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Endodontics Root Perforation: Causes, Identifications, and Management

A Project Submitted to

The College of Dentistry, University of Baghdad, Department of Conservative Dentistry in Partial Fulfillment for the Bachelor of Dental Surgery

By

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Certification of the Supervisor

I certify that this project entitled " **Endodontics Root Perforation"** was prepared by fifth-year student **Noor Nabil Ibrahim** under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the Bachelor Degree in Dentistry.

Dr. Noor Hayder Fadhil

April , 2023

DEDICATION

I would like to dedicate my humble effort to the reason of being here, who stood by myside. who taught me throughout 17 years , who believed on me, who supported me with every step of my long way

To My Dad The staff major general Nabil Ibrahim

To My kind mother Samar

To My sisters Maysam and Maria

And to my supportive friends

Noor Nabil

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Thank for Allah for giving me the strength to stand after each stumble and be able to make it to the end of this journey.

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Introduction

Introduction

Perforation is an artificial opening between the root canal system and the surrounding tissues of teeth **(Senthilkumar and Subbarao, 2017)** ,This issue can be caused by a pathological process (dental caries, root resorption) cause connectivity between the root canal and periodontium or an operative procedural accident. Pathological perforations are found in routine clinical exams, whereas iatrogenic root perforations may occur during access cavity opening, root canal preparation or during post preparation.**(Estrela et al., 2018).**

Root resorption and caries are the common causes for non-iatrogenic perforation. In approximately 2%–12% of endodontically treated teeth, accidental root perforations may occur, which may have serious implications. An infectious process once started at the perforation site either from the root canal or from periodontal tissues impairs the healing and initiates an inflammatory process that exposes the supporting tissues to infection, pain and suppurations. **(Deepak et al., 2021).**

The important factors in determining the success of a perforation repair are the time interval between the occurrence of a perforation and its repair, the size of the perforation, and its location. The location of the perforation in relation to the level of the epithelial attachment and crestal bone is probably the most important factor in terms of prognosis.The closer the perforation is to this critical zone, the poorer the prognosis, due to susceptibility of the site of perforation to contamination from microorganisms from the oral cavity. Moreover, if the perforation is not closed immediately, apical migration of the epithelial attachment may occur, resulting in a periodontal defect.The successful treatment depends mainly on immediate sealing of the perforation and prevention of infection.**(Baumann and Beer, 2010)**

Chapter One
Review Of literature

1.Aetiology:

1.1.Iatrogenic perforation:

Are often due to a lack of attention to the details of internal anatomy and a failure to consider anatomic variations. Any stage of endodontic therapy can result in iatrogenic perforation. Perforation of the pulp chamber may occur when the chamber is almost totally calcified as a result of aging or as a reaction to trauma or to an irritant. If the pulp chamber roof and floor approximate each other, perforation may result from the careless plunging of a bur through the relatively thin floor. Perforation may also be created as a result of inadequate removal of the pulp chamber roof that results in misdirection of a bur during access preparation. In a malaligned tooth, perforation may result if a bur is not properly angulated in relationship to the long axis of the tooth. **(Alhadainy, 1994) (Alshamrani et al., 2023).**

1.1.1 Perforations of the coronal third:

Perforations of the coronal third often result whilst attempting to locate and open canals **(Fig. 1)**, Calcifications of the pulp chamber and the orifices, misidentification of canals, significant crown root angulations and excessive removal of coronal dentine can easily result in perforations in the coronal or furcation regions.

The narrow mesiodistal diameter at the cervix of lower premolars and lingual inclination of their roots increase the frequencies of coronal perforations in these teeth. .**(Saeed et al., 2016)**

Fig. (1):ROOT PERFORATION

In an attempt to locate the canal of the 12 tooth the dentist has perforated through the buccal aspect of the tooth. The figures clearly demonstrate the divergence of the access cavity from thecanal structure.**(Saeed et al., 2016)**

1.1.2 Perforation of the middle third:

Classically this type of perforation occurs in curved molar roots when the instrumentation is too heavy on the inside curvature resulting in a furcational strip perforation **(Fig. 2a and 2b).** Perforations of the middle third may also occur during the pursuit of sclerosed canals. In these instances the dentist may need to use rotary or ultrasonic instruments well into the root of the tooth risking lateral perforation.**(Saeed et al., 2016)**

1.1.3 Perforation of the Apical third:

Inadequate cleaning and shaping of the canal can lead to blockages and ledges. Once formed, these can cause instruments to deviate, transporting the canal away from the centre of the root, until a perforation occurs. Stiff instruments placed into curved canals may also straighten the canal, causing zip perforations **(Figs. 3a and 3b)**. An apical perforation occurs when the clinician does not respect the apical anatomy and passes endodontic files too aggressively through the apical constriction **(Fig. 4)** .**(Saeed et al., 2016).**

1.1.4 Post space preparation:

Following obturation, careless post space preparation may result in perforation. Traditional approaches to placement of post retained restorations focus on achieving good length and width for the post. This creates the risk of both apical and strip perforation. Sometimes the post is not placed into the root canal but the adjacent dentine, resulting in catastrophic consequences **(Fig. 5). (Saeed et al., 2016)**

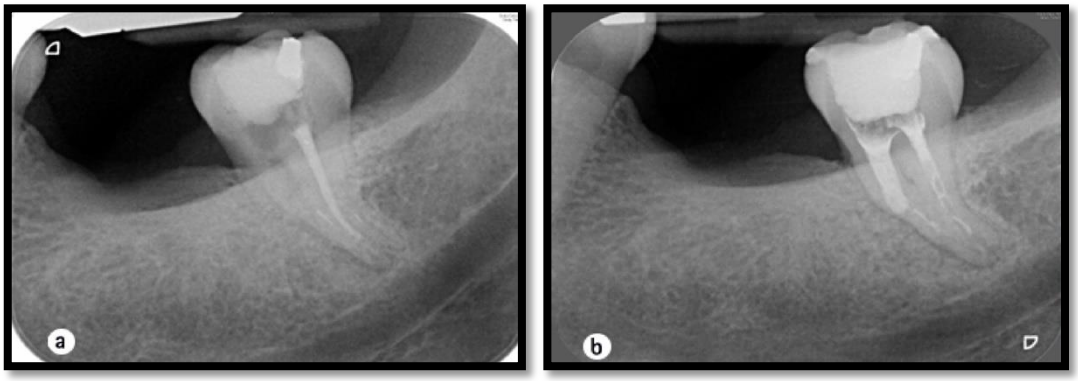


Fig.(2): Not only has an instrument fractured in the mesiobuccal canal of the lower 2nd molar but there has been a perforation of the middle third of the tooth in an attempt to remove and/or bipass the instrument. **(Saeed et al., 2016).**

