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Review Article

Management of perforation - A review

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ABSTRACT

The aim of this review is to discuss the etiology, classification, diagnosis, prognosis, and management of perforation. The objective is to review the literature and various related articles regarding the etiology, classification, diagnosis, prognosis, and management of perforation. Perforation is an artificial communication between the root canal system to the supporting tissues of teeth or to the oral cavity. Successful treatment depends mainly on proper diagnosis and immediate sealing of the perforation to eliminate the risk of infection.

Keywords: Iatrogenic perforation, perforation repair material, MTA, biodentine, intentional replantation

Introduction

Root perforation is one of the most common mishaps of endodontic treatment that a clinician or even an endodontic will encounter on a regular basis. By definition, root perforations are artificial communication between the root canal systems and the supporting tissues of teeth or to the oral cavity.[1] It occurs in approximately 2-12% of endodontically treated teeth.[2] This acts as a pathway for the ingress of microorganisms either from the oral cavity or periodontal tissues, thus contaminating the perforation site and preventing its healing process. If left untreated or unnoticed, it leads to secondary periodontal involvement, suppuration, fistula formation, and prognosis of such tooth becomes questionable and extraction becomes the most likely treatment option. This review discusses the etiology, classification, diagnosis, factors governing prognosis, and various treatment options.

Etiology

Often, the causes of perforation can be iatrogenic or non-iatrogenic.[3] Iatrogenic perforations occur mainly due to the lack of attention to the internal anatomy and failure to consider and anticipate the possible variations that can occur in the root canal system. These iatrogenic perforations can occur at any level of the endodontic treatment. During access cavity preparation, perforation tends to occur mainly at the coronal level; most common causes are misalignment of burs due to failure to appreciate the alignment and angulation of the tooth and its position, plunging the bur through relatively thin pulpal floor, or while negotiating canals in cases of completely calcified canals. During cleaning and shaping procedure, perforation tends to occur mainly at the coronal-, middle-, or apical-third of the root. Strip perforations occur at the coronal-third of small curved canals. The furcal area of the coronal-third in small curved roots is known as the "danger zone" as the dentin is relatively thin at these areas, in such cases, using a straight file or aggressive filing can cause strip perforation.[4] Midroot perforation mainly occurs due to misuse of rotary instruments while preparing post-space or while trying to bypass a ledge or a separated instrument. Apical perforation occurs because of instrumentation beyond the apical foramen or due to the transportation of canals.

Non-iatrogenic causes include resorption,[5] external, or internal, mostly secondary to trauma and caries that is extensively involving the furcal area.

Classification

According to fuss and trope, perforation can be classified based on time, size, and location.[1]

1. Based on time:
   a. Fresh perforation - perforations that occurs at the same appointment characterized by fresh blood at the perforation

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site. These, if treated immediately or shortly after occurrence under aseptic conditions, have a good prognosis.

b. Old perforation - previously not treated or unnoticed with likely bacterial infection, these have a questionable prognosis.

2. Based on the size:
   a. Small perforation - these are smaller than size 20 endodontic instruments because the mechanical damage to tissue is minimum, and the due to the ease of sealing, they have a good prognosis.
   b. Large perforation – it occurs mainly during post-preparation with significant tissue damage and obvious difficulty in providing adequate seal, there is obvious salivary contamination or coronal leakage, these have questionable prognosis.
3. Based on the location:
   a. Coronal perforation - perforations that occur coronal to the level of crestal bone and epithelial attachment, and they cause minimal damage to the supporting tissues and are easy to access and seal a good prognosis.
   b. Crestal perforation - perforations at the level of the epithelial attachment into the crestal bone, questionable prognosis.
   c. Apical perforation - perforations apical to the crestal bone and the epithelial attachment, minimal risk of salivary contamination, and hence, a good prognosis.

Diagnosis

Accurate diagnosis of root perforation can be tricky. Sudden bleeding and pain during instrumentation are warning signs of a potential root perforation. Continuous and profuse bleeding will occur in case of perforation, and the patient will complain of severe pain. The appearance of blood on paper points after instrumentation may be indicative of either strip perforation or apical perforation. However, it is unreliable as the bleeding may originate from the apical foramen also.

