Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(1), 2582-2592 | ISSN:2251-6727

Evaluation of Cold Ceramic and Mineral Trioxide Aggregate's Ph and Dimensional Stability in Dry, Blood and Saliva Contaminated Conditions -An in Vitro Study

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(**Received**: 25 January 2024 **Revised**: 20 February 2024 **Accepted**: 25 February 2024)

KEYWORDS

MTA(mineral trioxide aggregate), CC(cold ceramic), pH , dimensional stability

Abstract:

Background: The purpose of this investigation is to examine the pH and dimensional stability of cold ceramic (cc) and mineral trioxide aggregate (MTA) in dry, saliva, and blood contaminants. **Materials and methods:** 60 cylindrical discs of Cold Ceramic & 60 cylindrical discs of MTA having dimensions 6mm X 3mm were prepared by mixing the components to putty consistency in group 1 and 2 respectively. In each group half of the specimens were subjected to pH measurement and another half to test dimensional stability. Specimens were subsequently grouped into three subgroups (n=10) for each test, in below order: **Group 1**: Cold Ceramic; **1A**: Dry, **1B**: Saliva contaminated, **1C**: Blood contaminated **Group 2**: MTA; **2A**: Dry, **2B**: Saliva contaminated, **2C**: Blood contaminated. **For evaluation of pH**: Specimens were placed in containers containing 10ml of deionised water, and the initial pH was recorded immediately[T0], similarly readings were recorded after the first day[T1] and the seventh day[T2] using a digital pH meter. **For evaluation of dimensional stability:** Their lengths were measured with a digital calliper. After 30 days, the difference in length divided by the initial length gave us our estimation of dimensional stability. The data was statistically analysed through one-way ANOVA and a paired Student "t" test (P 0.05). **Results:** No significant differences was seen with respect to control, saliva contaminated and blood contaminated groups. There were no substantial differences in the dimensional stability of MTA and cold ceramic samples contaminated with saliva or blood from T0-T1 (p> 0.05). **Conclusion:** Both Cold Ceramic and MTA cement exhibited similar alkaline pH & dimensional stability in dry, saliva & blood contaminated areas.

Introduction :

The success rate of a conventional root canal treatment is high nearly approaching 95%.

At times reinfections are treated by nonsurgical retreatment. When there is failure of nonsurgical root canal treatment or when retreatment is not indicated, treatment by a surgical approach involving root-end resection, retrograde cavity preparation, and filling is indicated to obtain a good apical seal and resolve persistent infections.[1] Endodontic surgery's long-term success is frequently impacted by the root canal filling material.[2] Some of the most crucial requirements for the perfect RFM are biocompatibility, adequate bond strength, dimensional stability, good adaptability to the root canal walls, and no leakage.[3]

In endodontics, the use of calcium silicate-based materials has shown to be advantageous for periapical procedures that involve blood and moisture contamination. The primary reason why calcium silicate-based cements are utilised as root-end filling

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JCHR (2024) 14(1), 2582-2592 | ISSN:2251-6727

materials is because of their hydraulic nature, which enables them to set even in the presence of blood and tissue fluids.[4] In terms of biocompatibility and sealing ability, calcium silicate cements like Portland-based cements and mineral trioxide aggregate (MTA) have also demonstrated encouraging outcomes.[5] Mineral trioxide aggregate (MTA) is appropriate for the majority of endodontic procedures. It demonstrates higher sealing ability and biocompatibility with less cytotoxicity.[6] MTA however, has some drawbacks, including challenges in manipulation, a prolonged setting time, and limited antibacterial activity.[7]

The cold ceramic (CC), first presented by Modaresi from Yazd University in Iran[8] in 2000, is a material that resembles mineral trioxide aggregate (MTA). It is advised for use as an apical barrier in teeth with open apices, a root perforation repair material, a paste filling material for root canal obstruction, a capping material for pulp capping and pulpotomy.[9] Cold ceramic contains mainly calcium hydroxide with other biocompatible substances and sets in the presence of humidity. Recent investigations have revealed that it has superior sealing ability to amalgam and a comparable tissue reactivity to MTA.[10]

