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Endodontic Perforations : A Review

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Abstract

Context (Background) : Artificial communication between the root canal system and supporting tissues of the tooth or oral cavity lowers the prognosis of endodontic treatment, and often leads to extraction of the tooth. It has found that the second most common reason for failure associated with endodontic treatment is perforation

Aims : This review aims the accurate causes diagnosis, management, prevention and prognosis of different types of perforations and elaboration of different perforation repair materials used with nonsurgical and surgical techniques.

Methods : A review of the literature was performed by using electronic and hand-searching methods for the diagnosis, management, prevention and prognosis of different types of perforations and elaboration of different perforation repair materials used with nonsurgical and surgical techniques from1972 to 2009

Conclusions : Perforation defects may be repaired by nonsurgical or surgical techniques, diagnosis, prognosis, and management of perforations provides information for avoiding, detecting, and treating of such defects.

Key Words
MTA, Root Perforation, Barrier Material

Introduction

An endodontic perforation may be defined as an artificial opening in a tooth or its root, created by boring, piercing, cutting or pathologic resorption, which results in a communication between the pulp space and the periodontal tissues[1] Iatrogenic root occur in approximately 2 to 12 % of endodontically treated teeth.[2]

Consequences such as gingival down growth of epithelium into the perforation area inflammation, bone resorption and/or necrosis can result because of perforation. Repair of a perforation without periradicular inflammation may take place provided infection is avoided and asepsis maintained during treatment.

Except for resorption and caries, root perforations are iatrogenic and are the main cause for endodontic failures.

Materials used to repair perforations:

Hemostatics : Various materials have been used to control the bleeding at perforation side.

Calcium hydroxide : Calcium hydroxide is passively syringed into the canal, hydraulically moved to place and allowed to remain in the canal and defect or 4 to 5 minutes or longer. The calcium hydroxide is then flushed from the field using sodium hypochlorite. 2 or 3 applications of placing and then removing calcium hydroxide usually begins to control the bleeding. When hemostasis is obtained calcium hydroxide can be left in canal until a future appointment.[3]

Other materials like amalgam, cavit, glass ionomer calcium hydroxide calcium sulphate, freeze-dried bone, collagen and MTA are also used to achieve hemostasis.[4],[5],[6]

Barrier Materials: Barrier materials produce a dry field and also provide an internal matrix or back stop to condense restorative material against. The restorative materials used dictates the selection of barrier materials. There are divided into

a) Resorbable

b) Non-resorbable

Resorbable Barriers : Resorbable material should be placed in the bone not left within tooth structure. The barrier should conform to the anatomy of the furcation or root surface involved. Collagen and calcium sulfate materials are best used because of ease of handling, research and observed clinical results.

Collagen Materials : Collacote exhibit excellent working properties that provide complete hemostasis.[7] Collacote is biocompatible, supportive of new tissue growth, resorbable in 10 to 14 days left in situ. Hemostasis is typically achieved in 2 to 5 minutes. Collagen barriers have been widely used in conjunction with amalgam, super EBA and other non-bonded restoratives.[8] Collacote is contraindicated as a barrier if adhesive dentistry is contemplated because it absorbs moisture and will contaminate the restorative.

Calcium Sulfate : Capset can be used as both a barrier and hemostatic material in perforation management.[9] Calcium sulphate creates a tamponade effect, mechanically plugging the vascular channels once it sets. Capset is remarkably biocompatible, does not promote inflammation and is bioresorbable in 2 to 4 weeks.

This material is syringed through the tooth and into the osseous defect using a microtube delivery system. UFI are coated for sanding, scaled to work deep within the root canal space and their port technologies dispense irrigant precisely into the field of action.[10]

Non-resorbable Materials (barriers):

MTA:MTA is an excellent biocompatible material that can be used both as a non-resorbable barrier and restorative material.[11] it has many clinical. The setting time for the cement is 48 hrs. The compressive strength of MTA at 21 days is 70 MPa, which is comparable with that of IRM and super-EBA, but significantly less than amalgam (311 MPa). [12]

In vitro and in vivo experiments have compared the sealing ability and biocompatibility of MTA with those of amalgam, Super EBA and IRM. The sealing ability of MTA has been shown in dye and bacterial leakage studies to be superior to that of Amalgam and to be equal or better than super EBA. In animal study where MTA was implanted to bone it was found that the specimen were free of inflammation and direct bone opposition was found. MTA has an inductive effect on cementoblasts in dogs and monkey.[13]

MTA has been used as a capping material in mechanically exposed pulps, for root end induction, repair of root perforation and as a barrier during internal bleaching of endodontically treated teeth.[14]

Access Cavity Perforations [15]

Accidents such as excess removal of tooth structure or perforation may occur during attempts to locate canals. Perforation of crown can occur peripherally through sides either of the crown or through the floor of the chamber into the furcation.

furcation perforations are 2 types:

1) Direct
2) Stripping

Each type is created and managed differentially and prognosis varies.

