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Comparative Evaluation Of Sealing Ability Of Three Different Materials In Repair Of Furcation Perforation: An In-Vitro Study

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Abstract
Aim: *The aim of this in-vitro study was to compare the sealing ability of three different materials in the repair of Furcation Perforation- an invitro study.*
Materials and Methods: *This study was conducted on 45 recently extracted human molars. Standard access cavity preparation was made and intentional furcation perforations were made with a round bur centered between roots and perforations were treated with Pro Root MTA, Biodentine and Angelus Bio C Repair. The teeth were divided randomly into three groups each containing 15 teeth each. The perforations were sealed as follows: Group A with Pro Root MTA, Group B with Biodentine, Group C with Angelus Bio C Repair. The specimens were then be immersed in 2% methylene blue dye for 24 hours. After their removal, all the specimens were longitudinally sectioned and dye penetration were evaluated under the stereomicroscope (20x magnification).*
Statistical Analysis: *The Intergroup comparison of mean dye penetration score was compared using the ANOVA and pairwise comparison was done with Turkey post hoc test.*
Results*: The findings suggested that Bio- C Repair had better sealing ability than Pro Root MTA, Biodentine when used as a furcation perforation repair material.*
Conclusion: *The sealing ability of Bio- C Repair is best when used as a furcation perforation repair than Biodentine and Pro Root MTA and showed significant results.*
Keywords: *Sealing ability, Pro Root MTA, Biodentine, Angelus Bio C Repair, dye penetration, furcation perforation, Methylene Blue, Stereomicroscope.*

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I. Introduction

Success of endodontic treatment depends on the removal of infected canal contents followed by root canal filling using a material of adequate compatibility[1]. Occasionally mishaps occur during endodontic treatment and one among them is perforation of root canal wall which can have a significant impact on the prognosis of the root canal treatment[2]. Furcation perforation refers to a mid-curvature opening into the periodontal ligament space and leads to worst possible treatment outcome[3]**.** According to Seltzer, perforations were the second greatest cause of failure in endodontic therapy[4]. Ideally to prevent the bacterial contamination, perforations should be repaired as quickly as possible with a biocompatible material[5].

An ideal perforation repair material should be biocompatible and provide an adequate seal, not affected by blood contamination, bactericidal, induce bone formation healing, radiopaque, induce mineralization and easy in manipulation,placement and not be extruded during condensation[6]. Several materials have been

proposed for the sealing of perforations, which includes Zinc oxide eugenol cement, superortho ethoxy benzoic acid, intermediate restorative material, glass ionomer cement, resin cements, resin modified glass ionomer cement, Mineral Trioxide Aggregate. However, the divergent outcomes have demonstrated that so far- no material has satisfied all the ideal requirements[7]**.**

ProRoot MTA is a biomaterial that has been investigated for endodontic applications since early 1990s[8]**.** Despite its many advantages, it has some drawbacks such as a long setting time, manipulation problems and discoloration potential as compared to others[9].Various efforts have been made to overcome these disadvantages, new calcium silicate-based bioactive restorative cements have been developed, namely Biodentine. Advantages of this material are short setting time, high compressive and flexural strength, and color stability along with ease of manipulation[10].

Recently, Bio-C Repair (Angelus, Brazil, Londrina), a new ready-to-use bioceramic was introduced to endodontics in threaded syringe, it offers handling and insertion improvements, collaborating with the practice and saving time.The materials are chemically stable and helps in increasing fracture resistance, exhibit good radiopacity, excellent sealing ability, are easy to handle, have a high pH and do not undergo resorption[11].

The purpose of the present study was to evaluate the sealing ability of ProRoot MTA, Biodentine, and Bio- C Repair when used as furcation perforation repair materials in molars teeth using dye penetration method analyzed under the stereomicroscope.

II. Materials And Methodology

45 Sound human extracted molars were taken and the samples were randomly divided into different groups each containing 15 teeth with minimal and no caries, restoration, and fracture. The samples with cracks, open apices, root caries, and evidence of pathologic resorption were also excluded from the study. Then all the samples were disinfected in 5% sodium hypochlorite solution for 30 min and stored in physiological saline.