In most clinical scenarios, root end cavity preparations and filling materials come into close proximity with, or are mixed with, blood, saliva, or tissue fluids, resulting in contamination. The presence of moisture, saliva, or blood may influence the physical qualities of the root end filling materials. Any material used for root end filling must remain dimensionally stable and be able to endure the surrounding environment. Dimensional stability is connected to its capability to seal the root-end. The alkalinity of calcium silicate-based cements may affect antibacterial activity and calcium ion release. Calcium ions are the cause of hard tissue development[11].

The suitability of the materials for clinical applications depends on the characteristics of the tissue environment where they are used. CC and MTA come into contact with tissue fluids like blood and moisture for endodontic applications such as retro fillings, furcation repair, revascularization procedures, etc. During the endodontic treatment of necrotic teeth with periapical lesions, perforation, or furcal repair and retro preparation, the pH of the environment becomes acidic, which may impact the characteristics of the materials. Any material that is employed in endodontic procedures must be both environment and tissue-tolerant and should be dimensionally stable.

There have been no previous research that investigated the influence of pH and dimensional stability of cold ceramic and MTA in blood or saliva polluted settings. The current study's goal was to examine the same.

MATERIAL AND METHODOLOGY:

Preparation of specimens

60 cylindrical discs of Cold Ceramic(SJM co, Yazd, Iran; CC) & 60 cylindrical discs of MTA (ProRoot MTA Dentsply, USA) having dimensions 6mm (length) X 3mm (height) were prepared by mixing the components to putty consistency in group 1 and 2 respectively. The specimens were then taken out of the molds, and in each group, half of them were tested for pH and the other half for dimensional stability. Specimens were subsequently grouped into three subgroups (n=10) for each test, in this order:

Group 1: Cold Ceramic; **1A**: Dry, **1B**: Saliva contaminated, **1C**: Blood contaminated

Group 2: MTA; **2A**: Dry, **2B**: Saliva contaminated, **2C**: Blood contaminated

For evaluation of pH: Specimens of each group were placed in a closed containers with 10 ml of deionised water for about 1min and initial pH was recorded instantly[T0] using a digital pH metre.(Systronics, model 335, Gujarat, India). Subsequent readings after 1st day[T1] & 7th day[T2] were measured [Figure 1a]. To reduce error, the pH of each sample was measured three times before the final measurement was taken. However, before testing the sample, the apparatus was calibrated using buffer capsules having pH values of 7.0 ± 0.05 and 4.0 ± 0.05 (Merck life science private limited, Mumbai, India). Between sample measurements, the electrode was completely cleaned with distilled water and blot dried.

For evaluation of dimensional stability: Specimens of each group wrapped in a gauze sponge dampened with water, and placed in a 37^{0}C incubator. A digital calliper with a resolution of 0.01mm[T0] was used to measure their lengths after 48 hours, and the results were preserved at 37^{0}C in distilled water. Our measurement of dimensional stability is obtained by dividing the difference in length by the initial length, which was obtained after 30 days [T1]. [Figure 1b].

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JCHR (2024) 14(1), 2582-2592 | ISSN:2251-6727

STATISTICAL ANALYSIS:

The obtained data were put into an MS office Excel spreadsheet (Office 2011, Microsoft Corp., Redmond, USA) and statistically analyzed using the Statistical Package for Social Sciences (SPSS), Version 22.0 (SPSS Inc., Chicago, IL, USA). The data were analyzed using one-way ANOVA and the paired t test (P 0.05).

