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Root Perforations & Its Management: A Review Article

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Abstract

A root perforation is a mechanical or pathological communication formed between the supporting periodontal apparatus of the tooth and the root canal system. Such perforations might compromise the treatment outcome and persist as a significant complication if not repaired.

Unpredictable endodontic root/pulp chamber floor perforations resulting in unacceptable high rate of clinical failure has now been a lesser threat with the advent of new technologies and biocompatible materials that utilize the applications of basic research along with tissue engineering concept in clinical practice.

Keywords: Cementogenesis, Iatrogenic, Pathologic, Perforation, Osteogenesis.

Introduction

Root perforations can occur pathologically as a result of resorption and caries or iatrogenically during root canal treatment [1].

This perforation acts as an open channel encouraging bacterial entry either from root canal or periodontal tissues or both eliciting inflammatory response that results in fistulae including bone resorptive processes may follow.

The prognosis of a perforation defect is mostly guarded and depends on factors such as

1) level of perforation,

2) Size of the opening

3) Time elapsed

4) The sealing ability and biocompatibility of the of material being used [2,3].

These are explained below:

1) Level of perforation

Classification

Proposed by Fuss & Trope

1. Coronal perforation–

-Coronal to the level of crestal bone and epithelial attachment with minimal damage to the supporting tissues and easy access.

-Good Prognosis.

2. Crestal perforation–

-At the level of the epithelial attachment into the crestal bone.

- The close proximity to the gingival tissues can lead to the contamination of the perforation with bacteria from the oral cavity.

- If the perforation occurs in the furcation of multi-rooted teeth, then this can also be regarded in the critical zone due to its proximity to the epithelial attachment and the gingival sulcus.

-Questionable Prognosis.

3. Apical perforation–

-Apical to the crestal bone and the epithelial attachment,

-Good Prognosis

2) Size of the opening

A small perforation is usually associated with less tissue destruction and inflammation. Therefore, healing is more predictable and has a better prognosis.

3) Time elapsed

The most favourable healing is found when the perforations are sealed immediately; thereby reducing the likelihood of an infection and chronic granulation tissue or periodontal pocket occurring.

4) Materials used for perforation repair

Ideal requirements of Root repair material [4]

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.

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.

Different materials used are:

1. Indium foil

Historically Indium foil was used as a perforation repair material mainly to prevent gross overfilling[5]. Auslander and Weinberg introduced this technique in 1969. Amalgam alone provided significantly better clinical and histological results than indium foil matrices for the repair of furcation perforations.

2. Amalgam

El Deeb et al. in 1982 found that the use of amalgam in furcation perforations was superior to that of Cavit or calcium hydroxide [6]

It is possible that the moisture present in the perforation sites reduces the sealing ability of amalgam..

3. Plaster of Paris

Guliford recommended Plaster of Paris for furcation perforation repair long back in 1901.Bahn recommended plaster of Paris because it is stable, biocompatible, readily available, easily sterilized, and its rapid rate of resorption coincides with the rate of new bone growth. It was also found that plaster of Paris accelerates the rate of new bone mineralization by providing a ready source of calcium ions for early mineralization process. [7]

4. Super EBA (super ethoxy benzoic acid)

It has advantageous properties such as its ease of manipulation and its outstanding biological compatibility with the periapical tissues According to a study by J Kenneth Weldon et al., Super-EBA allowed significantly less microleakage than MTA at 24 hours; the combination of MTA and Super-EBA provided a more rapid seal than MTA alone.[8]

5. IRM (Intermediate Restorative Material)

Intermediate Restorative Material is reinforced zinc oxide–eugenol cement. When used without an internal matrix it showed a significant leakage, so it should be used only with the aid of a matrix[9]

6. Glass Ionomer Cement

Glass Ionomer Cement exhibits a greater sealing potential than conventional materials due to its adhesion property.

Alhadainy and Himel found that light-cured glass ionomer cement exhibited a better seal than amalgam or Cavit when used for furcation perforations repair [10]

In a dye leakage study, Dazey and Senia (1990) found that light-cured calcium hydroxide showed more sealing ability than chemically cured glass ionomer and amalgam when placed into lateral root perforations.