Preparation Of the Samples

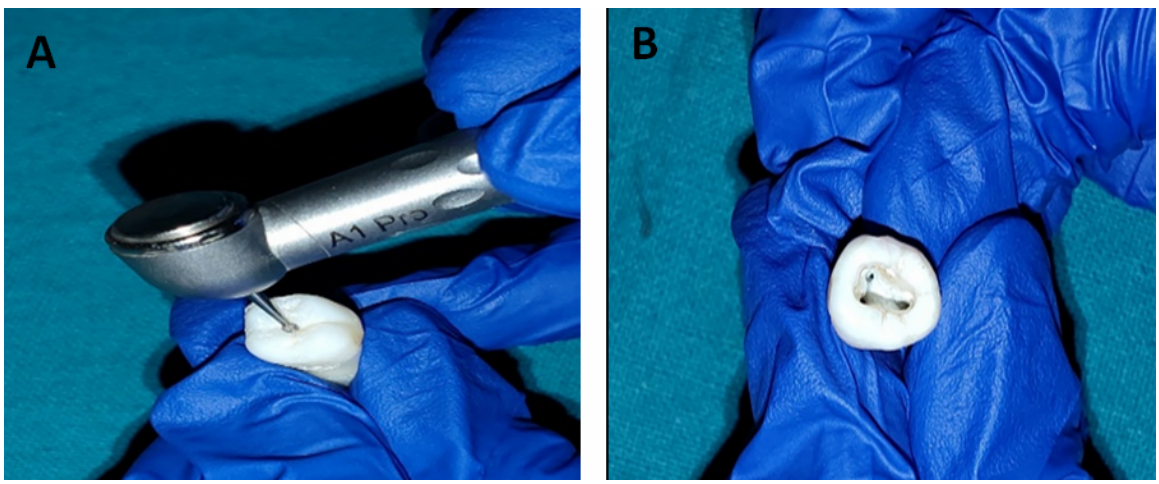
All of the samples had a standard access cavity prepared with a round diamond bur and with a high-speed handpiece and water spray irrigation followed by perforations that were made in the middle of the pulp chamber floor with a # 2 round carbide bur. The perforation was standardized in all samples to the diameter of 1mm. The chamber and perforation were flushed with saline and air dried.

Perforation Repair

The samples were randomly divided into three groups each group containing 15 teeth according to the perforation material used for furcal repair.

Group 1: Pro Root MTA Group
Group 2: Biodentine
Group 3: Angelus Bio C Repair

After sealing the perforations on all of the samples, the access cavities were sealed with composite and they were kept in incubator for 24 hours at 37 degrees Celsius to allow the materials to set.



