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CLINICAL AND RADIOGRAPHIC EVALUATION OF THREE DIFFERENT RETROGRADE FILLING MATERIALS-MINERAL TRIOXIDE AGGREGATE, MINERAL TRIOXIDE AGGREGATE PLUS AND BIODENTIN IN CASES OF ENDODONTIC SURGERY UTILIZING CONE BEAM COMPUTED TOMOGRAPHY-CLINICAL RESEARCH

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Conflicts of Interest: Nil

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ABSTRACT

The aim of this study was to evaluate the outcomes of the three different retrograde filling materials-mineral trioxide aggregate, mineral trioxide aggregate plus and biodentin in cases of endodontic surgery utilizing cone beam computed tomography and by comparing the healing success of cases having a lesion of endodontic/combined endodontic periodontal origin. A total number of 30 patients requiring periradicular surgery were included in the study. Patients were recalled at 6 months,9 months,12 months respectively to assess the healing of cases after endodontic surgery and which material shows better healing among these three different retrograde filling material(Mineral Trioxide Aggregate Plus, MTA Angelus and Biodentin after the surgical procedure.

Key words; Clinical outcome, cone beam computed tomography, endodontic surgery retrograde filling material, radiovisiography, success rate.

Introduction

Complete obliteration of the root canal system ensuring a fluid tight seal is one of the most important factors for the success of endodontic treatment. In addition, the presenting signs and symptoms of the disease associated with the tooth should also be eliminated. Despite the recent advances in endodontic materials, instruments and techniques, the complete resolution of periapical pathology is not achieved in some cases. Today the cause of persistent periapical disease is largely attributed to both inadequate cleaning and disinfection of the root canal space during the root canal therapy or recontamination of the whole root canal space after initial treatment due to a poor coronal seal. In addition, root cracks and fractures, iatrogenic perforations, blockages, missed canals can also act as microbial sources to the periapex. Sealing these sources from periapical egress has been the function of endodontic therapy. Therefore, under such circumstances, the only line of treatment is Surgical intervention.[1,2]

The scope of surgical endodontics is to accomplish the three dimensional cleaning, shaping and obturation of the apical portion of the root canal system which cannot be treated via an access cavity,but only via a surgical flap. Apical surgery belongs to the field of endodontic surgery that includes incision, drainage, closure of perforations, and tooth or root resections. The target of apical surgery is to surgically preserve a tooth that has an endodontic lesion which cannot be resolved by conventional endodontic retreatment and can be achieved by root end resection, root end cavity preparation, and a bacterial tight closure of the root canal system at the cut root end with a retrograde filling. In addition, the periapical pathological tissue should be completely debrided by curettage in order to remove the extraradicular infection, foreign body material, or cystic tissue.[3,4]

The term apicoectomy refers to a stage of the operation only. The principal objective is to seal the canal system at the apical foramen from the periradicular tissues. The aim of resection is to present the surface of the root so that the apical limit of the canal can be visually examined and to provide access for retrograde cavity preparation. Approximately 3 mm of root is removed which will include almost all lateral canals. Root end resection must be an adjunct measure to orthograde root treatment for two reasons. Firstly, there is very little chance of being able to seal all the lateral communications between the canal and the periodontal ligament with a retrograde root-filling technique. Secondly, the area of root-filling material exposed will be greater and the long-term success affected, because all root-filling materials are, to some extent, irritant to the tissues.[8]

Retrograde filling materials such as amalgam, gutta percha, zinc-oxide eugenol cements (IRM, Super-EBA), Glass

ionomer cements, composite resins, compomers, diaket, Ceramicrete, Bioaggregate, etc. are commonly used in endodontic surgical procedures.

All of these materials have been shown to be compatible with tissue cicatrisation and the reconstitution of periradicular alveolar bone, but none of them is able to induce cementum formation and full periodontal ligament repair. Mineral trioxide aggregate (MTA), a calcium silicate-based material developed by the modification of Portland cement, has been introduced to address this problem and has shown good biocompatibility and sealing properties. This material permits a full regenerative healing and can be considered as the material of choice in endodontic surgery. In addition, the sealing properties of MTA are not affected by moisture during treatment. However, there are several drawbacks to its use such as its difficult handling properties and its long setting time.[9]

Several new calcium silicate-based materials have recently been developed with the aim of improving clinical use and overcoming MTA limitations. One of these materials, Biodentine has shown reduced time setting with interesting physical and biological properties as a dentine restorative material.[9]