7. Metal-Modified Glass Ionomer Cement

Zvi Fuss et al., evaluated the sealing ability of silver glass ionomer cement (Chelon silver) in treating furcation perforations in vitro and compared it with amalgam. Results have shown that perforations repaired with Chelon Silver leaked significantly less than those repaired with amalgam[11]

8. Composite

Bisfil had shown better sealing ability of composite than amalgam and Intermediate Restorative Material when used for lateral perforation repair. However, the drawback of this material is it had shown highest rate of overfilling when used to repair lateral perforations[12]

9. Decalcified Freezed Dried Bone

DFDB chips are biocompatible, relatively nontoxic, easy to obtain, easy to use, relatively inexpensive, easy to manipulate, completely degrades during the repair process and acts as an excellent barrier against which filling material could be placed.

10. Calcium Phosphate Cement

Calcium phosphate cement (CPC) is a mixture of two calcium phosphate compounds of which one is acidic that may be either dicalcium phosphate dehydrate {CaHPO4"2H20}, or anhydrous dicalcium phosphate {CaHPO4}, and the other basic tetra calcium phosphate {Ca4(PO4)}2 . Water is used as a vehicle for dissolution of the reactants and precipitation of the product.

In a study by James et al., Calcium phosphate cement showed no significant differences in the percent leakage or perforation depth when compared with light-cure glass ionomer cement, however, extrusion of Calcium Phosphate Cement was noted in all specimens while glass ionomer cement exhibited no extrusion[13]

11. Tricalcium Phosphate Cement

When used as perforation repair material tricalcium phosphate showed evidence of healing by the presence of layers of epithelium, collagen, and bone, with few inflammatory cells at the perforation site.[14]

12. Hydroxyapatite

It can be used both as an internal matrix and as a direct perforation repair material. When used as furcation perforation repair material has shown to reconstruct furcation bone loss due to iatrogenic root perforation [15]

13. Calcium hydroxide-

Himel et al. evaluated the repair of mechanical perforations of the pulp chamber floor using tricalcium phosphate or calcium hydroxide. Histologically they found that calcium hydroxide was more toxic and caused more destructive reaction than tricalcium phosphate and that the latter is more effective in inducing hard tissue apposition[16].

Trope and Tronstad suggested that repeated application of calcium hydroxide over a long period of time may result in hard tissue closure of root perforations.[17]

14. Portland Cement-

Portland cement was invented and patented by Koseph Aspdinin in 1824 in England.

It induces bone and cementum formation when used as perforation repair material. The biological properties of type I Portland cement and MTA are very similar; both materials release calcium ions, leading to the formation of carbonate apatite, which is involved in biomineralization.[18]

15. Mineral Trioxide Aggregate (MTA)-

MTA has been applied with good treatment outcomes owing to its properties of biocompatibility, low provocation of inflammation, good seal even in presence of moisture/blood and a high pH (12.5) which promotes growth of cementum and regeneration of periodontal ligament.MTA has the same basic composition of type I Portland cement with the addition of bismuth oxide as a radiopaque agent.

Bismuth oxide is added to MTA for radiopacity, but in the long term bismuth oxide can cause changes in the cement, resulting in increased porosity and decreased resistance5,23. On the other hand, the presence of Portland cement can be detected in radiographs without the addition of radiopaque agents [19]

MTA can be delivered to the perforation using micro-syringes such as the MTA MAPS System or Dogvan Carrier.

16. Biodentine

Compared to MTA, Biodentine handles easily and needs much less time for setting.

Pradelle-Plasse et al. found that Biodentine causes alkaline corrosion on the hard tissue, which leads to a so-called “mineral interaction zone”. Due to remodelling processes, the sealing of the dentine by Biodentine improves in the course of time. They reported that Biodentine can deposit impermeably onto the cavity walls and prevents microleakage [20].

17. Endosequence root repair material-

Endosequence root repair material (ERRM) has been developed as ready-to-use. This premixed bioceramic materials is recommended for perforation repair. The major advantage of this material is improved handling characteristics over traditional MTA.

ERRM is composed of calcium silicates, calcium phosphate monobasic, zirconium oxide, tantalum oxide, proprietary fillers and thickening agents.

Hirschberg et al. compared the sealing ability of MTA to the sealing ability of ERRM using a bacterial leakage model. They concluded that Samples in the ERRM group leaked significantly more than samples in the MTA group. [21]

18. Bioaggregate-

BioAggregate is new generation of a root canal repair filling material. The manufacturer claimed that BioAggregate is produced under controlled conditions to form contamination free ceramic nano-particles. According to manufacturer, BioAggregate is developed as a result of utilizing the advanced science of nano-technology to produce ceramic particles that, upon reaction with water produce biocompatible and aluminum-free ceramic biomaterials.