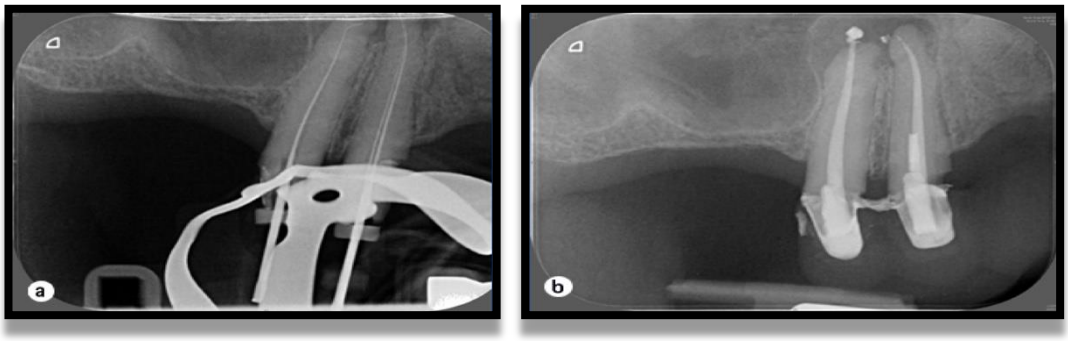


Fig. (3): a) There is an acute curve distally in the apical region of the upper 1st premolar. **b)** This has not been respected during instrumentation resulting in straightening of the canal and apical perforation. **(Saeed et al., 2016).**

Fig. (4): A lack of control during the distal Canal preparation of the lower 1st molar has resulted in over preparation and significant overextension of the gutta percha**. (Saeed et al., 2016).**

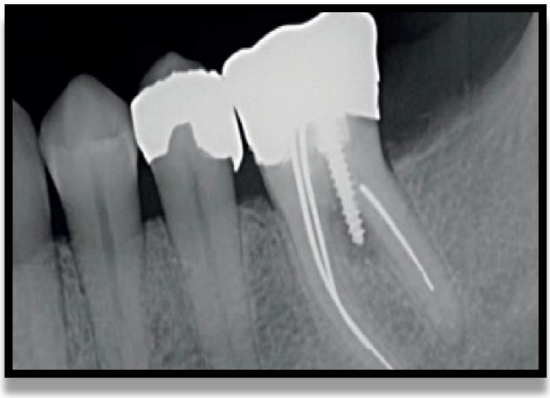


Fig.(5): A threaded post has been placed though the furcation. **(Saeed et al., 2016).**

1.2 Non-iatrogenic perforations (pathologic perforations):

These can result from root resorption or caries.Root resorption When occurring within the root canal system it is known as internal inflammatory root resorption. It's seen radiographically as an oval shape enlargement of the root canal system. The exact cause is not known, but this process can follow trauma, pulpal inflammation and pulpotomy procedures. Though the process is uncommon and often self-limiting, it can progress into a perforation. Thus, early detection and intervention is essential to control the disease before such an event occurs. External inflammatory root resorption can occur following damage to the cementum and periodontal ligament cells on the root surface. The ability to control the resorption is dependent upon the type, site and extent.

An untreated carious lesion may either perforate the pulp chamber floor or extend along the root, resulting in perforation of the root. Treatment of these perforations may require root canal treatment , crown lengthening, and either root extrusion or root resection in order to retain valuable radicular segments. Unfortunately, perforation in most of these cases renders the tooth unrestorable. **(Saeed et al., 2016).**

2. Classifications:

Based on factors impacting the outcome of treatment, fuss and trope classified perforation as follows:

2.1.Based on time:

a. Fresh perforation: Fresh perforation occurs during operative or endodontic procedure characterized by fresh blood at the site of perforation. If treated immediately, it has a good prognosis.

b. Old perforation: The untreated perforation acts as a source of infection either from periodontium or by secondary caries. **(Senthilkumar and Subbarao, 2017)**

2.2.Based on size:

a. Small perforation: These are smaller than size #20 endodontic instrument and have a good prognosis.

b. Large perforation: It occurs during post-space preparation, and due to salivary contamination and coronal leakage, these have a questionable prognosis. **(Senthilkumar and Subbarao, 2017)**

2.3.Based on location:

a. Coronal perforation: These are perforations that occur coronal to crestal bone and epithelial attachment and have a good prognosis.

b. Crestal perforation: These occur at the level of epithelial attachment into the crestal bone, and these have a questionable prognosis.

c. Apical perforation: These occur apical to the crestal bone and epithelial attachment and have a good prognosis as there is less risk of salivary contamination. **(Senthilkumar and Subbarao, 2017)**

Fig.(6): Perforations caused by procedural error, caries, or a resorption process. **Left**: Radiograph showing a crestal perforation, due to a misaligned post placement.
Middle: Radiograph showing deep caries resulting in perforation.
Right: Radiograph showing cervical invasive resorption resulting in perforation.**(Baumann and Beer, 2010)**

3. Diagnosis of Root perforation

As accurate detection of root perforations and determination of location are crucial to the treatment outcome, certain signs, and tools must be recognized in making the diagnosis.**(Tsesis and Fuss, 2006).**

Iatrogenic perforations are invariably identified from the profuse bleeding that follows the injury. This can often be seen directly when a perforation occurs in the coronal portion of the tooth, A paper point inserted into the canal reveals the bleeding, Blood that appears along the side of the paper point but not at the tip may indicate a strip perforation. Repeated insertion of paper points may result in the tips being soaked with blood, which indicates an apical perforation. If no local anaesthetic is given, sudden unexpected pain during

treatment may also indicate a perforation. Systemic conditions, medication, teeth with an open apex and internal resorption and acute apical periodontitis may be associated excessive bleeding, and be confused with root perforation. **(Estrela et al., 2018). (Saeed et al., 2016) (Alhadainy, 1994) .**

Apex locators are very useful in detecting perforations. By placing the file onto the perforation this will give a zero reading, indicating a communication with the periodintal ligament.

A dental operating microscope is another helpful Tool effective in detecting root perforations during orthograde root canal therapy and in surgical endodontic treatments. High magnification with co-axial illumination allows precise detection and visualization of perforations along straight non curved root canals. **(Tsesis and Fuss, 2006).**

The application of radiographs in cases of perforation is possible, Periapical radiography is the imaging method frequently indicated for endodontic diagnosis, treatment plan, and follow-up. A radiolucency associated with a communication between the root canal walls and the periodontal space constitutes an important vestige of this procedural accidents ,although they do have some limitations because they only provide a two-dimensional image, making it potentially challenging to determine the location and severity of the perforation. This can be somewhat remedied by taking a second film and changing the radiography beam angulation to the mesial or distal aspect. **(Estrela et al., 2018).**

A combination of clinical evaluation, radiography, and the features of the presentation are usually used to make a late diagnosis of pathological perforations. Serous discharge or fistula from the perforated site, sensitivity on percussing, isolated periodontal pocketing, and chronic gingivitis when the inflammation has reached the alveolus can all be signs of unresolved

perforations.Along with the previously mentioned techniques, radiography may show radiolucent areas that have grown after the perforation because there might be localized osteolytic lesions. **(Alshamrani et al., 2023).**

Cone-beam computed tomography (CBCT) scans were recently shown to be a valuable diagnostic tool in the following stages of the endodontic treatment: characterizing the periapical lesion and its healing process, diagnosing vertical root fractures, assessing the anatomy of the internal and external aspects of the tooth, and localizing root resorption defects**. (Estrela et al., 2008), (Hassan et al., 2009) (Haung et al , 2010) , (Blattner et al., 2010) .**

Shemesh et al compared ex vivo the sensitivity and specificity of CBCT scans and digital periapical radiographs in detecting strip and root perforations in 45 curved mesial roots of mandibular molars.They found that the risk in misdiagnosing strip perforations was high with both methods, but CBCT scans showed a significantly higher sensitivity than PA. There was no significant difference between the methods for detection of root perforations **.** A major drawback with CBCT scans is the high radiation dose and financial costs that are higher than conventional radiographs **(Shemesh et al., 2011)**.