RESULTS

Initially, there was no significant difference in the pH of cold ceramic and MTA in the control, saliva, and blood contaminated groups, but after 24 hours and 7 days, pH was found to be considerably higher first in the blood contaminated samples, followed by saliva and the control group (Table 1,2 & 3). When the pH of cold ceramic and MTA was compared immediately, after 24 hours, and after 7 days, no significant variations were found between the control, saliva contaminated, and blood contaminated groups (Table 3,4 & 5). There were no significant differences in the dimensional stability of MTA and cold ceramic samples contaminated with saliva or blood between T0 and T1 (p> 0.05). (Table 6)

DISCUSSION :

A root canal filling material ought to be dimensionally stable, biocompatible, nontoxic, and non- carcinogenic. It should also be insoluble in tissue fluid. Its capacity to seal should remain unaffected by the presence of moisture. It should be controllable and radiopaque enough that a radiograph can identify it.[12]

In endodontics, calcium silicate cement materials are considered to be successful for all difficult cases. They can set in the presence of blood and fluids in the surrounding tissues because to their inherent hydraulic qualities, making them appropriate for most endodontic operations.They have improved sealing and biocompatibility while causing less cytotoxicity.[13]MTA has some downsides, including extended manipulation, long setting times, and poor bactericidal capabilities.[14]

All of these applications—root-end filling, root perforation repair, apical barrier in teeth with open apices, paste filling for root canal obstruction, and capping material for pulp capping and pulpotomy —are possible with Cold Ceramic, a mineral trioxide aggregate (MTA). Silica, calcium, barium, and sulfur trioxide make up 93% of the primary elemental components of cold ceramic. MgO, MnO, Fe2O3, Na2O, K2O, and TiO2 are the remaining constituents.[15]

During endodontic procedures such as root end preparations, peri-radicular tissue fluid commonly comes into touch with root-end filling materials. Some materials may be stable immediately after setting but may disintegrate over time.[16] Whenever there is a contamination to an existing material, it affects the properties of that material, which might be seen immediately or after sometime. MTA is widely used for endodontic applications, but the new material cold ceramic is recently introduced. Hence there is a scarcity of literature regarding the dimensional stability and pH determination of new combination of these materials. hence, this study was undertaken to add light on these aspects of cold ceramic. In our present study the pH of both MTA and CC showed values more than 9. The pH values of the CC were determined by Modaresi et al. The results indicated that the pH value was 7.36 following mixing and increased to 10.11, 10.84, and 11.16 after 1-2 hours and 7 days. This indicates that CC might gradually produce an alkaline atmosphere.[17] It was demonstrated by Estrela C et al. that bacterial cellular membrane enzymes may become permanently or reversibly inactivated at pH values higher than 9, which would result in a loss of biological activity. McHugh CP et al. came to the conclusion in their investigation that most bacteria, particularly Enterococcus faecalis, are inhibited by a pH higher than 11.5.

Alkaline pH plays an important role in biocompatibility, antibacterial activity, and osteogenic potential.[18] Alkaline pH was maintained in the current study throughout the study time. The advantage of this study's methodology is that it permits pH readings at intervals longer than the setting period, which is a good representation of the material's pH and alkalinization potential.[19]

The sealing qualities of MTA and CC were compared in different conditions by Hasheminia SM et al. The results showed similar sealing capacity for Cold Ceramic and MTA under various circumstances, with no significant differences, similar to the findings in the current study, which investigated pH and dimensional stability instead.[21] Modaresi et al. used methylene blue penetration to investigate the sealing capacity of two root-end filling materials. Their findings demonstrated that CC has a much lower apical barrier microleakage than calcium hydroxide.[20] An in vitro dye penetration test was used to examine the sealing characteristics of MTA and CC in different conditions. The results

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showed that CC had a better sealing property than MTA in blood- contaminated conditions and a similar sealing property to MTA in dry and saliva-contaminated conditions.[21]

In the present study, both MTA and CC showed almost similar dimensional stability in control, saliva and blood contaminated conditions at different time intervals.The experimental cement's dimensional stability was favorable. The measure for dimentional stability cannot be more than 1.0% of contraction or 0.1% of expansion, according the Iso and Ansi/Ada. The experimental cement did not exceed 1% of contraction than the original dimension.