1) Direct perforation occurs during search of canal orifice. It is more of a punched out defect into the furcation with a bur therefore, it is accessible and may be small and have walls.
2) Stripping perforation involving the furcation side of the coronal root surface results from excessive flaring with files or drills. The sequalae is inflammation followed by development of pockets.

Causes:

1) Lack of attention to the degree of axial inclination of a tooth in relation to adjacent teeth or to alveolar bone may result in either gouging or perforation of the crown or the root at various levels.
2) Failure to direct the bur parallel to the long axis of a tooth will cause gouging or perforation.
3) Failure to check the orientation of the access opening during preparation may also result in perforation.
4) Searching for pulp chamber or orifices of canal through unprepared access cavity.
5) Failure to recognize when the bur passes through a small or flattened pulp chamber in a multirooted tooth result in gouging or perforation of the furcation.
6) Directing the bur along the misaligned casting may result in coronal or radicular perforation.

Recognition:

Signs of Perforations:

1) Sudden pain during the working length determination when local anesthesia was adequate during access preparation.
2) Sudden appearance of hemorrhage when crown is perforated into the periodontal ligament.
3) Burning pain or a bad taste during irrigation with sodium hypochlorite when access cavity perforation is above the periodontal attachment.
4) Radiographically malpositioned file.
5) Apex locator that is far short of the working length on an initial file entry. [16]
6) Unusually severe postoperative pain may result from cleaning and shaping procedure performed through an undetected perforation. At a subsequent appointment, the perforation site will be hemorrhagic due to inflammation of the surrounding tissue.

Correction or Treatment:

1) Perforations above the alveolar crest: This is repaired intracoronally without need for surgical intervention. Cavit can be used to seal the perforations during endodontic treatment.
2) Perforations into PL laterally or furcation should be done as soon as possible to minimize the injury to the supporting tissue of tooth.

The 2 types of furcation perforation are treated differently and the prognosis vary:

a) Punched out defect should be repaired immediately with MTA or if proper conditions exist (dryness), GIC or composite can be used.
b) Stripping perforation are inaccessible and require more elaborate approach. It is treated either surgically or non-surgically.

i. Non-surgical treatment

If feasible non-surgical treatment is preferred to surgical treatment. Traditionally various materials such as amalgam, gutta-percha, zinc oxide eugenol, cavit calcium hydroxide, freeze dried bone, indium foil has been used clinically and experimentally to seal these defects. The repair should be sealed immediately but the patency of the canal must be protected. Repair is difficult because of potential problems visibility hemorrhage control and management and sealing ability of the repair material. Immediate repair of perforation with MTA offers the best results.

The introduction of the optical microscopes into practice has provided dentists with the ability to explore the root canal anatomy in greater details. Hatems A Alhadainy et al. have done in vitro study to repair furcal perforation using artificial floor technique in which calcium sulfate and hydroxyapatite were used as artificial floor and found less die penetration in their group compared to control group.

GTR (guided tissue regeneration)

Formally introduced by Nyman et al. offers a treatment for regenerating the attachment apparatus and membrane barrier to support the gingival tissues and the apical migration of sulcular epithelium into the perforation site. The membrane isolates and protects the blood clot, so that it can organize. Healing occurs primarily from formative cells of the PL that deposits new cementum and produce ligamental fibers.

ii. Surgical Treatment

Surgery requires more complex restorative procedures and more demanding oral hygiene from the patient. Surgical alternatives are hemisection, bicuspidization, root amputation and intentional replantation.

Root Perforations:

Roots may be perforated at different levels during cleaning and shaping. To radicular perforations can be identified as cervical, middle and apical perforations.

Perforations in all locations are caused by 2 main errors:-

1) Creating a ledge in the canal wall during initial instrumentation and perforating through the side of the root at the point of canal obstruction or root curvature.
2) Using too large or too long an instrument and either perforating directly through the apical foramen or wearing a hole in the lateral surface of the root by overinstrumentation (canal stripping).

Repair of root perforations:

Root perforations can occur during root canal therapy or post space preparation. In an in vitro study, Lee and associates compared the sealing ability of MTA with that of amalgam or IRM for repair of experimentally induced root perforations in extracted teeth. The result showed that MTA had significantly less leakage than IRM or amalgam and it showed the least overfilling tendency whereas IRM had the least underfilling tendency.[17] In a recent study Nakata and associates compared the effectiveness of MTA and amalgam in repairing furcal perforations using a dual-chambered, anaerobic bacterial leakage model and reported that MTA was superior to amalgam in preventing leakage of fusobacterium nucleatum past furcal perforation repairs.[18]

Ford and co-workers examined the histological response of intentional perforations in the furcation of mandibular premolars of dogs repaired with MTA or amalgam. An delayed group, all the amalgam samples were associated with inflammation, in contrast only 4 of 7 filled with MTA were inflamed. Based on the results of these studies, it seems MTA is a suitable material for perforation repair.[19]