Diagnostic errors occur and constitute a serious problem ,errors are frequently detected in association with a metallic or solid structure of higher density, which produces an image artifact, lacking homogeneity and being defined by image contrasts. Misdiagnosis is a serious problem that has encouraged the search for alternatives to reduce the beam hardening effect during image acquisition and reconstruction **(Pauwels et al., 2014) ,(Katsumata et al., 2006) , (Azevedo et al., 2008).**

Metallic artifacts associated with intracanal posts constitute potential risks for misdiagnosis, particularly when root perforation or bone destruction is suspected.

A map reading strategy to diagnose root perforations near metallic intracanal posts using CBCT images was previously suggested by Bueno et al. The strategy suggested minimizing metallic artifacts associated with intracanal post and endodontic material by making sequential axial slices of each root with an image navigation protocol from the coronal to the apical direction (or apical to coronal), and with axial slices of 0.1 mm/ 0.1 mm. This directional orientation provides precious information concerning the exact localization of vestiges that suggest points of communication between the root canals and the periodontal space, associated with radiolucent areas, suggesting root perforation (Fig. 7) **(Bueno et al., 2011) (Shemesh et al., 2011) (Adel et al., 2016).**

The dynamic navigation of CBCT images has made it a distinct tool by revealing what was once static. In the slices located near the post apex, the beam hardening effect is reduced, because CBCT allows us to capture a lesser amount of metal on the images. A new software program able to reduce metallic artifacts in future reconstructions of CBCT images has been tested (e.g., e-Vol DX, CDT, Bauru, SP, Brazil). The appropriate management of CBCT images could reveal abnormalities that are difficult to detect in conventional periapical radiographies. **(Verma et al., 2021) (Patel et al., 2007) (Estrela et al., 2008)**

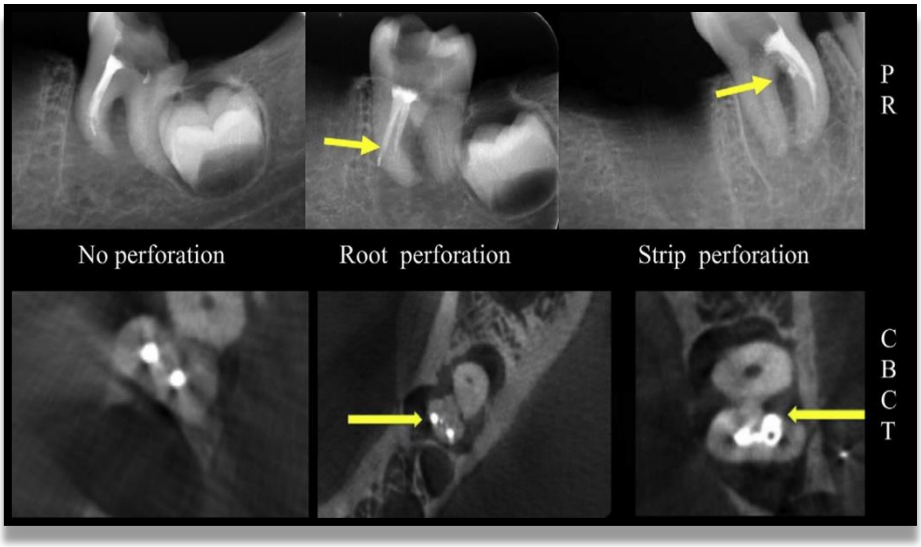


Fig. (7): Root and strip perforation as seen through PRs and CBCT scan. **(Shemesh et al., 2011)**

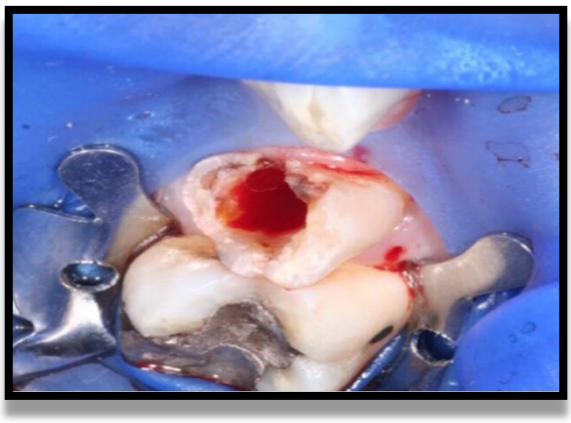


Fig.(8): Profuse bleeding resulting from A perforation during endodontic access of the 15**(Saed et al., 2016)**

Fig.(9) : The post in the 45 perforates the mesial aspect of the root wall. A periodontal pocket has resulted from the chronic inflammation **(Saed et al., 2016)**

4-Prognosis:

Root perforation could affect the prognosis of root canal treatment and retreatment. Whether or not a root perforation can be successfully treated depends on whether the perforation can be repaired such that bacterial infection of the perforation site can either be prevented or eliminated. Three clinical factors have been considered as relevant in the prognosis and healing of root perforations: **(Tsesis and Fuss, 2006).**

4.1 Site of perforation :

The position of the perforation relative to the level of the crestal bone and the epithelial attachment is critical when assessing prognosis. This is named the critical zone as in **(Fig.10)** ,The worst prognosis lies when the perforation is within this critical zone. The close proximity to the gingival tissues can lead to the contamination of the perforation with bacteria from the oral cavity. **(Tsesis and Fuss, 2006).**

A periodontal defect will be created if there is apical migration of the epithelium into the perforation site **(Hartwell and England, 1993)**. This rapid pocket formation leads to the lowest success rate
of repair. If the perforation occurs in the furcation of multirooted teeth, then this can also be regarded in the critical zone due to its proximity to the epithelial attachment and the gingival sulcus. **(Figs 11a and 11b).(Saed et al., 2016)**

Perforations that are coronal to the critical zone have a good prognosis. This is because they are easily accessible and an adequate seal with conventional materials is possible without periodontal involvement. If the canal is accessible and root canal treatment possible, perforations that are located apical to the critical zone also have a more favorable able prognosis as they can be cleaned and sealed with a much lower risk of bacterial entry from the oral cavity and a chronic inflammatory lesion developing **(Sinai , 1977) (Frank, 1974) (Saeed at al., 2016).**