CONCLUSION :

Based on the results obtained from this study, Cold Ceramic cement exhibited similar alkaline pH & dimensional stability compared to MTA in dry, saliva & blood contaminated areas. Thus, in addition to its equivalent biocompatibility and quicker initial setting time, it may be recommended as a substitute root end filling material. However, more research is required to determine the clinical usage of this material.

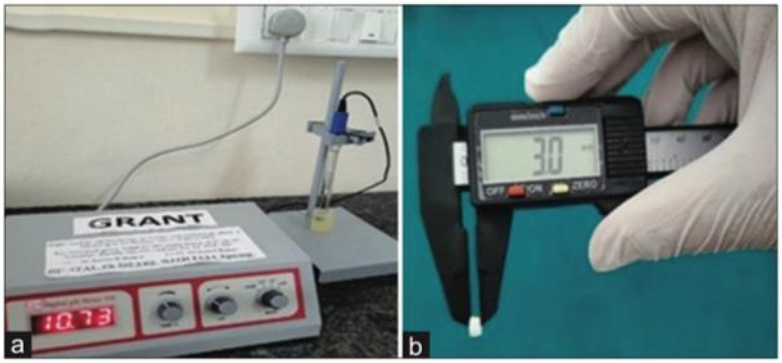

Figure 1: Determination of (a) pH of the test sample and (b) dimensional stability

Table 1: pH of cold ceramic & MTA in control group immediate, after 24 hours and after 7 days by ANOVA & t test

CONTROL GROUP		N	Mean	Std. Deviation	Std. Error Mean	P value
IMMEDIATE	Cold ceramic	10	7.3800	.16865	.05333	0.112
	MTA	10	7.5800	.02108	.00667	
AFTER 24 HRS	Cold ceramic	10	11.6750	.34258	.10833	0.064
	MTA	10	12.0900	.20028	.06333	
AFTER 7 DAYS	Cold ceramic	10	12.0000	.05270	.01667	0.701
	MTA	10	12.4750	.00527	.00167	

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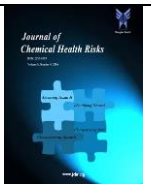

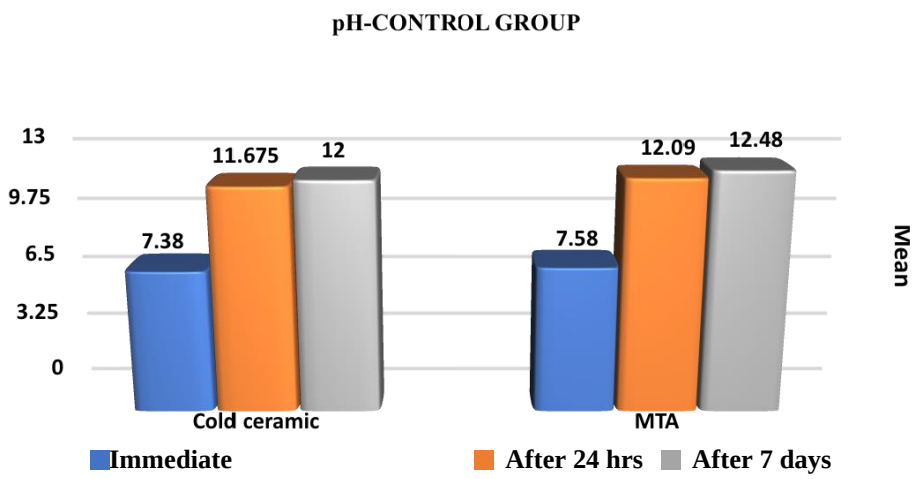

Table 2: pH of cold ceramic & MTA in saliva contaminated immediate, 24 hours and after 7 days by ANOVA & t test

SALIVA CONTAMINATED		N	Mean	Std. Deviation	Std. Error Mean	P value
IMMEDIATE	Cold ceramic	10	7.3950	.20555	.06500	0.333
	MTA	10	7.4600	.02108	.00667	
AFTER 24 HRS	Cold ceramic	10	10.6800	.08433	.02667	0.211
	MTA	10	12.3900	.06325	.02000	
AFTER 7 DAYS	Cold ceramic	10	11.4200	.12649	.04000	0.172
	MTA	10	12.5750	.01581	.00500	