CBCT (CONE BEAM COMPUTED TOMOGRAPHY)

Cone-beam computed tomography (CBCT) is a new medical imaging technique that generates 3-D images at a lower cost and absorbed dose compared with conventional computed tomography (CT). This imaging technique is based on a cone-shaped X-ray beam centred on a 2-D detector that performs one rotation around the object, producing a series of 2-D images. These images are re-constructed in 3-D using a modification of the original cone-beam algorithm developer. CBCT imaging is a useful tool for diagnosing periapical lesions. CBCT images can be used to differentiate between apical granulomas and apical cysts by measuring the lesion's density.CBCT is a reliable pre-surgical tool for assessing a tooth's proximity to adjacent vital structures, allowing for accurate measurement of the size and extent of a lesion and the anatomy of the area.(16)

Therefore,the purpose of this study was to clinically and radiographically evaluate three different retrograde filling materials (MTA Angelus, MTA Plus and Biodentin)in cases of endodontic surgery by utilizing cone beam computed tomography

The steps for carrying out this procedure are: 1. Pre-operative care. 2. Anaesthesia and haemostasis. 3. Soft-tissue management. 4. Hard-tissue management. 5. Curettage of area. 6. Resection of root. 7. Retrograde cavity preparation. 8. Retrograde filling. 9. Replacement of flap and suturing. 10. Post-operative care.[8]

Materials & Methods

Patients irrespective of age & sex requiring periradicular surgery in the anterior (maxillary and mandibular) teeth were included in the study. A particular criteria was included in the selection of patients-

INCLUSION CRITERIA-

- Absence of a periradicular lesion with no mobility, a normal pocket depth, but had unresolved symptoms after non-surgical therapies had been exhausted.
- Presence of a small periradicular lesion in the apical quarter and by clinical symptoms such as discomfort or sensitivity to percussion as sinus tract. Such teeth had normal periodontal probing depths and no mobility.
- Large periradicular lesions progressing coronally, but without periodontal pockets and /or mobility.
- Clinically similar to those in Class C,but had periodontal pockets >4mm,and there was no communication with the pocket and the periradicular lesion.
- Deep periradicular lesions with endodontic-periodontal communication to the apex, but no obvious fracture.
- Apical lesion and complete denudement of the buccal plate but no mobility.

EXCLUSION CRITERIA-

- Teeth with class 2 mobility or greater, horizontal and vertical fractures and perforation were excluded from the study.

All the patients were randomized into three groups of 10 each. A pre structured performa was used to collect the relevant information**.** Consent was taken by the patient before starting the procedure.

SURGICAL PROCEDURE

Before the surgical procedure, a preoperative radiograph and Cone Beam Computed Tomography was taken to measure the lesion.

Prophylactic administration of oral antimicrobials was prescribed to prevent systematic disease and also to prevent postoperative infection.

The patient was anesthetized with 2% Lignocaine with 1:80,000 adrenaline. As haemostasis is of benefit at the surgical site, which is more easily achieved when a local anaesthetic containing a vasoconstrictor is used.

Surgical procedures like flap design and elevation was done. Relieving incisions were made on sound bone i.e, a sulcular and mucogingival incisions were made with Surgical Blade (SM-64 and SM-67), Flap elevation was done using Elevator (DISC SHAPED ELEVATOR OR DISSECTOR).

An assessment of the length of the root and its axis was done radiographically to remove bone from the desired

site. Osteotomy was performed by using no-4 and 6 round carbide bur with Impact Micro-motor handpiece and curette (DISK SHAPED CURETTE-1.5mm) was used for periradicular curettage. The apicoectomy was simulated by cutting the apical 2 mm of the roots with a diamond fissure burr size 1.0 mm using sterile saline for cooling. The root-end cavities were prepared to a depth of 3 mm with a tungsten carbide fissure bur with a diameter of 0.8 mm, parallel to the canal, leaving a 3 mm deep root-end cavity free of gutta percha. Sterile saline in a syringe was used for cooling.

Prepared root end cavity was dried with irrigator/drier and filled with materials such as Mineral Trioxide Aggregate Angelus, Mineral Trioxide Aggregate Plus and Biodentine respectively followed by placement of a bone graft to induce bone regeneration. Adaptation of filling material was confirmed by using radiograph. A careful debridement of the bony crypt was made to ensure that haemostatic agents, root-end filling material and debris are removed.