4.2 Size of perforation:

Himel et al. studied the mandibular teeth of the dogs to study the influence three materials that was used for healing the perforations of the pulpal floor and it was noticed that the larger teeth that has smaller perforations had greater incidence of healing. A small perforation is usually associated with less tissue

destruction and inflammation .Therefore, healing is more predictable and has a better prognosis.Smaller perforations are easier to seal effectively, preventing bacteria from reaching the periradicular tissues.**(Hegde at al., 2017)**

4.3 Time of perforation:

Time is a most critical factor determining outcome of treatment. Beavers et al.observed consistent periodontal healing following treatment of experimentally produced root perforations in a monkey model. Lantz & Persson produced root perforations in dogs that were treated either immediately or after some delay. The most favorable healing response was evidenced when perforations were sealed immediately. Proper treatment of the perforation may not always be possible, due to lack of time, lack of experience of the operator, and proper equipment.**(Singh et al., 2016)**

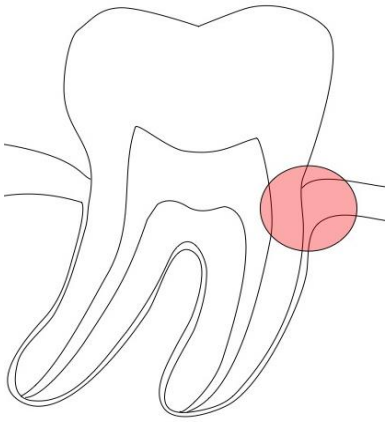


Fig.(10) : The critical zone: a perforation into the gingival sulcus and the crestal attachment may have the most significant consequences as bacterial entry and pocket formation can quickly ensue. It is important to recognise the critical zone may not necessarily be at the CEJ but rather follow the biological width, thus if there is recession, the critical zone will be located more apically accordingly. **(Saed et al., 2016)**

Fig.(11): A) In an attempt to locate the disto-buccal canal of the 26, there were multiple perforations of the pulp chamber floor. **b)** Upon re-entry the disto-buccal canal could not be located but the perforation was repaired with MTA. There was radiographic evidence of furcational bone loss. The tooth remained symptomatic and the tooth was removed. **(Saed et al., 2016)**

Table 1: classification of root perforation

(Baumann and Beer, 2010).

Good prognosis	**Poor prognosis**
Fresh	Old
Small	Large
Apical –coronal	High alveolar ridge

5-Materials Used For Perforation Repair :

An ideal material used in the management of root perforation for root perforation material is still challenging. The endodontic literature published

over the years presents reports on several intracanal medicaments that have been studied to treat infected root canals.

5.1 Ideal Requirements of Root Repair Material:-

The material requirements of perforation repair materials vary depending on whether the perforation is located inside (intraradicular) or outside the root canal (extraradicular). Requirements of root perforation repair materials used in the canal: **(Kakani et al., 2015)**

1. It should provide adequate seal.
2. It should be biocompatible.
3. It should have ability to produce osteogenesis and cementogenesis.
4. It should be bacteriostatic, and radiopaque.
5. It should also be beneficial to use a resorbable matrix in which a sealing material can be condensed.
6. It should be relatively inexpensive.
7. It should be non-toxic, non-cariogenic and easy to place.
8. Unaffected by blood.
9. It should be possible to prevent extrusion of the material into the surrounding tissues.

No material offers all of these properties. In search for the ideal material, numerous sealing materials and techniques have been tested over the years with varying success. For perforation repair, found hemostatic are needed to control the hemorrhage and make the area dry so that optimal placement of restorative material can be accomplished.

Material which can be used as hemostatics include calcium hydroxide, calcium sulphate, freezed dried bone and MTA. Whichever is the material used; the ultimate goal is to seal the defect with a biocompatible material and maintain an intact periodontal attachment apparatus. **(Nisha, 2010)**

5.2 Various Materials Used For Perforation Repair :-

1. Indium foil
2. Amalgam
3. Plaster of Paris (calcium sulfate/burnt gypsum).
4. Zinc Oxide Eugenol
5. Super EBA
6. IRM (Intermediate Restorative Material)
7. Gutta Percha
8. Cavit
9. Glass Ionomer Cement
10. Metal-Modified Glass Ionomer Cement
11. Composite
12. Dentin chips
13. Decalcified Freezed Dried Bone
14. Calcium Phosphate Cement
15. Tricalcium Phosphate Cement
16. Hydroxyapatite
17. Calcium hydroxide
18. Portland Cement
19. MTA
20. Biodentine
21. Endosequence
22. Bioaggregate
23.. Calcium Enriched mixture . **(Kakani et al., 2015) (Hartwell and England, 1993).**

5.2.1 Bioceramic:-

This is a bioceramic material which refers to a mixture of calcium silicate and calcium phosphate **(Hegde et al., 2017):**

5.2.1.1 Endosequence :-

It is bioceramic material composed of calcium silicates, zirconium oxide, tantalum oxide, calcium phosphate mono basic and filler agents. It has a working time of more than 30 minutes and a setting reaction initiated by moisture with a final set achieved in approximately 4 hours. Bioceramics can be used in two forms either as premixed putty or in a premixed syringe. The syringe eliminates need of

hand instruments and also need for mixing. The bioceramic particle size is less than 2 µ thus can be delivered by a 0.012 capillary tip which allows premixed material to be placed by syringe **(Fig. 12) (Hegde et al , 2014).**

Nanosphere particles are produced which enables the material to enter in the dentinal tubules and thereby initiating the setting reaction by interacting with the moisture, this creates a mechanical bond on setting and makes it dimensional stable, The material also shows superior biocompatibility characteristics due to its high pH **(Damas et al., 2011) (Nasseh A , 2009).**

Jeevani et al. conducted a study on furcation repair with Endosequence, biodentine and MTA and showed that endosequence has better sealing ability compared to others. **(Jeevani et al., 2014).**

Fig.(12): Brasseler Endosequence Root Repair Material (Brasseler USA). This material has better handling characteristics than MTA and minimizes discoloration of the tooth. **(Berman et al 2021).**

5.2.1.2 Bioaggregate :-

is a bioceramic material composed of tricalcium silicate, dicalcium silicate, calcium phosphate mono basic, amorphous silicon dioxide and tantalum pent oxide. It promotes mineralized tissue formation and leads to precipitation of apatite crystals that become larger which increases on immersion time suggesting it to be bioactive **(Zhang et al, 2009).**