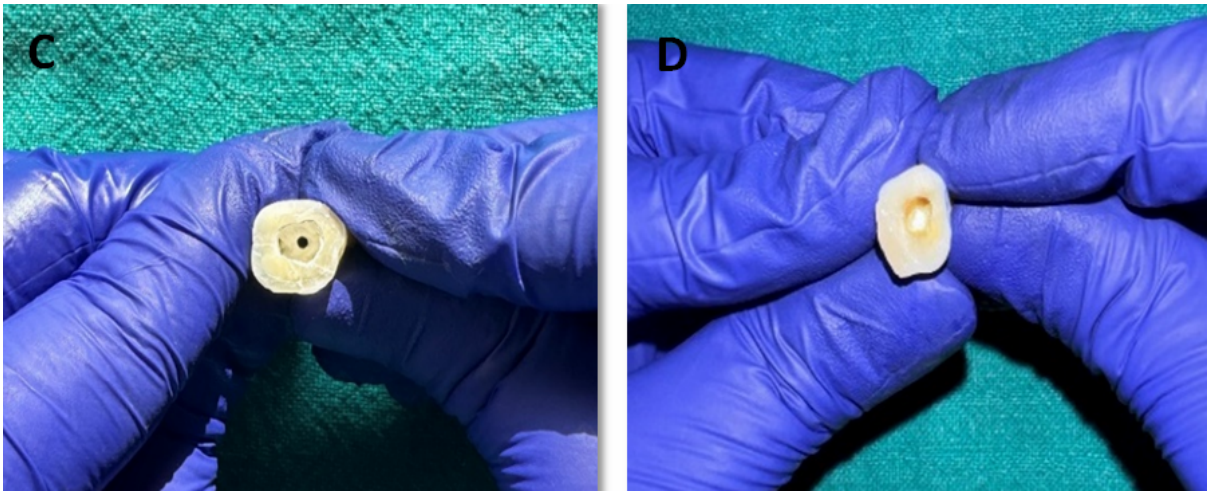


Figure 1: (A) Preparation Of Samples Figure (B) Standard Access Cavities (C) Artificial Perforation Createdfigure (D) Perforation Repair Done And Orifices Sealed With Sticky Wax

Dye Penetration

To prevent the dye from permeating, experimental samples were uniformly coated with two layers of nail varnish except for 2 mm around the area of the perforation site and the apices of the teeth was sealed using sticky wax. Sticky wax was also placed over the orifice of each canal. All of the samples were immersed in a 2 % methylene blue solution for 24 hours at room temperature. Samples were then removed from the dye and rinsed under tap water for 30 seconds and then air dried, all the samples were directly sectioned buccolingually in longitudinal direction by using a diamond disc along with a water coolant. The sectioned samples exhibited the material between the two walls of perforation with one end towards the pulp chamber and the other end was towards the furcation. The perforation wall of the sectioned sample with more dye penetration was selected for the microleakage evaluation.

In each section, the actual value of dye leakage was calculated from outer margins of perforation cavity to the level of pulpal floor. The sectioned halves were evaluated for dye penetration under stereomicroscope (20x magnification).

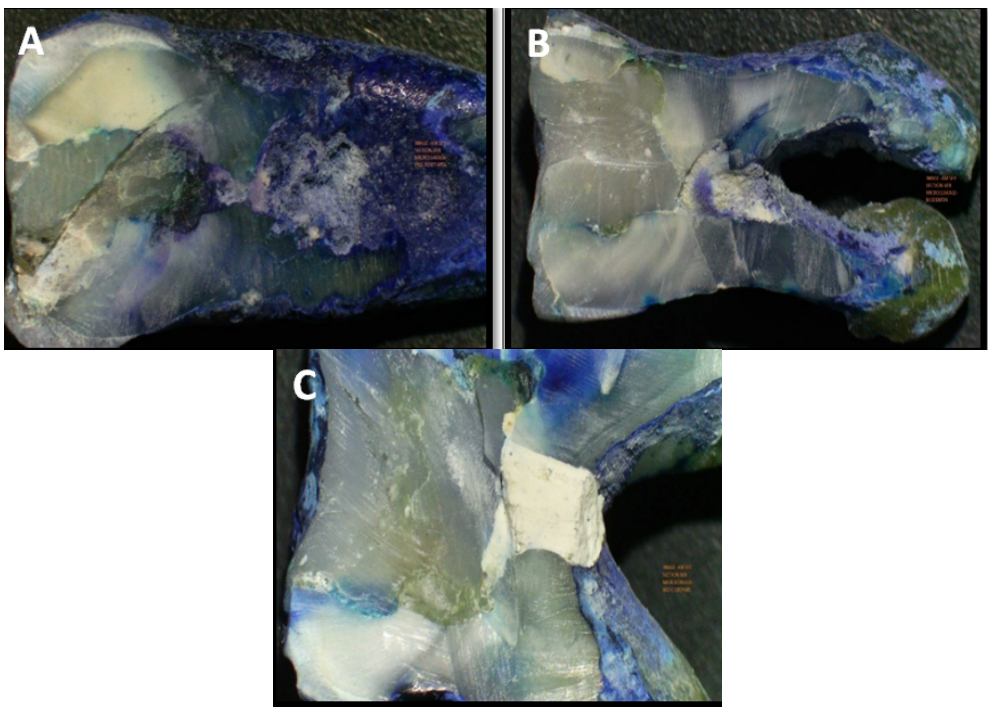


Figure 2: (A) Stereomicroscopic Image Showing The Dye Penetration Of Pro Root Mta (B) Stereomicroscopic Image Showing The Dye Penetration Of Biodentine (C) Stereomicroscopic Image Showing The Dye Penetration Of Bio- C Repair

III. Results

The microleakage for study groups was evaluated and results obtained were subjected to statistical analysis. The depth of dye penetration was evaluated using scoring criteria given by Saunders et al. (Table 1).