Radiographic verification of the quality of the root end filling is appropriate before wound closure. The soft tissue flap was then re-apposed with sutures as optimum healing is being achieved with primary closure. After suturing, the tissues were compressed with damp gauze for 3–5 minutes the patient was then asked to follow post operative instructions such as to apply cold compresses with an ice pack for the first 4–6 hours after surgery, followed by mouth rinses to maintain a good oral hygiene. The patient was also prescribed antimicrobials for 5 days. Sutures were then removed after 4-7days post-operatively (providing the wound was stable), i.e when reattachment of the periodontal fibres at the gingival margin had taken place. In addition, the healing progress was checked and recorded properly.

After whole procedure, the patients were then recalled at 6 months-9 months-1year to assess the clinical and radiographic signs of healing by use of Cone Beam Computed Tomography.

Figure 1: Micro-Motor Handpiece (NSK)

Figure 2: Surgical Kit (API)

Figure 3: SM67 & SM64 B.P. Blade (BLUDENT INDIA LTD)

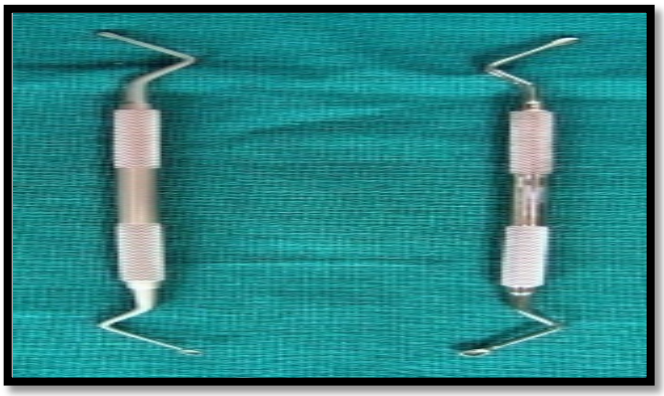


Figure 4: Curettes (Disk Shaped Curette-1.5mm from BLUDENT INDIA LTD)

Figure 5: Round Carbide PRODUCT 170 I Tapered Fissure Bur (S.S WHITE)

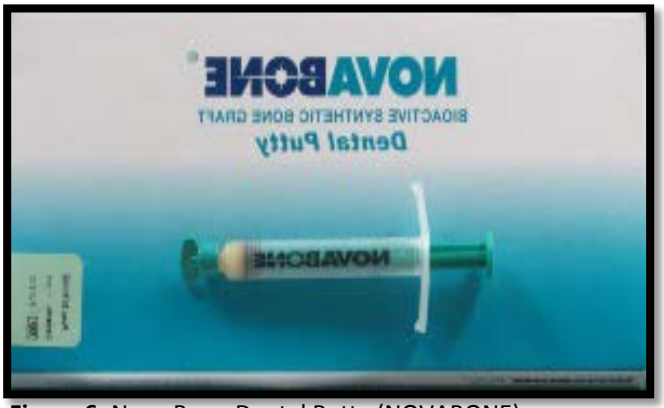


Figure 6: Nova Bone Dental Putty (NOVABONE)

Figure 7: MTA Plus

Figure 8: Biodentine

Figure 9: Mineral Trioxide Aggregate (Angelus)

Figure 10: MTA Carrier

Figure 11: (I) 2% Lignocaine with 1:200:000 adrenaline (ICPA HEALTH CARE INDIA LTD.)
(II)Adrenaline ampules for additional hemostasis (EPTRATIE, SUNWAYS INDIA LTD.)
(III) Latex Surgical Gloves Gloves (LIFE CARE, INDIA LTD.)
(IV)Gauge Piece (EPI BLEMA 7CM2MT),
(V)Betadine (WIN-MEDICARE, INDIA)
(VI)Sutures 3-0 (ETHICON BY JHONSON & JHONSON LTD.)