Radiographs taken at different angles with radiopaque materials such as calcium hydroxide or barium sulfate or radiopaque instruments in the root canal are better option and may confirm the presence of perforation.

Electronic apex locators can accurately determine the location of perforations, making them more reliable than radiographs. A dental operating microscope is another effective tool in detecting perforation during orthograde root canal therapy and in surgical endodontic treatment.

Measures to Prevent Perforation

The following few precautions can be followed to prevent the complication of perforation:

- Before root canal access, a pre-operative x-ray must be well studied regarding the number of canals, angulation of the root and curvature of the canals, the distance between the floor and roof of the pulp chamber, the and presence of calcifications.[6]
- During access preparation, understanding the tooth anatomy and applying the basic principles such as the location of pulp chamber centrally at the level of CEJ and the canals are located at the junction of floor and walls of the pulp chamber and the location of canals directly under their respective cusps.[7]
- During cleaning and shaping, pre-curving the files for curved canals prevents strip perforation and transportation. Accurate determination of working length using both radiographs and apex locators to prevent apical perforation.

Management of Perforation

The successful management of root perforation depends on early diagnosis, choice of treatment, materials used, and the experience of the practitioner.[8] The main aim is to achieve a tight and permanent seal that will prevent bacteria and its by-products in the root canal from entering the surrounding tissues. Perforations can be managed either by non-surgical or orthograde approach and surgical approach or intentional replantation.

Non-surgical approach

Non-surgical or orthograde approach is done in cases of small, uncomplicated perforations that are easily accessible. Perforations present at the crown portion of the tooth can be repaired by conventional filling material such as GIC or composite. Those that are present subgingivally can be treated by endodontic–orthodontic approach by orthodontically extruding the tooth so that the perforation site becomes visible after which repair is attempted. However, this technique is not followed because it is time-consuming. Perforations present at the coronal-third of the root can be filled nonsurgically, provided it is accessed easily.

Ideal requirements of the root repair materials are as follows:[9]

1. It should provide adequate seal.
2. It should be biocompatible.
3. It should have the ability to produce osteogenesis and cementogenesis.
4. It should be bacteriostatic and radiopaque, non-toxic, and non-cariogenic.
5. It should provide an absorbable matrix over which the sealing material may be condensed.

Conventionally, amalgam, EBA, gutta-percha, and cavit were used as root repair material. However, with the immense research on material science, newer materials are being constantly introduced. The newer materials include GIC, composite, dentin chips, decalcified freeze-dried bone, calcium phosphate, calcium hydroxide, Portland cement, MTA, Biodentine, endosequence, Bioaggregrate, and new endodontic cement (NEC).

Amalgam

In studies conducted by Mahmoud *et al*.[10] and Benenati *et al*.,[11] amalgam had superior sealing properties of furcal perforation than cavit, calcium hydroxide, and gutta-percha.

Super EBA

Super EBA is an alumina-reinforced zinc oxide-eugenol cement. It is easy to use, biocompatible, and it is highly adhesive and adapts well to the dentinal walls. Kenneth Weldon *et al*. showed that Super-EBA allowed significantly less microleakage than MTA at 24 h.[12]

Glass Ionomer Cement

It exhibits a greater sealing ability compared to the other materials used previously because of its chemically adhesive nature. Alhadainy and Himel found that light-cured glass ionomer cement has superior sealing ability compared to chemically cured glass ionomer cement.[13]

Fuss *et al*. had used metal modified glass ionomer cement in treating furcation perforations and concluded that leakage with metal modified GIC was significantly less than amalgam. Resin-modified glass ionomer cement can also be used as a repair material, and it is said to be superior to the conventional, chemically set glass ionomer cement and composite resin when used for perforation repair.[14]

MTA

It was introduction by Mahmoud Torabinejad in 1992. MTA consists of fine hydrophilic particles of tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide, calcium sulfate dihydrate, tetracalcium aluminoferrite, and small amounts of mineral oxides.[15] It has a setting time of 165 $\pm$ 5 min, evokes cementogenesis, and is biocompatible with the periradicular tissues. When amalgam, IRM, and mineral trioxide aggregate were tested for repair of experimentally created root perforations by Torabinejad *et al*., the results showed that the MTA had significantly less leakage than IRM or amalgam.[16]

Biodentine

Biodentine is a calcium silicate-based bioactive material composed of tricalcium silicate, dicalcium silicate, calcium carbonate and oxide, iron oxide, zirconium oxide as powder, and liquid consisting of calcium chloride and hydrosoluble polymer.