Table 1: Scoring Criteria

Groups	No. Of Specimens	0 (No Leakage)	1 (<1mm)	2 (1-1.5mm)	3 (>1.5mm)
Proroot Mta	15	0	4	5	6
Biodentine	15	3	2	9	4
Bio C Repair	15	3	5	7	0

Table 2: Descriptive Analysis

	Pro Root Mta	Biodentine	Bio - C Repair
Mean	1.38	0.96	0.666
Standard Deviation	0.476	0.570	0.632
Minimum	0.5	0	0
Maximum	2	1.6	1.5
Count	15	15	15

Table 3: Anova Test

Source Of Variation	**Ss**	**Df**	**Ms**	**F Value**	**P-Value**
Between Groups	**3.86044**	**2**	**1.940**	**6.054**	**0.004**
Within Groups	**13.3453**	**42**	**0.321**		
Total	**17.20574**	**44**			

Table 4: Post Hoc Test

Groups	**P Value**	**Significance**
Pro Root Mta Vs Biodentine	**0.014519**	**Yes**
Pro Root Mta Vs Bio C Repair	**0.00208**	**Yes**
Biodentine Vs Bio C Repair	**0.386658**	**No**

Using one-way analysis of variance (ANOVA), it was revealed that there was a statistically significant difference between the groups, $p < 0.004$ for microleakage evaluation.The mean values of microleakage, according to the dye penetration test for all the three study groups were calculated. The maximum mean was found to be in Group I -Pro Root MTA followed by Group II -Biodentine and least in Group III-Bio C Repair which shows the least microleakage.

There was significant difference ($p < 0.05$) in mean microleakage evaluation values between Group I - Pro Root MTA and Group II -Biodentine, tested using independent sample t test. There was no significant difference between mean microleakage evaluation between Group II- Biodentine and Group III -Bio C Repair (Table 3 and 4).

On individual comparison of the mean difference between all three groups using Tukey's post hoc test it was observed that a statistically significant difference in the dye penetration values was found between Groups I and Group II, Group I and Group III. But no statistically significant difference was observed in dye penetration values in Group II and Group III. However, in some samples of Group III, it was observed no leakage clinically.

IV. Discussion

ProRoot MTA is a mixture of a refined Portland cement, bismuth oxide, and gypsum and is reported to contain trace amounts of SiO2, CaO, MgO, K2 SO4 and Na2 SO4[12]. ProRoot MTA is used in variety of endodontic applications such as pulp capping, perforation repair, apexification, apexogenesis, root end filling material and pulpotomy due to its unique feature of antibacterial nature, good compressive strength (67Mpa), biocompatibility, more radiopacity then conventional gutta-percha and dentin and thus easily distinguishable on radiographs, better sealing ability due to its slight expansion upon setting[13].

The results of our study showed that **Group I -ProRoot MTA** is difficult to handle due to its granular consistency, slow setting time (2 hrs45 min), initial looseness resulting in possible displacement out of the cavity once the mixture starts to dry it loses its cohesiveness and becomes hard to handle, surface disintegration which may lead to micro leakage, loss of marginal adaptation and altered microhardness of dentin.

According to our study the microleakage showed by **Group I -Pro Root MTA** was maximum, followed by **Group II -Biodentine** and the least microleakage was shown by **Group III -Bio C Repair.**The

same results were achieved by **Ankita Khandelwal et al** when they have compared these two same groups i.e. **Group I- Pro Root MTA,Group II-Biodentine** as taken in our study[14].