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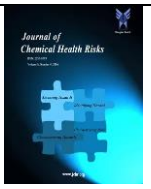

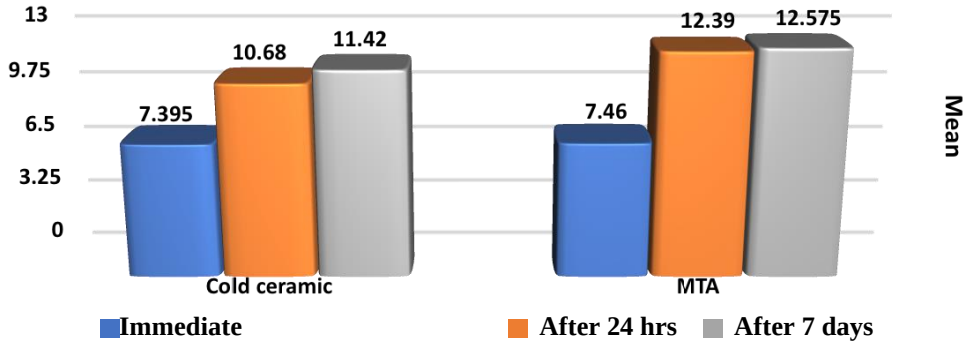

Table 3: pH of cold ceramic and MTA in blood contaminated immediate, after 24 hours and after 7 days by ANOVA & t test

BLOOD CONTAMINATED		N	Mean	Std. Deviation	Std. Error Mean	P value
IMMEDIATE	Cold ceramic	10	7.3850	.05798	.01833	0.112
	MTA	10	7.4500	.00000	.00000	
AFTER 24 HRS	Cold ceramic	10	11.9500	.05270	.01667	0.121
	MTA	10	12.1250	.06852	.02167	
AFTER 7 DAYS	Cold ceramic	10	12.3250	.02635	.00833	0.877
	MTA	10	12.5850	.00527	.00167	

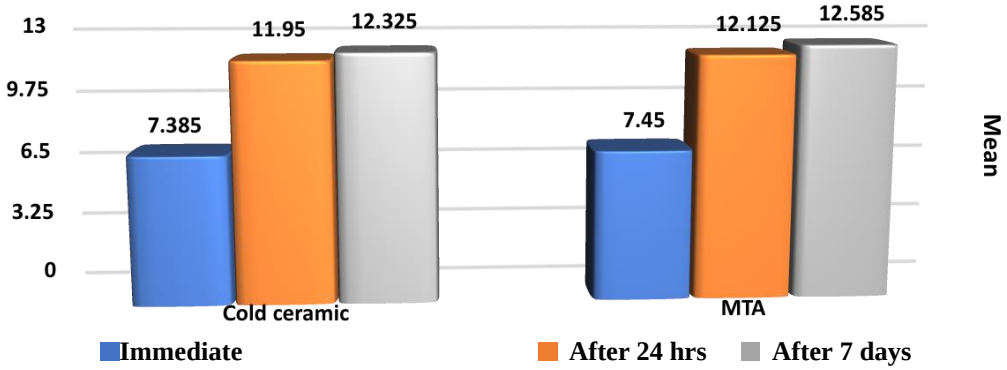

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Table 4: pH of cold ceramic in control, saliva & blood contaminated immediate, after 24 hours and after 7 days by ANOVA

		Mean	Std. Deviation	P value
IMMEDIATE	CONTROL	7.3800	.16865	0.978
	SALIVA CONTAMINATED	7.3950	.20555	
	BLOOD CONTAMINATED	7.3850	.05798	
AFTER 24 HRS	CONTROL	11.6750	.34258	0.898
	SALIVA CONTAMINATED	10.6800	.08433	
	BLOOD CONTAMINATED	11.9500	.05270	
AFTER 7 DAYS	CONTROL	12.0000	.05270	0.881
	SALIVA CONTAMINATED	11.4200	.12649	
	BLOOD CONTAMINATED	12.3250	.02635	