BioAggregate’s radiopacity properties, convenient setting and hardening time and easy workability and handling properties make it an ideal root canal filling material.

The composition of BioAggregate is tricalcium silicate, dicalcium silicate, tantalum pentoxide, and calcium phosphate monobasic. To provide radiopacity, tantalum pentoxide is used in BioAggregate rather than the bismuth oxide used in MTA.

Aminov et al. compared the recovery rate after treatment of root perforations in the interradicular area of the molars, using two different materials: MTA and ceramic nanoparticles mineral cement BioAggregate, by a clinical-radiological and statistical analysis over a period of up to 24 months. They reported that both MTA and BioAggregate are excellent materials for root perforation repair.[22]

19. New Endodontic Cement

Later termed as Calcium Enriched Mixture (CEM). It is composed of calcium oxide, calcium phosphate, calcium carbonate, calcium silicate, calcium sulfate, calcium hydroxide, and calcium chloride. It has a setting time of less than 1 hour and sets in aqueous medium.

Asgary et al., observed cementogenesis and periodontal regeneration when CEM was used as perforation repair material.[23]

Diagnosis

1] Iatrogenic perforations are invariably identified from the profuse bleeding that follows the injury.

2]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 periodontal ligament.

3] Operating microscopes are becoming increasing popular in identifying perforations.

4] Radiographs can be used at the time of perforation, but do have their limitations: they are only a two-dimensional representation and so it may be difficult to accurately assess the site and extent of the perforation. Taking a second film and shifting the radiographic beam angulation to the mesial or distal aspect can partly overcome this.

5] Cone beam computed tomography is important in the assessment of perforations .The presence of pre-existing GP, posts and core restorative materials will create artefacts

6] Endoscope , and an optical coherence tomography scan. However, none of these could diagnose perforations in already filled roots because they are based on visualization of the empty root canal or penetration into it.

Types of Perforation

I. Iatrogenic perforations

Accidental root or pulp chamber perforation is amongst the major complications of endodontic and restorative treatments, that results in loss of integrity of root and adjacent periodontium.[24]

Iatrogenic perforations are often due to a lack of attention to the details of internal anatomy and a failure to consider anatomic variations. In a malaligned tooth, perforatio n may result if a bur is not properly angulated in relationship to the long axis of the tooth.

Resultant chronic inflammatory reaction characterized by formation of granulation tissue, may consequently lead to irreversible attachment, bone and tooth loss.[25]

Perforations of the coronal third of root:

Perforations of the coronal third often result whilst attempting to locate and open canals.

Perforations of the middle third of root:

Strip perforations of the middle third may occur if there is overzealous instrumentation in canals too aggressively away from the centre of the root.

Classically, this occurs in curved molar roots when the instrumentation is too heavy on the inside curvature. May occur in calcified canals while trying for patent canal and to bypass broken instrument.

Perforations 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 at apical third.

Post-space preparation:

Following obturation, careless post space preparation may result in perforation

II. Pathologic perforations

a) Due to resorption-

Root resorption is the progressive loss of dentine and cementum by the continued action of osteoclastic cells [26].

This resorption may be internal or external.

Internal resorption

Is a pathologic process that originates in the pulpal cavity and results in loss of root structures.

This process is usually asymptomatic and may swiftly destroy the tooth in untreated cases.

Causes

Although trauma, pulp inflammation, and calcium hydroxide pulpotomy have been suggested as possible causes of internal root resorption, the exact cause is uncertain [27].

External root resorption

This type of perforation has most often been attributed to trauma in which crushing of the periodontal ligament and possibly pulpal death induce the inflammatory reactions culminating in odontoclastic activity. Inflammatory tissue in periodontal pockets has been suggested as another mechanism of external resorption. Bleaching may lead to external resorption or it may be idiopatic.

b) Due to caries

By invading the floor of the pulp chamber and extending through the furcation, caries may cause a perforation.

This is particularly common in older patients where salivary quality and quantity is diminished and gingival recession has led to dentine exposure.

Treatment of these perforations may require root canal treatment, crown lengthening, and either root extrusion or root resection. Perforation in most of these cases renders the tooth unrestorable.