Figure 12: Operating Cone beam computed tomography unit

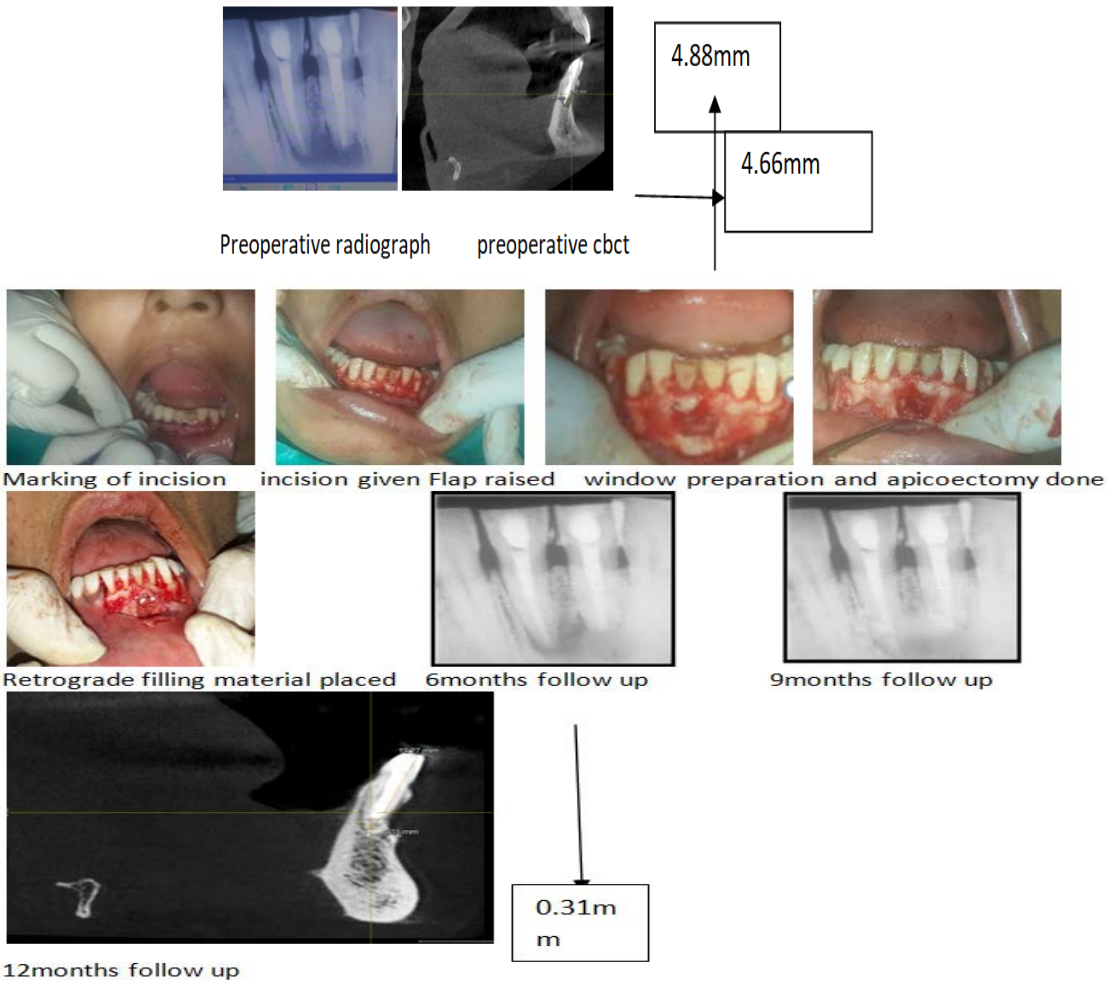


Figure 13: Periapical surgery of mandibular anterior teeth USING BIODENTIN

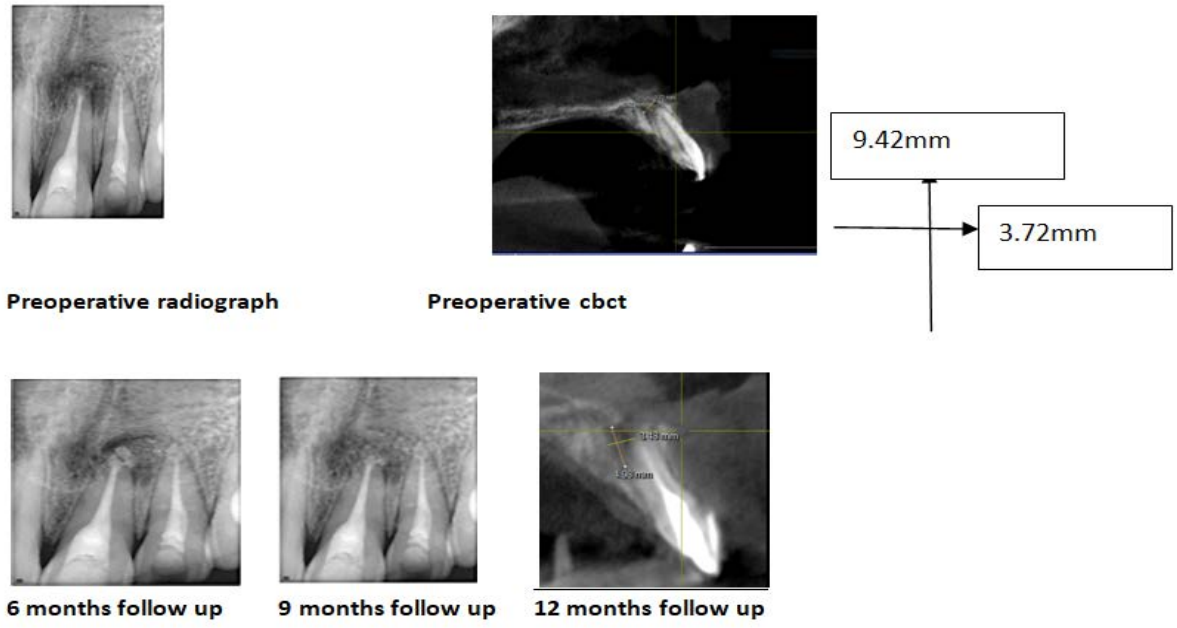
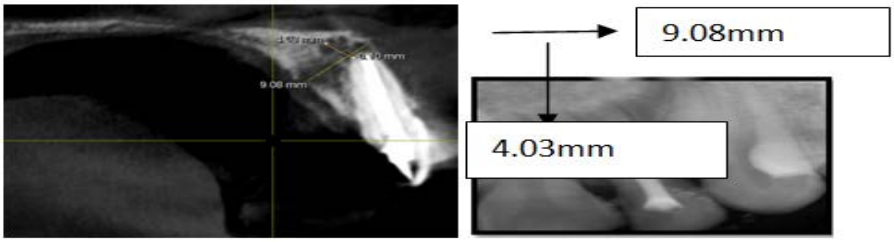
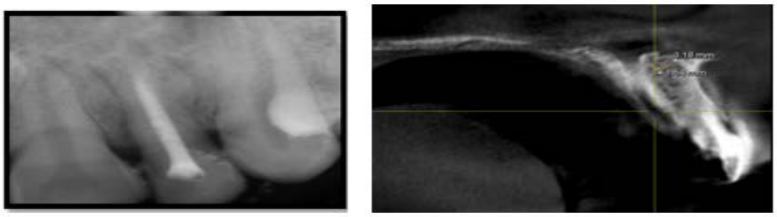


Figure 14: Periapical surgery of maxillary left central incisor USING Mta Plus

Preoperative radiograph



Preoperative cbct 6months follow up



9 months follow up 12months follow up

Figure 15: Periapical surgery of Maxillary Left Lateral Incisor using MTA ANGELUS

Summary & Results

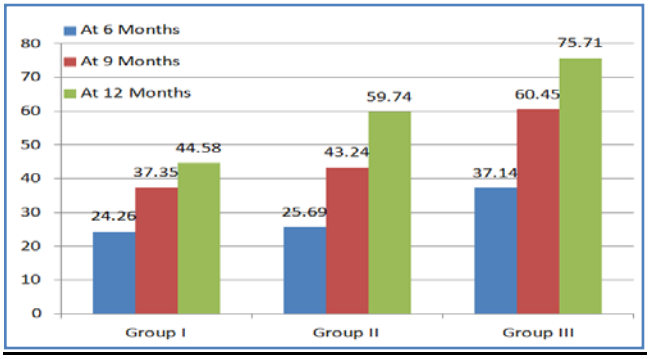