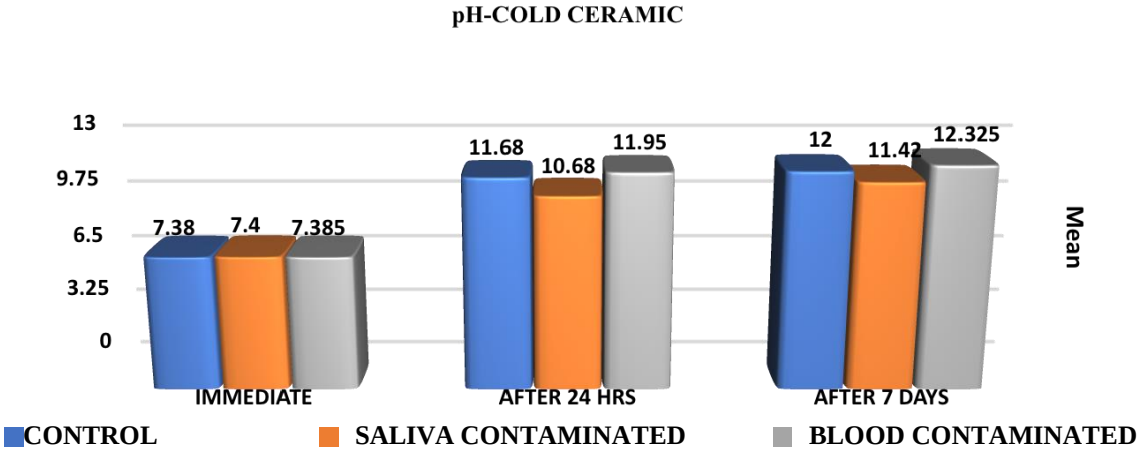

Table 5: pH of MTA in control, saliva and blood contaminated immediate, after 24 hours and after 7 days by ANOVA

		Mean	Std. Deviation	P value
IMMEDIATE	CONTROL	7.5800	.02108	0.789
	SALIVA CONTAMINATED	7.4600	.02108	
	BLOOD CONTAMINATED	7.4500	.00000	
AFTER 24 HRS	CONTROL	12.0900	.20028	0.321
	SALIVA CONTAMINATED	12.3900	.06325	
	BLOOD CONTAMINATED	12.1250	.06852	

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AFTER 7 DAYS	**CONTROL**	**12.4750**	**.00527**	**0.143**
	SALIVA CONTAMINATED	**12.5750**	**.01581**	
	BLOOD CONTAMINATED	**12.5850**	**.00527**	

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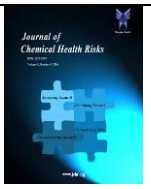