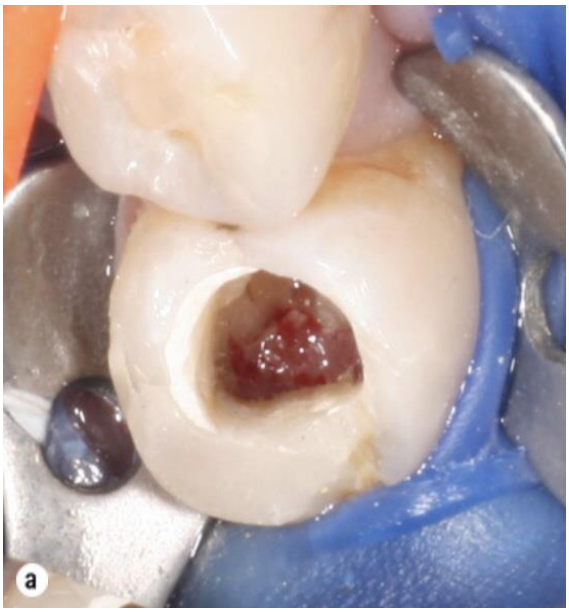
6.2.2 Calcium Hydroxide

In 1920s, Bernhard W. Herman suggested the use of calcium hydroxide for dental pulp treatment. This material favors the healing process of pulp and Periapical tissues. It's obtained by the calcination of calcium carbonate, which is transformed into calcium oxide, and then hydrated to form calcium hydroxide. The reaction between calcium hydroxide and carbon dioxide forms calcium carbonate. The ionic dissociation of calcium hydroxide into calcium and hydroxyl ions, and the action of these ions on tissues and bacteria explains its biological and antimicrobial properties. It is one of the most biologically compatible material which is used in dentistry. It is very much compatible with the pulp and the periapical tissue **(Estrela et al., 1995) (Sharma et al., 2020).**

By composition calcium hydroxide consists of a base paste and catalyst paste. When root perforation detected in teeth with infected root canals, calcium hydroxide is the first antibacterial option for intracanal dressing. The sanitization process (emptying, irrigation, enlargement, intracanal medication) has led to significant reduction of microorganisms in contaminated root canals. Calcium hydroxide paste may be prepared with a saline solution vehicle (water-soluble in nature). Its placement should be very well condensed within the root canal to avoid empty spaces when filling the root perforation. Its consistency must be thicker than toothpaste. Proper management and placement of calcium hydroxide paste into the root perforation are necessary for better performance of this intracanal dressing. In the second appointment, the calcium hydroxide is removed from the root canal and from the site of root perforation with the residual paste acting as a matrix , taking care to avoid overfilling. The root perforation is then sealed with mineral trioxide agregate (**Estrela et al., 2018)(Holland et al , 2017).**

5.2.3 Calcium silicate based cements (biodentine)

It's a based cements has a powder liquid system in which powder consist of Tri-calcium silicate, Dicalcium silicate, Calcium carbonate and oxide such as Iron oxide, Zirconium oxide and Liquid consist of Calcium chloride,
Hydro soluble polymer. Biodentine has shorter setting time approximately 12 minutes and it is easy to handle and has high alkaline pH which makes it a biocompatible material and thus making it a favorable material for perforation repair. a study by Guneser et al., Biodentine showed considerable performance as a perforation repair material even after being exposed to various endodontic irrigants as compared to MTA **(Fig. 13-a-d) (Guneser et al., 2013) (Priyalakshmi and Ranjan, 2014) (Han and Okiji , 2011) .**



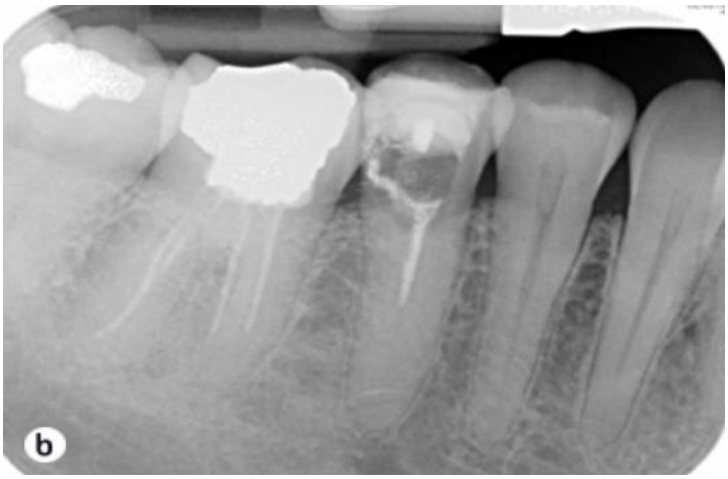


Fig.(13): a-b) A perforation occurred during Endodontics access of the 45.

c-d) The cavity was repaired with Biodentin. The setting time of 12 min. allowed the operator to continue RCT without significant delay to the patient's care.**(Saeed et al., 2016)**

5.2.4Mineral Trioxide Aggregate (MTA) :-

Mineral trioxide aggregate (MTA) has been considered as an ideal material for perforation repair, apexification retrograde filling, pulp capping etc. MTA is a mineral powder that is made up of hydrophilic particles, whose principal components are dicalcium silicate, tricalcium of slica aluminium and oxide along with other mineral oxides.**(Main et al , 2004) .** When mineral trioxide aggregate was introduced for perforation repair, the choice of which repair material to use became more clear. MTA has many advantages over previous restoratives when being used for perforation repair , The materials seals well even if the cavity preparation is contaminated with blood , It's very biocompatible rarely eliciting any response from the periradicular tissues, and a cementum like material has been consistently shown to grow directly on the material after placement, MTA has also been shown to have a high degree of clinically favorable long-term outcomes when used as a perforation repair material.**(Berman et al., 2021).**

MTA is available in the original gray formulation and an off-white option **(Fig.14),** Their sealing ability seems comparable **(Ferris &Baumgartner , 2004) ,** but questions remain as to whether white MTA exhibits the same biocompatibility **(Perez et al , 2003)** and will have the same long-term success as the older variety. Also, both types of MTA cause significant tooth discoloration. This is an effect that is seen in all the bioceramics, but it is much less pronounced in the newer ones like Biodentine and EndoSequence Root Repair Material **(Mozynska et al , 2017) (Berman et al 2021).**

Fig.(14): MTA is available in the original gray- colored preparation (left), and the newer white-colored version (right). The latter is indicated for esthetically demanding areas of the mouth **(Baumann and Beer, 2010).**

5.2.4.1 Disadvantages of using MTA:

• It is difficult to manipulate and handling requires both time and practice .

• The setting time of around 3-4 hours may compromise the application , with the possibility of solubilized by being in contact with oral fluids as this process occurs, In supra-crestal cases the material may be washed out before it has set.

• Both grey and white MTA can discolor the tooth and therefore compromise aesthetics. This needs to be considered especially in the anterior region and with those patients who have a high lip line.**(Clauder&Shin ,2006) (Saeed et al., 2016)**

5.2.4.2 Mode of action of MTA:-

The mode of action of MTA is based on the following mechanisms **(Verma et al., 2021) :**

- Formation of Ca(OH)2 and its release of calcium ions;
- Alkaline pH of about 12.5
- Effects on cytokine production

- Promotes the differentiation and migration of cells
- involved in hard tissue formation;
- Formation of hydroxyapatite on the surface of MTA.

