bioceramic Sealer In The Apical Third Of Four Groups

In all thirds, all the groups showed highest value for push out bond strength at the coronal third followed by the middle third. The lowest value for push out bond strength was observed in the apical third (Table 3, Graph 4).

Table 3- Comparison Of Push Out Bond Strength- Within Group

		EDTA	PENTENTIC	MALEIC	CONTROL
APICAL		3.16±0.25	4.43±0.38	3.25±0.10	0.07±0.02
MIDDLE		3.21±0.28	4.91±0.77	3.37±0.49	0.25±0.01
CORONAL		3.89±0.05	8.17±0.46	3.61±0.10	0.64±0.01
P VALUE (REPEATED MEASURES OF ANOVA TEST)		0.0001*	0.0001*	0.0001*	0.0001*
P VALUE (Boneferroni) POSTHOC TEST)	A vs M	0.29	0.06	0.88	0.0001*
	A vs C	0.0001*	0.0001*	0.0004*	0.0001*
	C vs M	0.0001*	0.0001*	0.001*	0.0001*

***P<0.05 is statistically significant**



Graph 4: Graph showing push out bond strength of bioceramic sealer within the groups

IV. Discussion

An ideal root canal obturation material should bond and penetrate as much as possible to the root canal wall [9]. The push-out test is a useful test to measure this bond strength. The present study evaluated the effect of different chelating agents on the push out bond strength of a bioceramic sealer, Meta CeraSeal.

The results of the present study showed that pentetic acid exhibited higher push out bond strength values as compared to the other groups in all the thirds of the root. This may be attributed to the fact that EDTA has four carboxylic groups and two amine groups, whereas pentetic acid has five carboxylic groups and three amine groups to bond with the metal ions to form an octadentate ligand. Thus, pentetic acid has more complexing sites than EDTA for its chelating action. Moreover, the formation constants of pentetic acid for its complexes are 100 times greater than those of EDTA [7]. The stability of a complex ion increases with increase in its formation constant. Hence, the complexes formed by pentetic acid are more stable than those formed by EDTA. These reasons might be responsible for better pushout bond strength values obtained with pentetic acid. In the coronal and middle thirds, the push out bond strength of maleic acid was greater than that of pentetic acid. This is in accordance with the findings of Ballal et al. who reported that 7% maleic acid had better smear layer removal ability than 17% EDTA in the apical and middle thirds [3]. Smear layer removal enables a better and closer adaptation of the sealer to the radicular dentin, which in turn increases the displacement resistance of the sealer. The lower push out bond strength values of EDTA in the apical third may be attributed to the fact that dentin in the apical third is much more sclerosed and EDTA may not have such a pronounced action on the sclerosed dentin [10].

The present study also investigated the effect of root-thirds on bond strength. In all experimental groups, the bond strength values increased from apical to coronal direction, and revealed a significant difference. This could be explained by apical radicular dentin having a lesser number of tubules, thus a reduced area for bond formation, than the coronal part. The coronal part of the root canal system has a more complex tubular structure with higher tubular density and larger diameter tubules, and apparently yields a better infiltration compared to its sclerotic apical counterpart [11]. This is in agreement with the findings of Carneiro et al. [12] and Nagas et al [13].

The present study has some limitations. Our findings are limited to straight canals, which are often an exception rather than a norm. These findings may not be extrapolated onto teeth with anatomic variations that a clinician encounters on a daily basis. Also, 5% pentetic acid solution in this study was freshly prepared, whereas a commercially prepared 17% EDTA solution was used in this study. Using freshly prepared 17% EDTA may have resulted in higher bond strength values. Also, some studies suggest greater apical preparation sizes for better irrigant penetration [14]. However, the apical preparation size in the present study has been limited to size 25, so as to not decrease the fracture resistance of the teeth. To establish a more direct connection with clinical practice, the findings of this research should be tested in ex vivo and clinical studies. Further research has to be focused on the effect of different formulations of pentetic acid, using freshly prepared EDTA and using different apical preparation sizes.

V. Conclusion

It may be concluded that the use of 5% Pentetic acid has the potential to facilitate the bonding of the bioceramic sealer Meta CeraSeal to root dentin.

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Nil.

Conflicts Of Interest
There are no conflicts of interest.

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