Similarly in contrast to our study, **Ovsay et al** evaluated the microleakage of repair materials of furcation perforation and the results showed Pro Root MTA as the most successful in terms of better sealing ability than Biodentine[15].Also, **Hassan et al** concluded that Pro Root MTA and Biodentine performed equally well as furcation perforation repair material which was in contrast to our study as there was significant difference between **Group- I Pro Root MTA** and **Group – II Biodentine[16].**

The results of our study showed that the mean dye penetration values were found to be significantly lesser for **Group II-Biodentine** than **Group I -Pro Root MTA.** The probable reasons could be Biodentine forms tag like structures when it comes in contact with dentine as an interfacial layer called the "mineral infiltration zone", where the alkaline caustic effect of calcium silicate cements hydration products degrades the collagenous component of interfacial dentine. It is available in form of powder and liquid. Powder is composed of tricalcium, dicalcium silicate, calcium carbonate, zirconium dioxide. In liquid calcium chloride is added in aqueous solution in increase its setting time. This Biodentine has to be triturated for 30 s prior to insertion. The setting time is about 12 min[17]**.**

Hanand Okiji et al showed that there is calcium and silicon ion uptake in dentine which leads to formation of tag - like structures in Biodentine which was higher than Pro Root MTA[18]. Better sealing ability of Biodentine can be credited because of addition of setting accelerators and softeners; a new pre-dosed capsule formulation for use in mixing device improves its sealing ability. Biodentine has better handling properties thus adaptation to cavity walls is better which improves its sealing ability. It has fast-setting time (12min) thereby sealing the interface earlier to increase the amount of micro leakage and bacterial contamination. According to **Raskin A et al,** it has smaller particle size which adapts to cavity surface sealing its interface. Porosity and pore volume in set Biodentine material is also less than MTA that could be one of the reasons for better sealing ability[19].

Although Biodentine have above discussed advantages but it has its limited radiopacity, more solubility and the difficulty of attaining the desired or optimized consistency which led to the introduction of Bioceramics[20]**.**Bioceramics consist of calcium silicates, calcium phosphate, calcium hydroxide, zirconium oxide, tantalum oxide, putties, and thickeners[21]**.** The distribution and particle size of tricalcium silicate powders affect handling and setting properties, since smaller particles can penetrate dentin tubules, leading to quicker hydration[22]. According to **Ghilotti J et al** zirconia oxide, used as a radio-opacifier, was detected at high levels in Bio-C Repair[23].

Bioceramic cements present potential bioactivity, that is, the capacity to produce hydroxyapatite, influencing the connection between dentin and filling material[24]**.** These materials are chemically stable, may aid in increasing root fracture resistance, exhibit good radiopacity, have a high pH, are easy to handle, and do not undergo resorption. Moreover, these materials interact with stem cells from periapical tissues, producing a biological seal, and inducing the repair process[25]. Recently, Bio-C Repair (Angelus, Londrina, Brazil), a new ready-to-use bioceramic material, was introduced to endodontics in a threaded syringe, which offers handling and insertion improvements, collaborating with the practice and saving time. This material has similar cytotoxicity, biocompatibility, and biomineralization properties to MTA High Plasticity and white MTA[26]**.**

The result of our study showed that the mean value of microleakage showed by **Group II -Biodentine** was more than that showed by **Group III -Bio C Repair** but statistically both the groups showed insignificant results.

In the present study **Group III -Bio C repair** has the best results when used as a furcation perforation repair compared to **Group I -Pro Root MTA** and **GroupII -Biodentine** because of following reasons. It is a bioceramic reparative material ready to use. It is hydrophilic so it absorbs moisture from the environment and starts the setting process and it sets usually in 120 minutes. It is non- toxic as it does not contain heavy metals and has average particle size 2 microns which leads to greater reactivity and accelerates the healing process. It contains silica nanoparticles and particles are very close to each other allowing greater cohesion of the cross link of the phases formed during the hydration process: hydrated calcium silicates and calcium hydroxide particles, making it best material used for furcation perforation repair. It leads to more release of calcium ions which stimulates tissue regeneration and healing, more deposition of hydroxyapatite crystals, chemical adhesion to dentin which prevents less bacterial infiltration and leakage. It has zirconium oxide as radio-opacifier rather than bismuth oxide so it does not stain and has high radiopacity.