Management

Non surgical management

Supracrestal perforations

Have no periodontal involvement as they communicate directly with the oral environment. Conventional restorative materials such as glass ionomer and composite may be used but care should be taken to ensure the margins of the repair are smooth externally and do not become a plaque-trap.

Middle third perforations

The aim of perforation management is regeneration of healthy periodontal tissues against the perforation without persistent inflammation or loss of periodontal attachment.

If only a small defect is suspected, and haemostasis is achieved immediately, it may be obturated conventionally. It is necessary to place the instruments in the original canal and not the perforation. This is facilitated by prebending root canal instruments and filing away from the defect. Canal apical to perforation can be obturated conventionally then perforation is repaired by MTA or other material and remaining canal is obturated with gutta percha.

If possible, root canal treatment and definitive obturation should be completed. If not, the canals should be protected with an easily removable material such as Cavit, cotton wool, gutta percha or paper points. This prevents iatrogenic blockage of the canals with the reparative material.

Sodium hypochlorite should be used with caution. Chlorhexidine may be a preferable alternative.

When the lesions are larger they can often present with hyperplastic and vascular granulation tissue, which then protrudes into the defect. This granulation tissue should be carefully curetted and removed with spoon excavator. This may lead to profuse bleeding. It is preferable to achieve haemostasis using collagen, calcium sulphate or calcium hydroxide.

In cases of delayed repair there is breakdown of the periodontal ligament and surrounding bone into which granulation tissue proliferates. Removal of such granulation tissue may therefore leave a bone cavity around the perforation site. Extrusion of repair material into this cavity may occur. Attempts have been made to control this and to increase the sealing ability of the repair materials with internal biocompatible barriers/matrices such as collagen or calcium sulphate

In a case report presented by Rhythm Bains et al having pulpal floor perforation and grade II furcation defect ; successfully treated by placing platelet rich fibrin in furcation area surgically and sealing of perforation by MTA. [28]

Subgingival perforations that are slightly apical to the crestal bone can be restored with the use of an endodontic-orthodontic technique. The perforated tooth is orthodontically extruded to elevate the root perforation coronal the level of the alveolar crest. In such a position, the perforation site would be accessible and would allow restoration of the tooth without excessive surgery.[29]

Apical third perforations:

These perforations can be difficult to manage. Using MTA to restore these defects may be impossible unless it is a straight wide canal. Attempting to re-access the original anatomy and, following cleaning and shaping, obturation with warm vertical compaction of gutta percha, relying upon the sealer and some GP to flow into the defect. If re-access is not possible then obturation to the defect may be carried out, with warm vertical compaction of gutta percha. It must be noted, however, that apical perforations with uninstrumented canals may face a much poor prognosis and cannot be managed successfully in all cases.

Surgical management

Indications

-The defect is subcrestal and associated with pathology and/or symptoms.

-Internal access is not possible because of an extensive intracoronal/extra coronal restoration.

-There is a large defect preventing control over materials.

- There is an apical third perforation with persistent disease that cannot be adequately cleaned and repaired.

-There is external cervical resorption not amenable to internal repair.

A surgical flap is then reflected at the perforation site to provide access for surgical repair. A biologically compatible material should be thoroughly compacted into the cavity to ensure a dense fill. It is reported that success rates may vary between 30% and 80%.

Large perforations in the furcation area can be treated by bicuspidization, hemisection, or root amputation. This choice depends on the level of the crestal bone and its relationship to the furcation, the degree of convergence of the root at the furcation, and the length of the root.

Apical perforations frequently complicate convenient instrumentation and obturation of root canals. In such situations, it has been suggested that an apicectomy be performed if a satisfactory crown-root ratio remains after surgery.

Intentional replantation

This procedure can be recommended as a substitute for surgical treatment when the perforation defect is too large for repair and when the perforation is inaccessible without excessive bone removal(30)

The procedure involves atraumatic tooth extraction to avoid excessive damage to the cementum and periodontal ligamentum. .After removal, the tooth should be kept in forceps and washed gently in a balanced salt solution. Then perforation site is sealed and tooth is replanted.

Teeth with divergent or long and curved roots are not suitable for intentional replantation because of the risk of fracture during extraction. The success rate reported in clinical follow-ups ranges from 80% to 90% for carefully performed procedures with proper case selection.

Extensive perforations or unaccessible sites 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.

Conclusion

Perforation repair is a challenging problem to the dentist. So thorough idea regarding its restorability is essential which includes knowledge of site, size, time of perforation and various materials used for successful management of perforation.

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