The treatment success was analysed statistically with Mean & standard deviation (S.D), Independent "t" test and one way ANOVA "F" test at 5% level of significance i.e. P<.05 along with percentage reduction test.
Group 1=Mta plus
Group 2=Mta angelus
Group 3=Biodentine

Table 1: Intergroup comparison of percentage reduction in vertical lesion size between different time intervals

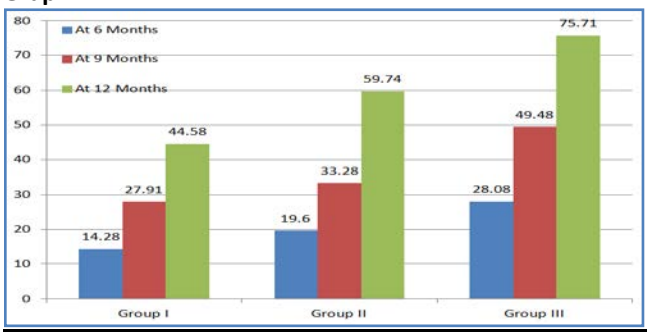
	At 6 Months	At 9 Months	At 12 Months	P value	Significance
Group I	14.28±9.75	27.91±17.01	44.58±24.63	0.003	Significant
Group II	19.60±9.15	33.28±10.95	59.74±16.57	0.001	Significant
Group III	28.08±9.37	49.48±10.23	75.71±13.08	0.001	Significant