It is easy to handle, has short setting time approximately 12 min and high alkaline pH, and is a biocompatible material.[17] Guneser *et al*. compared biodentine and other perforation repair materials and that biodentine had considerable performance as a perforation repair material even after being exposed to various endodontic irrigants as compared to MTA.[18]

Endosequence

Endosequence is a bioceramic material. It has an initial working time of 30 min and can set in the presence of moisture with a final working time of 4 h. It is referred to as bioceramic because it has a property of simulating tissue fluid and can precipitate hydroxyapatite crystals that increase in size with time. In a study by Jeevani *et al*., endosequence showed better sealing ability when compared to MTA and biodentine.[19]

Bioaggregate

Bioaggregate is also a bioceramic material; it induces mineralized tissue formation and precipitation of apatite crystals that become larger with increasing immersion time.[20] A study by Hashem and Amin concluded that MTA is more influenced by acidic pH than bioaggregate when used as perforation repair material.[21]

NEC

Bioactive material consisting of different calcium compounds are referred to as calcium-enriched mixture (CEM). It is composed of different calcium compounds in higher concentration, therefore causes rapid precipitation of hydroxyapatiteb and this would make CEM cement preferable as a furcal perforation repair material in close proximity to the exposed periodontium. Asgary *et al*. observed cementogenesis and periodontal regeneration when CEM was used as perforation repair material.[22]

For larger perforations, internal matrix technique has been suggested.[23] This can be done only if there is adequate access and visibility, the site should be sterile. In this technique, a matrix material such as plaster of Paris, hydroxyapatite, calcium sulfate, and resin-modified glass ionomer is placed at the perforation site initially which serves as an artificial floor barrier over which the repair material is condense to adequate thickness, an this is done to minimize the risk of pushing the material into the surrounding tissues.

Surgical Approach

Surgical intervention is required in cases of large perforations that are not easily accessible, such as due to resorption, failure to heal after non-surgical repair. The main purpose of surgical treatment is to provide a tight seal against the entry of bacteria and its by-products into the periodontium. The success of the surgical repair depends on the following factors:[24]

- Amount of remaining bone
- Extent of osseous destruction
- Periodontal disease status
- Duration of perforation
- Soft tissue attachment level
- Patients oral hygiene status
- Operator's expertise.

Rud *et al*. suggested that the slightest bridge of crestal bone present should be preserved. Buccal perforations are easy to repair compared to lateral and lingual perforations due to its ease of access.

In case of surgical intervention, it is advisable to properly treat and fill the root canals before repair. The flap is elevated at the perforation site, and the repair material is packed directly on to the defect carefully without extruding it to the adjacent tissues, after which the flap is approximated. In cases of apical perforations, resection of the apical

root to sound root structure with adequate filling is recommended. Crestal perforations are tricky to repair, as it will certainly result in loss of epithelial attachment and apical migration of tissues leading to pocket formation and secondary periodontal involvement. In such scenario's, guided tissue regeneration has been attempted as the GTR membrane acts as a barrier for apical migration of the epithelium.

Intentional Replantation

Intentional replantation may be considered in surgically inaccessible perforations or if the defect is extensively large.[25] The tooth is non-traumatically extracted without extensive damage to cementum or periodontal tissue, repair done externally and immediately replanted with minimal extraoral time to the risk of external resorption. Teeth that are periodontally compromised and those with long, curved canals, and divergent roots are contraindicated for intentional replantation. Inflammatory resorption and ankylosis are the complications that may occur.

Conclusion

The prognosis of perforation repair varies greatly depending on the above-discussed factors. The practitioner should have a well-updated knowledge and expertise to treat perforation. The successful management of root perforation depends on early diagnosis, choice of treatment, materials used, and the experience of the practitioner.

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