5.2.4. 3 Application of Mineral Trioxide Aggregate (MTA) :-

If the perforation is associated with a large osseous defect, it may be beneficial to use an extra-radicular matrix to prevent extrusion of the repair material. Most publications agree that using a matrix allows better control of the repair material **(Lemon, 1992) (Alhadainy and Himel, 1994).** Whether this will result in a better treatment outcome remains to be demonstrated.

Matrix materials should be biocompatible and bioresorbable. A number of materials have been used as matrix materials, including tricalcium phosphate, hydroxyapatite, demineralized freeze- dried bone, collagen, and calcium sulfate.

After controlling the hemorrhage, the repair material is placed using appropriate instruments. In the case of MTA, carriers or small spatulas are used to deliver the material to the perforation site. It has been shown that indirect ultrasonic activation of MTA results in a denser filling than with hand compaction **(Yeung et al., 2006)**. This can be achieved by using a plugger to compact the MTA and having the dental assistant touch the plugger with an ultrasonic tip at the same time.

If MTA becomes too moist during compaction, thick paper points may be used to wick out the surplus moisture.

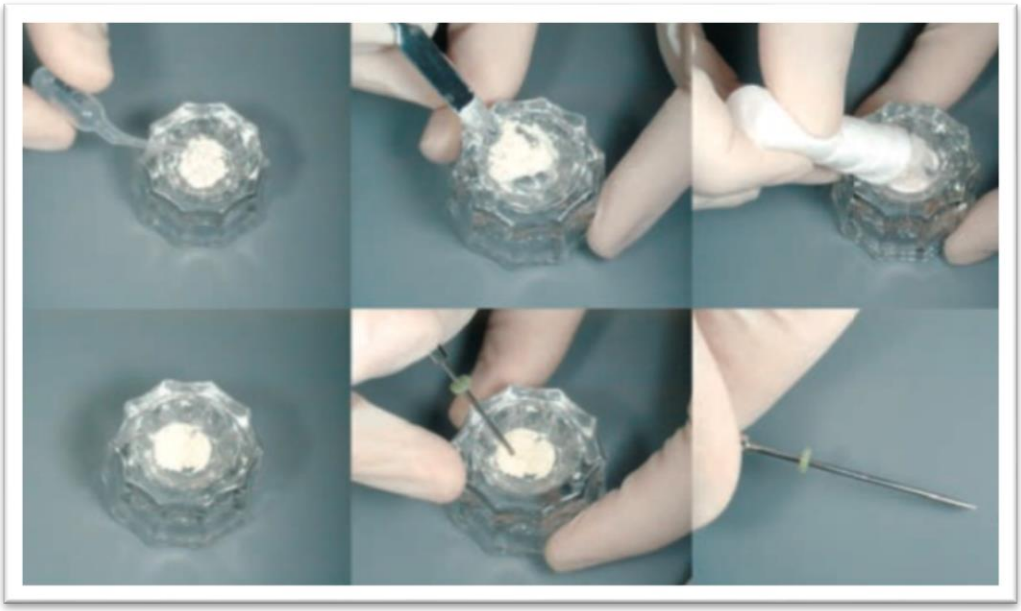


Fig.(15) :Armamentarium

The consistency of the mixture of MTA is critical for correct handling. It should have the consistency of wet sand, and the pellet that is extruded from the carrier should retain its form. **(Baumann and Beer, 2010).**

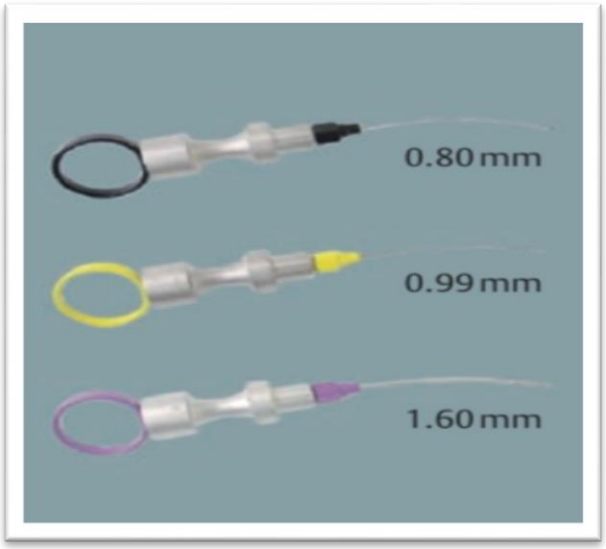


Fig.(16): Dovgan MTA carriers are available in three different diameters(ADS,Vaterstetten, Germany). **(Baumann and Beer, 2010).**

Fig.(17): :Perforation in the furcal floor of a maxillary molar, with attachment loss

Left: The patient was referred for retreatment of tooth 16. The radiograph reveals a periradicular lesion. A sinus tract was present, which was traced with a gutta percha cone. **Middle and right**: The presence of a sinus tract and pocket formation may indicate the existence of a perforation. In this case, a probing depth of 8 mm on the buccal aspect was observed. **(Baumann and Beer, 2010).**

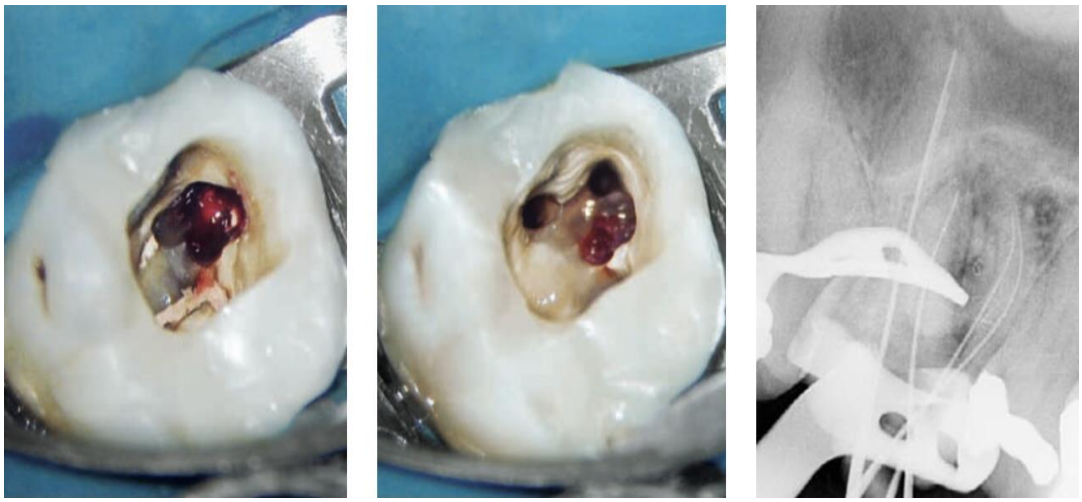


Fig.(18): Localizing the perforation

Left: After removal of the restoration, a perforation was made apparent by profuse bleeding from the floor of the pulp chamber.

Middle: The bleeding tissue was partly removed using an electrosurgical tip. After removing gutta percha from the canals, a second mesiobuccal canal was identified.