Table 2: Intergroup comparison of percentage reduction in horizontal lesion size between different time intervals

	At 6 Months	At 9 Months	At 12 Months	P value	Significance
Group I	24.26±8.16	37.35±11.77	44.58±7.31	0.001	Significant
Group II	25.69±7.64	43.24±10.24	59.74±17.14	0.001	Significant
Group III	37.14±10.66	60.45±12.22	75.71±8.48	0.001	Significant



Graph 1:



Graph 2:

- The values of endodontic lesion selected for the study were evaluated preoperatively by using cone beam computed tomography in which horizontal and vertical parameters of the lesion were recorded followed by a follow up at 6months,9months which were evaluated by radiovisiographic examination and a 12 month follow up was taken again using cone beam computed tomography.
- All these values are expressed in terms of Mean and Standard Deviation(S.D) respectively.(table 4,8)
- After fulfilling the criteria, normality of the data independent "ANOVA"test was applied to find the difference in the healing rate of the lesions included in the study at 6months, 9months and 12months respectively.
- Therefore,Group 3 revealed a significant reduction at 6months,9months,12 months in the measurement of lesions horizontally and vertically as compared to group 2 and group 1 respectively which shows group 3 has a faster healing rate.(table 4, table8)

Discussion

The main objective of this study was to place the three different retrograde filling materials Mineral Trioxide Aggregate, Mineral Trioxide Aggregate Plus and Biodentin) after apicoectomy in order to achieve a potent barrier between the root canal and the periapical tissues and also to evaluate the healing rate of these three retrograde filling materials by cone beam computed tomography.

30 patients were divided into three groups of 10 patients in each group (groupA-MTA plus, group B-MTA angelus and group C-Biodentin). The healing rate of all groups using these three retrograde filling materials and and with bone grafts respectively after the endodontic surgery using Cone Beam Computed Tomography in relation to two parameters i.e. vertical and horizontal parameters of periapical lesion were compared between all Endodontic lesion groups .

At 6 months of follow up, the radiographic evaluation showed blending of the graft with the surrounding bone which indicated osseous ingrowth in the hydroxyapatite material. At 9 months of follow up, the radiographic evaluation displayed uniform radiopacity of the graft followed by the follow up of 12 months i.e, uniform radiopacity of the graft and surrounding bone was observed in all the three groups of Mta plus and in cases of Mta Angelus approximately as compared to Biodentin. Thus, a significant better healing was present at different time points for vertical as well as horizontal parameters of lesions using cone beam computed tomography i.e P > .05.

Zirconium dioxide is added to Biodentin to achieve radiographic contrast against the surrounding tissue. The present study showed that the contrast for Biodentine on the follow-up radiographs could be higher which is previously reported .Teeth treated with MTA showed more distinction between the retrograde material, dentine and the surrounding periapical tissue.[40]

The setting time is one of the most clinically relevant factors. A long setting duration may cause clinical problems because of the cement's inability to maintain shape and support stresses during this period. The setting time of MTA Angelus mixed with water was 15 min. In contrast, Biodentine exhibited shorter setting time (6.5 min) though not statistically significant. Accelerated setting reduces the risk of dislodgement and contamination of MTA like cements when used as root end filling material. An important feature of a root end filling material is its handling property. Hence, it was used for determining handling characteristic. MTA Angelus is grainy and has a poor consistency, making it difficult to manipulate in clinical situations. In contrast, Biodentine was relatively easier to handle and on thorough amalgamation it rolled into dough like consistency that could be easily condensed. An ideal root end filling material should adhere and adapt to the walls of root end preparation, prevent leakage of microorganisms and their toxins into the periradicular tissues, be biocompatible, be insoluble in tissue fluids and dimensionally stable and remain unaffected by the presence of moisture.([12,15)]

A study conducted by Han and Okiji (2011) demonstrated that Biodentine has more prominent biomineralization ability than MTA, with wider calcium and silicon rich layer at material dentine interface.[40]

From a biomechanical point of view, the sealing properties of Biodentine have been reported to be superior to MTA. The formation of mineral tags was similar to those observed with MTA. along with resistance to acid degradation, as observed in inflammatory sites. The main difference between Biodentine and commercially available MTA calcium silicates is the absence of calcium aluminates and calcium sulfate in the formulation which are known to bring decreased mechanical strength as well as longer setting time. The primary clinical advantage of Biodentine is its fast setting . This is an advantage when compared to the 170 min of MTA since a delayed setting time leads to an increased risk of partial material loss and alteration of the interface during the finishing phases of the procedure (cleaning and rinsing the crypt).