V. Conclusion

The results of the study obtained after evaluation and comparison of the sealing ability of Pro Root MTA, Biodentine and Bio C Repair under the stereomicroscope, it can be concluded that:

a) Bio C Repair is better alternative than Biodentine and Pro Root MTA when used as a furcation perforation repair material.

b) The lowest mean value of microleakage was shown by Bio C Repair, followed by Biodentine and Pro Root MTA which shows that Bio C Repair had the best sealing ability as compared to other materials used in the study.
c) The highest value of microleakage was shown by Pro Root MTA when compared to Biodentine and Bio C Repair.
d) Though Bio C Repair and Biodentine showed no statistically significant results but mean value of microleakage was found more in Biodentine than Bio C Repair.
e) On comparison of Pro Root MTA with Biodentine and Pro Root MTA with Bio C Repair, the results were statistically significant.

References

[1] B.S. Chong, T. R. Pitt Ford, T.F. Watson.The Adaptation And Sealing Ability Of Light-Cured Glass Ionomer Retrograde Root Fillings, International Endodontic Journal, The Official Journal Of British Endodontic Society And European Society Of Endontology, September 1991, Volume 24 Issue 5, Page 223-232.
[2] Maram M Alshehri, Bushra F Alhawsawi , Atheer Alghamdi , Salem O Aldobaikhi , Maha H Alanazi, Fahad A Alahmad, The Management Of Root Perforation: A Review Of The Literature,Cureus 16(10): E72296. DOI 10.7759/Cureus.72296, October 2024.
[3] Roshan Chandrakant Sinkar , Sanjay S Patil , Nitin P Jogad, Vandana J Gade, Comparison Of Sealing Ability Of Proroot MTA, Retromta, And Biodentine As Furcation Repair Materials: An Ultraviolet Spectrophotometric Analysis, J Conserv Dent 2015 Nov-Dec;18(6):445–448.
[4] Seltzer S, Bender IB, Smith J, Freedman I, Nazimov H. Endodontic Failures: An Analysis Based On Clinical, Roentgenographic And Histologic Findings. Oral Surg. 1967;23:500–16. Doi: 10.1016/0030-4220(67)90546-4.
[5] Kokubo T, Kim HM, Kawashita M, Nakamura T. Process Of Calcification On Artificial Materials. Z Kardiol 2001;90:86-91.
[6] Aggarwal V, Singla M, Miglani S, Kohli S. Comparative Evaluation Of Push-Out Bond Strength Of Proroot MTA, Biodentine, And MTA Plus In Furcation Perforation Repair. J Conserv Dent 2013;16:462-5.
[7] El Tawil SB, El Dokkyl NA, El Hamid DA. Sealing Ability Of MTA Versus Portland Cement In The Repair Of Furcal Perforations Of Primary Molars: A Dye Extraction Leakage Model. J Am Sci 2011;7:1037-43.
[8] Ding SJ, Kao CT, Shie MY, Hung C Jr., Huang TH. The Physical And Cytological Properties Of White MTA Mixed With Na2hpo4 As An Accelerant. J Endod 2008;34:748-51.
[9] Watts JD, Holt DM, Beeson TJ, Kirkpatrick TC, Rutledge RE. Effects Of Ph And Mixing Agents On The Temporal Setting Of Tooth-Colored And Gray Mineral Trioxide Aggregate. J Endod 2007;33:970-3.
[10] Grech L, Mallia B, Camilleri J. Investigation Of The Physical Properties Of Tricalcium Silicate Cement-Based Root-End Filling Materials. Dent Mater 2013;29:E20-8.
[11] Kenia Soares De Toubes, Stephanie Quadros Tonelli,Caroline Felipe Magalhãesgirelli, Camila Grasielle De Sá Azevedo, Ana Carolina Tocafundo Thompson, Eduardo Nunes, Frank Ferreira Silveira, Bio-C Repair - A New Bioceramic Material For Root Perforation Management: Two Case Reports, Brazilian Dental Journal (2021) 32(1): 104-110.