Right: After establishing working length with an apex locator and two radiographs, all canals were cleaned and shaped, and a dressing of calcium hydroxide was placed in the canals and the perforation site. A second visit was then scheduled.

(Baumann and Beer, 2010).

Because MTA needs at least 3 hours to set, a moist cotton pellet is placed over the material and the tooth is sealed with a temporary restoration. On reentry, MTA should be completely set and well fitted to the perforation site. Subsequently, the tooth should be definitively restored as soon as possible with an adhesive material to prevent coronal leakage.

Perforations in the furcation area of multi rooted teeth are usually considered as crestal perforations, because of the close proximity to the epithelial attachment and possible communication with the gingival sulcus. Fuss and Trope in 1996 stated that the rate of success of their repair is low, because these furcal perforations are most susceptible to apical proliferation of epithelium and subsequent pocket formation.

However, **Main et al. (2004)** demonstrated that the use of MTA for repair of infected furcal perforations resulted in normal tissue architecture adjacent to the repair site after 1 year **(Baumann and Beer, 2010).**

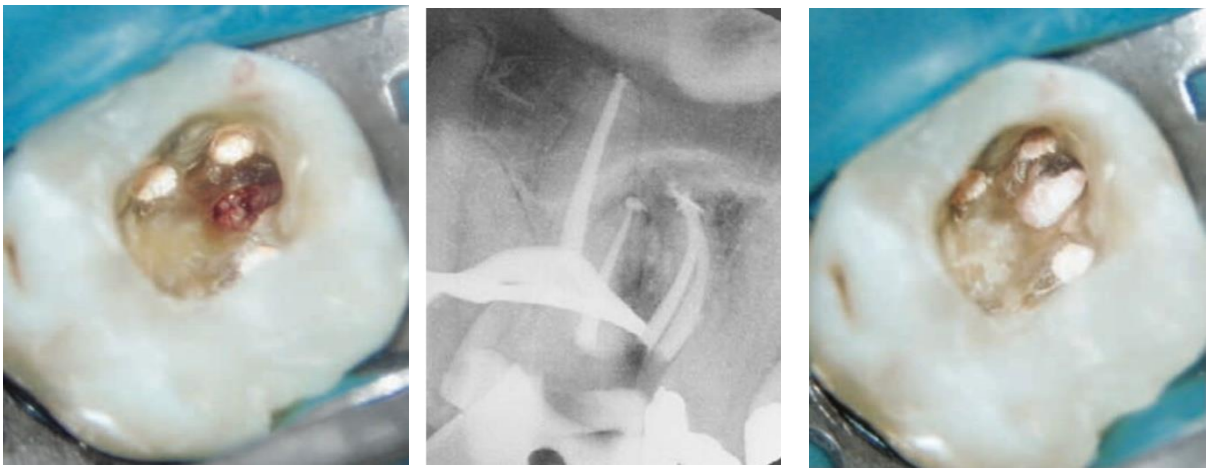


Fig.(19): obturation and application of a matrix of calcium sulfate
Left: Upon re-entry the tissue in the perforation site exhibited superficial necrosis, due to the high pH of calcium hydroxide. Bleeding was negligible and the outline of the perforation was clearly visible.
Middle : Radiograph showing obturation of the canals.
Right: After obturating the canals, an extraraddicular matrix was placed in the perforation to recreate the external root contour and act as a berrier against which MTA can be appplied.
(Baumann and Beer, 2010).

Fig.(20): Perforation repair with MTA
Left: After setting of the calcium sulphate, which takes several minutes, MTA was applied with a carrier. It was compacted with pluggers and the blunt end of thick paper points to absorb the surplus moisture.
Middle: MTA applied to a thickness of 3 mm.
Right: Because MTA requires 3 hours to set, a moist cotton pellet was introduced on top of the MTA and the access was closed with a temporary restoration.
(Baumann and Beer, 2010).

6.MANAGEMENT OF ROOT PERFORATION:-

The aim of perforation management is regeneration of healthy periodontal tissues against the perforation without persistent inflammation or loss of periodontal attachment. If there is a case of periodontal breakdown, then the aim here is to reestablish tissue attachment.**(Pitt Ford et al.,1994) (Saeed et al., 2016)** Therefore, successful perforation repair depends on the ability to seal the perforation and re-establishing a healthy periodontal ligament.

Clearly, irrespective of site, size or time to repair, if a tooth is symptomatic, treatment must be offered. There are only two options in this case: repair or extraction. The tooth must first be assessed for restorability. Extensive pathological perforations invariably render the tooth unrestorable. If the tooth is unrestorable or endodontic treatment deemed impossible to complete, the patient must be counselled upon the benefits of extraction and possible prosthodontic options. For some teeth, access to the perforation may be impossible without significant risk of collateral damage or risk of failure, therefore, extraction may be the only option. If the tooth is considered restorable, repair may be considered. An important factor to consider is good visibility as this is essential to see the damaged site. Access to an operating microscope is recommended.**(Clauder and Shin, 2006).**

6.1 Non-Surgical Management Of Perforation:-

Non-surgical management of perforation includes orthograde approach, management of crestal root perforation, intentional replantation, and iatrogenic perforation. **(Senthilkumar and Subbarao, 2017).**

6.1.1 Orthograde approach:-

Fresh perforations that occur during endodontic and operative procedure are followed by hemorrage. Hemorrage can be controlled first by applying pressure or irrigation and perforation should be sealed adequately.**(Tsesis and Fuss, 2006).**

Bleeding can be controlled using hemostatic agents and materials that arrest bleeding. To control bleeding, calcium hydroxide can be syringed into the canal and allow to remain for 4–5 min and then flush calcium hydroxide using NaOCl, repeat this procedure for 2–3 times.**(Kim and Rethnam, 1997) (Senthilkumar and Subbarao, 2017).**

Other hemostatic materials used to control bleeding are collagen, calcium sulfate, freeze-dried bone, and mineral trioxide aggregate.

Calcium hydroxide material is used for perforation management. Absorbable barrier materials used are collagen and calcium sulfates. Non-absorbable barrier materials are MTA, super EBA, resin cement, composite bonded restoratives, and calcium phosphate cement.**(Koh et al., 1998) (Behnia et al., 2000) (Senthilkumar and Subbarao, 2017).**

6.1.2 Crestal root perforation management:-

Any biocompatible substance with a quick setting time and good sealability should be used for sealing. For single rooted teeth, it is advised to use. orthodontic extrusion to move the perforation to the coronal position, where it can be superficially sealed without the need for surgery. **(Kim and Rethnam, 1997).** To prevent the ejection of repair material, internal matrix method is advised for significant perforations in the furcal zone of molars **(Rafter et al., 2002).** The finest materials for furcation perforation include MTA, iRoot BP, calcium-enriched mixture cement, Pro-root MTA, and biodentine.**(Kerner and Bronnec, 2015) ,**Cementum like tissue is created when MTA and a cement mixture high in calcium are used. The optimum material for crestal root perforations is thought to be biodentine. In the treatment of perforation, the

application of stem cells in combination with a cured dentin matrix improves bone development. **(Bakhtiar et al, 2017) (Alshamrani et al., 2023).**