Another advantage of Biodentine as retrograde obturation is the micromechanical adhesion in the interface between the material and the human dentine.This owes to the obturation of the dentinal tubules by recrystallization from the biodentin material.Although similar interface pattern is observed in MTA.In addition,Biodentine has the releasing

capabilities of free Ca ions adding the interface progression over Proroot Mta.[35]

Clinical applications of CBCT are rapidly being applied to dental practice. However, although CBCT allows images to be displayed in a variety of formats, the interpretation of the volumetric data set, particularly when it comprises large areas, involves more than the generation of 3D representations or application of clinical protocols providing specific images. Interpretation demands an understanding of the spatial relations of bony anatomic elements and extended pathologic knowledge of various maxillofacial structures.

The result of this case series study using the three different root end filling materials in an established and a well documented periapical surgery procedure indicates that biodentin can be a new promising retrograde filling material.

Conclusion

Within the limitations of this study,after analyzing the results and obtaining a complete follow up of 12 months radiographically and by using CBCT,it can be concluded that Biodentine had the faster healing rate as compared to MTA angelus and MTA plus .However,further clinical trials are needed to explore thoroughly its clinical behaviour on long term basis and to compare the material to other well documented materials

References

1. *Bhagwat SA, Hegde S, Mandke LP*. An investigation into the effectiveness of periapical surgery with Biodentine™ used as a root‐end filling alone or in combination with demineralized freeze‐dried bone allograft and plasma rich fibrin: A 6 months follow‐up of 17 cases. Endodontology 2016;28:11‐7.
2. *Nasseh A A,Brave D* .Apicoectomy: The Misunderstood Surgical Procedure 2015 ,5-11
3. *Castelluci A.* The use of Mineral Trioxide Aggregate in clinical and surgical endodontics ;5-13
4. *Thomas V A*,Apical surgery a review of current techniques and outcomes Saudi dental journal 2011;23,9;15
5. *Evans G E, Bishop K, Renton T* . Guidelines for Surgical Endodontics .Faculty of dental sciences.2012;Version 2 :Version 1: 2001
6. *Jones R.*Contemporary Endodontic Microsurgery: Procedural Advancements and Treatment Planning Considerations American Association of Endodontists.2010:2-7
7. *Kim E,Song J S,Jung I Y,Lee S J,Kim S* .Prospective clinical study evaluating endodontic microsurgery outcomes for cases with lesions of endodontic origin compared with cases with lesions of combined periodontal-endodontic origin JOE. May 2008;35(5).
8. *Carrotte P*. Surgical endodontics. BRITISH DENTAL JOURNAL. JANUARY 22 2005; VOLUME 198 NO. 2
9. *G Caron et al* .Use of a new retrograde filling material (Biodentine) for endodontic surgery: two case reports International Journal of Oral Science advance online publication. 9 May 2014.
10. *Astrup I I*. Biodentine™ as a root-end filling 2012;6-25
11. *William Ha* . The properties of Mineral Trioxide Aggregate and how it can be manipulated .Australian Society of endodontology.2015
12. *Silva W J D, Souza P H C, Rosa E A R, Cury A A D B, Rached R N*Rev. odonto ciênc. 2010;25(4):386-390
13. *Saxena P,Gupta S K,Newaskar P.* Biocompatibility of root-end filling materials: recent update (Restor Dent Endod 2013;38(3):119-127)
14. *Priyalakshmi.S, Manish Ranjan* .Review on Biodentine-A Bioactive Dentin Substitute IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) . Jan. 2014;Volume 13, Issue 1 Ver. III : PP 13-17
15. *Camilleri J, Formosa L, Damidot D.*The setting characteristics of MTA Plus in different environmental conditions. International Endodontic Journal.2013;46: 831–840.