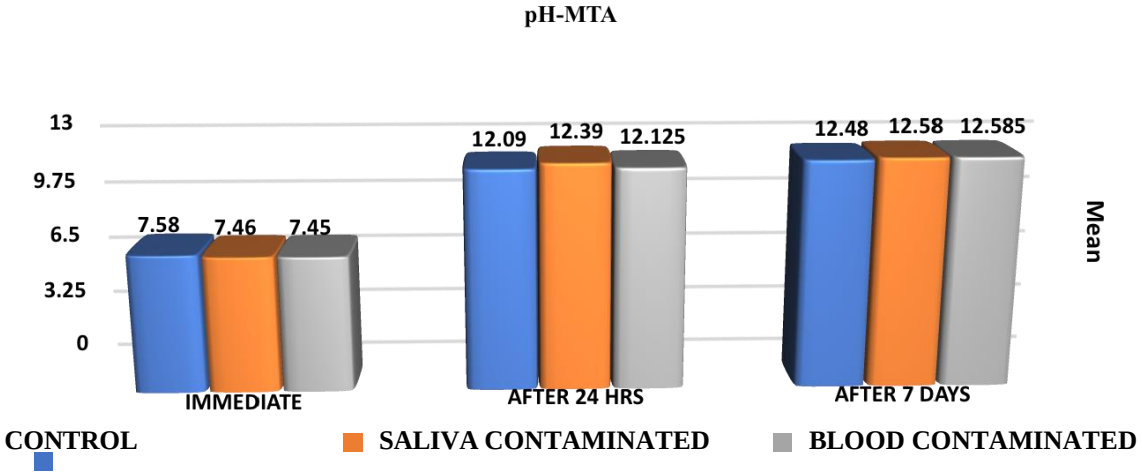
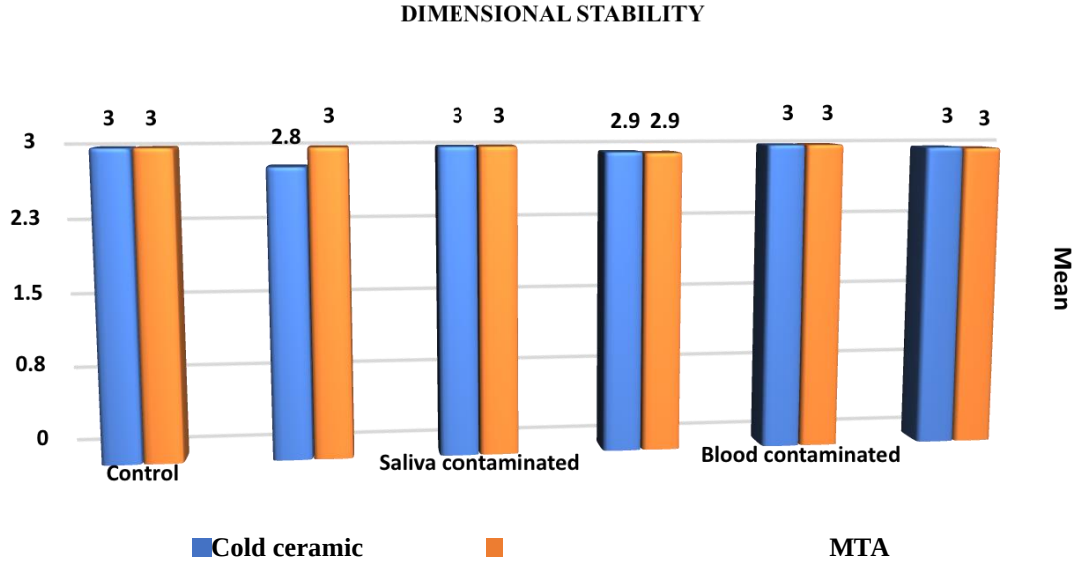


Table 6: Dimensional stability of cold ceramic and MTA in control , saliva and blood contaminated after immediate, 24 hours and after 7 days by t test

		Mean	Std. Deviation	Mean difference	P value
1A	T0	3.0000	.00000	0.18	0.122
	T1	2.8170	.33882		
1 B	T0	3	0.00	0.05	0.111
	T1	2.94	0.010		
1C	T0	3	0.000	0.028	0.1211
	T1	2.97	0.01033		
2A	T0	3	-	-	-
	T1	3	-		
2 B	T0	3	0.00	0.065	0.789
	T1	2.93	0.015		
2C	T0	3	0.001	0.032	0.987
	T1	2.96	0.010		



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JCHR (2024) 14(1), 2582-2592 | ISSN:2251-6727

ACKNOWLEDGEMENT

We sincerely acknowledge Dr Rahul Halkai (Professor and Head), Al Badar Rural Dental college & hospital, Dr. Supriya, Professor, Department of Conservative Dentistry and Endodontics, HKE's S Nijalingappa Institute of Dental Science and Research, Kalaburgi, Karnataka, Reza & Dr Modaresi for their immense support in carrying out this study.

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