6.1.3 Intentional replantation:-

When orthograde and invasive procedures are not an option, this approach is taken into account. It is indicated when the perforation is too large to heal and impossible to reach without removing a lot of bone. The tooth should be extracted gently without causing any harm to the nearby tissues. A balanced salt solution should be used to gently wash the tooth after removal while it is being held in forceps. Replanting needs to be carried out as soon as feasible. Ankylosis and inflammatory root resorption are complications.**(Tsesis and Fuss, 2006)**

6.1.4 Iatrogenic Perforation

The prognosis will be better, the more apically the perforation is located. A negative prognosis is associated with perforations that develop in the coronal third of the root underneath the crestal bone. In cases of strip perforation, MTA can be utilized as an obturating agent and perforations situated at the point of epithelial attachment and bone. **(Adiga et al,. 2010) (Alshamrani et al., 2023).**

6.2 Surgical management

Large perforations, perforations brought on by resorption, and lack of healing following non-surgical repair all call for surgical intervention. The amount of surviving bone, the degree of osseous destruction, the age of the defect, the presence of periodontal pathology, the extent of soft tissue attached, dental hygiene, and the surgeon's skill in managing tissue are all factors taken into account before surgical therapy. **(Tsesis and Fuss, 2006)**

Perforation is being managed with guided tissue regeneration. An elevated buccal full thickness flap enables the perforation location to be seen. MTA is then used to close the perforation, and the flap is sutured after that. Sutures are extracted from postoperative wound after they have healed, and the post can then be sealed **(Fig.21) (Nagpal et al., 2013) (Alshamrani et al., 2023).**

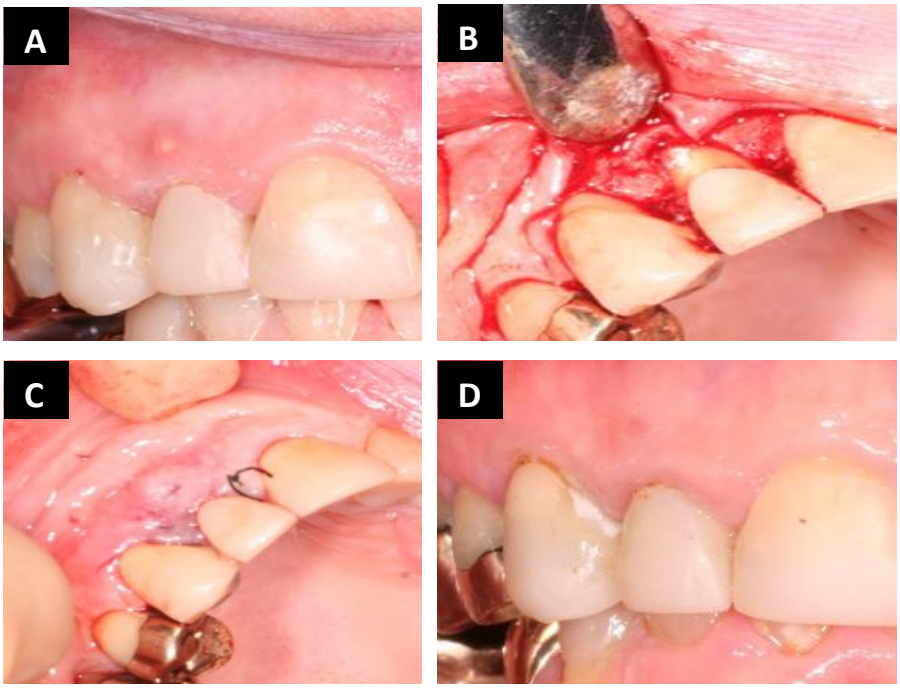


Fig.(21) : Surgical management of perforation
a) A perforation occurred during RCT of the 12 resulting in a persistent sinus. **b–c)** An intra-sulcular incison was made and a flap raised without relieving incisions. Surgical repair with MTA was performed. **d)** There was evidence of healing and no pocketing at a 4week review

6.3 Microscope in management of perforation:-

Microscope enhances the visibility of perforation in a magnified field. It helps in locating even smaller perforation site so that it can be treated earlier preventing from future infection.It helps mainly in sealing the cervical perforation with vitremer, iatrogenic cervical perforation during access preparation.**(Schmidt et al., 2016)**

7. Prevention of perforation:-

To avoid perforation during endodontic treatment we have the following key concepts: **(Ricketts et al., 2005) (Saeed et al., 2016)**

- Use magnification and good illumination when providing endodontic treatment.
- Remove impediments to straight line access, this reduces the curvature of the canal.
- Begin a crown down approach before apical instrumentation. This facilitates instrumentation, prevents instruments locking in the canal and allows improved irrigation.
- Negotiate canals initially with size 10 ISO files and progress to size 20 ISO files before introducing rotary instruments.
- Use ‘fine files frequently’ between larger files to prevent blockages and ledging.
- Use copious irrigation with 1%-5.25% sodium hypochlorite to remove debris
- In curved canals use balanced force technique for hand filing.
- Always follow manufacturer guidelines on rotary instrument protocols.
- Never force a file.
- If you suspect a blockage or ledge, do not use rotary instruments.
- In teeth with multiple roots always file away from the furcation with brush strokes of the instruments.
- If there is any doubt about access, working length or possible perforation, take a check radiograph.

Chapter Two

Discussion

DISCUSSION

The life of an endodontically treated tooth is associated with correct diagnosis and treatment planning, root canal shaping, sanitization, sealing, and lastly, tooth rehabilitation. The successful treatment of a root perforation depends on certain factors, like sealing material, perforation extent and location, time between diagnosis and treatment, presence of contamination and related operator experience, presence of preoperative lesions, communication of the perforation with the oral environment, and type and quality of the final restoration. MTA has been the most widely indicated material to seal root perforations. No repair material used before the introduction of MTA was able to stop inflammatory processes resulting in attachment loss or to maintain tissue health at the perforation site. MTA is able to stimulate regenerative processes resulting in tissue attachment and cement formation, Even with all the advantages described above, it is important to remember that MTA also has disadvantages that must be taken into account. Histological studies have shown lateral and furcal perforations that have been repaired with MTA, and that have been found to have mineralized tissue over the material, However MTA appears to provide a biocompatible and long term effective seal for root perforation, with a higher success rate.

Chapter Three

Conclusion

CONCLUSION:-

Chronic infections brought on by perforations can eventually lead to tooth loss. All medical interventions must include measures to reduce iatrogenic harm. Perforations can, and often do, happen for a wide range of reasons. The physician must be able to spot a perforation when it occurs and know the best course of action for repairing the injury. All practitioners should think about doing an appropriate repair right away. Delaying treatment by referring to a more skilled peer may have a substantial bearing on the therapy's outcome. The drawbacks and benefits of either keeping the tooth untreated or having it extracted and replaced with a prosthesis must be explained to patients before they give their assent. Long-standing perforations may be challenging to correct.

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