16. *Alshehri M A* .CBCT applications in dental practice:A literature review,2010
17. *Hartzell T B, Minn M* .APICOECTOMY—ITS INDICATIONS AND CONTRAINDICATIONS AND ROOT-CANAL TECHNIC :The Journal of the National Dental Association.1919; Volume VI, Number IV, Pages 370-373.
18. *Ramachandran Nair PN*. Non-microbial etiology: foreign body reaction maintaining post-treatment apical periodontitis. 15 June 2004
19. *Ozata F, Erdilek N, Tezel H.* A comparative sealability study of different retrofilling materials.Int Endod J. 1993 Jul;26(4):241-5.
20. *Torabinejad et al.*Outcomes of Nonsurgical Retreatment and Endodontic Surgery: A Systematic Review JOE. July 2009;Volume 35, Number 7.
21. *Zuolo et al*.Periradicular surgery. International Endodontic Journal. 2000;33: (91-98)
22. *Duarte et al.*pH and calcium ion release of 2 root-end filling materials (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;95:(345-7)
23. *Economides N, Pantelidou O, Kokkas A, Tziafas D.*Short-term periradicular tissue response to mineral trioxide aggregate (MTA) as root-end filling material. International Endodontic Journal. 2003; 36: 44-48.
24. *Castelluci A.* The use of Mineral Trioxide Aggregate in clinical and surgical endodontics ;5-13;2003
25. *Menezes R, Bramante CM, Letra A, Carvalho VG, Garcia RB.* Histologic evaluation of pulpotomies in dog using two types of mineral trioxide aggregate and regular and white Portland cements as wound dressings.Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004 Sep;98(3):376-9
26. *Kim and Kratchman* -Modern Endodontic Surgery Concepts and Practice .JOE.July 2006; Volume 32, Number 7
27. *Sarkar et al*. Physicochemical Basis of the Biologic Properties of Mineral Trioxide Aggregate JOE. February 2005; Volume 31, Number 2.
28. *Xavier C B, Weismann R, Oliveira M G, Demarco F F, Pozza D H.* Root-end filling materials: apical microleakage and marginal adaptation.J Endod. 2005 Jul;31(7):539-42
29. *Tsesis et al* .Retrospective Evaluation of Surgical Endodontic Treatment: Traditional versus Modern Technique. J Endod 2006;32:5,(412–416)
30. *R. Winik et al*. Sealer Penetration and Marginal Permeability after Apicoectomy Varying Retrocavity Preparation and Retrofilling Material;Braz Dent J (2006) 17(4): 323-327
31. *Scarfe etal* .Clinical Applications of Cone-Beam Computed Tomography in Dental Practice .February 2006;Vol. 72, No. 1
32. *García B, Martorell L, Martí E, Peñarrocha M*. Periapical surgery of maxillary posterior teeth. A review of the literature. Med Oral Pathol Oral Cir Buccal .2006;11:E1(46-50).
33. *Asgary etal.*SEALING ABILITY OF THREE COMMERCIAL MINERAL TRIOXIDE AGGREGATES AND AN EXPERIMENTAL ROOT END FILLING MATERIAL-IEJ.2006; VOL 1;3.
34. *Kratchman S I*. Endodontic Microsurgery Compendium • June 2007;28(6):324-331
35. *Penarrocha M,Marti E,Garcia B,Gay C.*J ORAL MAXILLO FAC SURG. 65;1526-1529,
36. *Taschieri S,Fabbro M D*.Endoscopic endodontic microsurgery: 2-year evaluation of healing and functionality Braz Oral Res 2009;23(1):23-30

37. *Torabinejad et al.*Outcomes of Nonsurgical Retreatment and Endodontic Surgery: A Systematic Review JOE. July 2009;Volume 35, Number 7

38. *Scarfe etal* .Clinical Applications of Cone-Beam Computed Tomography in Dental Practice .February 2006;Vol. 72, No. 1

39. *Patel S, Durack C, Abella F, Shemesh H, Roig M, Lemberg K.*Cone beam computed tomography in Endodontics – a review. International Endodontic Journal, 48, 3–15, 2015.

40. *Laurent P, Zygouritsas S, Burger AS, Camps J, Dejou J*. Activation of human dental pulp progenitor/stem cells in response to odontoblast injury.Arch Oral Biol. 2005 Feb;50(2):103-8. Epub 2005 Jan 4.

41. E. Valyi, n. Plasse-pradelle, d. Decoret, p. Colon, and b. Grosgogeat.Antibacterial Activity of New Ca-Based Cement Compared to Other Cement.Oral Session at IADR Congress July 2010