[12] Sarkar NK, Caicedo R, Ritwik P, Moiseyeva R, Kawashima I. Physicochemical Basis Of The Biologic Properties Of Mineral Trioxide Aggregate. J Endod 2005;31:97-100.
[13] Silva Neto JD, Brito RH, Schnaider TB, Gragnani A, Engelman M, Ferreira LM. Root Perforations Treatment Using Mineral Trioxide Aggregate And Portland Cements. Acta Cir Bras 2010; 25(6): 479-84.
[14] Ankita Khandelwal, J. Karthik, Roopa R. Nadig, Arpit Jain, "Sealing Ability Of Mineral Trioxide Aggregate Andbiodentine As Root End Filling Material, Using Twodifferent Retro Preparation Techniques -An In Vitrostudy," Int J Contemp Dent Med Rev, Vol. 2015, Article ID: 150115, 2015. Doi: 10.15713/Ins.Ijcdmr.48.
[15] E Ovsay, R F Kaptan, F Şahin , The Repair Of Furcal Perforations In Different Diameters With Biodentine, MTA, And IRM Repair Materials: A Laboratory Study Using An E. Faecalis Leakage Model, Biomed Res Int 2018 Jan 15; 2018:5478796.
[16] Fida N. Hassan Dunia Al Hadi And Saeed MH FURCAL PERFORATION REPAIR USING MTA & BIODENTINE™, AN IN VITRO EVALUATION USING DYE EXTRACTION METHOD, International Journal Of Recent Scientific Research Vol. 6, Issue, 3, Pp.3172-3175, March, 2015.
[17] Timothy F Watson, Amre R Atmeh, Shara Sajini, Richard J Cook, Frederic Festy Present And Future Of Glass-Ionomers And Calcium-Silicate Cements As Bioactive Materials In Dentistry: Biophotonics-Based Interfacial Analyses In Health And Disease Dent Mater 2014 Jan;30(1):50–61.
[18] Han L, Okiji T. Uptake Of Calcium And Silicon Released From Calcium Silicate-Based Endodontic Materials Into Root Canal Dentine. Int Endod J 2011;44:1081-7.
[19] Raskin A, Eschrich G, Dejou J, In Vitro Microleakage Of Biodentine As A Dentin Substitute Compared To Fuji II LC In Cervical Lining Restorations Journal Of Adhesive Dentistry 2012 14(6).
[20] Rafiqul Islam, Mdrefat, Readul Islam, Toru Tanaka, Mohammad Khursheed Alam, Hany Mohamed Aly Ahmed, Hidehiko Sano, Direct Pulp Capping Procedures – Evidence And Practice,Japanese Dental Science Review,Volume 59, December 2023, Pages 48-61.
[21] Leal F., De-Deus G., Brandão C., Luna A., Souza E., Fidel S. Similar Sealabilitybetween Bioceramic Putty Ready-To-Use Repair Cement And White MTA. Braz. Dent. J. 2013;24:362–366. Doi: 10.1590/0103-6440201302051.
[22] Greer E Mcmichael, Carolyn M Primus, Lynne A Opperman, Dentinal Tubule Penetration Of Tricalcium Silicate Sealers, J Endod2016 Apr;42(4):632-6.
[23] Ghilotti J, Sanz JL, López-García S, Guerrero-Gironés J, Pecci-Lloret MP, Lozano A, Et Al. Comparative Surface Morphology, Chemical Composition, And Cytocompatibility Of Bio-C Repair, Biodentine, And Proroot MTA On Hdpcs. Materials 2020;13:2189.
[24] Lopez-Garcia S, Lozano A, Garcia-Bernal D, Forner L, Llena C, Guerrero-Girones J, Et Al, Biological Effects Of New Hydraulic Materials On Human Periodontal Ligament Stem Cells. J Clin Med 2019;8:1-13.
[25] Mendes AT, Silva PBD, Só BB, Hashizume LN, Vivan RR, Rosa RAD, Et Al. Evaluation Of Physicochemical Properties Of New Calcium Silicate-Based Sealer. Braz Dent J 2018;29:536-540.
[26] Benetti F, Queiroz IOA, Cosme-Silva L, Conti LC, Oliveira SHP, Cintra LTA. Cytotoxicity, Biocompatibility And Biomineralization Of A New Ready-For-Use Bioceramic Repair Material. Braz Dent J 2019;30:325-332.