Considerations influencing perforation repair [20]:

1) The four dimensions of a perforation:

a) Level: - Perforations occur in the coronal, middle and apical one thirds of roots. Coronal/ furcation perforations threaten the sulcular attachment and pose different treatment challenges than more apically occurring perforations.
b) Locations: - Perforations occur circumferentially on the buccal, lingual, mesial and distal aspects of roots. The location of the perforation is not so important when non-surgical treatment is selected. Its position is critical and may preclude surgical access if this approach is considered.
c) Size: - Perforation size greatly affects the clinician's ability to establish a hermetic seal. The area of a circular shaped perforation can be mathematically described as r2. Therefore doubling the perforation size with any bur or instrument increases the surface area to seal four-fold.
d) Time: - Regardless of the cause, a perforation should be repaired as soon as possible to discourage further loss of attachment and prevent sulcular breakdown. Chronic perforations exhibiting a loss of sulcular attachment pose treatment challenges that potentially escalate to surgical correction and effort directed toward guided tissue regeneration procedures.[21]

Microscopes, paper points, electronic apex locators such as Root ZX and diagnostic radiopaque contrast solution such as the middle solution are used in determining the level, location and extent of a perforation and the potential for successful management.

2) **Periodontal Conditions :** Periodontal involvement is another cause of failure of endodontic treatment. Example the granulomatous tissue formed in the furcation regions of posterior teeth may eventually involve the periapical tissue.
   Teeth that have been perforated must be thoroughly examined periodontally with a probe.[22]-[23]

3) **Esthetics :** Patients that exhibit a high lip line can be esthetically compromised by soft tissue defects such as cleft, reossious or discrepancies in the incisogingival dimensions of a crown when compared with the adjacent teeth.

4) **Vision :** Magnification glasses, headlamp and trans-illuminating devices facilitate vision and are important adjuncts in addressing perforation.

6) **Restoratives:** Restoratives should be,

- Nonresorbable
- Biocompatible
- Esthetically pleasing
- Provide complete seal

The choice of the restorative repair material is based on the technical access to the defect, the ability to control moisture of the esthetic consideration.

Various materials are used like amalgam, super EBA resin cement, composite bonded restoratives, calcium phosphate cement and MTA. [17]

Prognosis:

The prognosis of perforation depends on,

1) Perforation size
2) Location of the perforation
3) Length of time the perforation is open to contamination
4) Ability to seal the perforation
5) Accessibility to the main canal
6) Existing periodontal condition

Prevention:

1) Thorough examination of diagnostic pre-operative radiographs is the paramount step to avoid this mishap.
2) Checking the long axis of the tooth and aligning the long axis of the access bur with the long axis of the tooth can prevent unfortunate perforations of a tipped tooth.
3) The presence, location and degree of calcification of the pulp chamber noted on the preoperative radiograph are also important information to use in planning the access preparation.
4) Perforations can be avoided by preparing adequate access.
5) Perforations can be prevented by close attention to the principles of access cavity preparation, adequate size and location, both permitting direct access to the root canals.
6) A thorough knowledge of tooth anatomy, specifically pulp anatomy is essential for prevention of perforation.

Cervical Canal Perforations:

The cervical portion of the canal is most often perforated during the process of locating and widening the canal orifice or inappropriate use of Gates-Glidden burs.

Recognition

a) Recognized by the sudden appearance of blood,
b) Magnification with either loups, endoscope or a microscope.
c) If the perforation is not visible directly a small file can be kept in the area that has been exposed and radiograph taken.

d) The electronic apex locators can also be used to locate the perforations.[16]

Correction

Perforation on lateral aspects of root are ovoid by nature of occurrence. If the perforation is mechanical and has just occurred. It is probably clean. In this situation and if hemostasis is present the defect can be immediately repaired. If the perforation is chronic and exhibits microleakage it needs to be clean and prepared before receiving the restoration material. Ultrasonic finishing instruments are ideal for preparing perforation site because of their geometries coating and post technologies.

Perforation repair may include both internal and external repair. A small area of perforation may be sealed from inside the tooth. If the perforations is large it may be necessary to seal first from the inside and then surgically repose the internal aspect of the tooth and repair the damaged tooth structure.

One the defect has been properly prepared, an appropriate barrier material and restorative are then selected based on the following esthetic considerations.

- In a coronal one third perforation where esthetics is a concern, a calcium sulfate barrier in conjunction with adhesion dentistry is generally used.
- Historically amalgam and more recently, super EBA have been used to repair coronal one-third perforation when esthetics was not an issue. Presently MTA is rapidly become the barrier and restorative of choice for repairing non-esthetic coronal one-third defects because of its many desirable attributes.

After perforation repair, the care can be 3-D cleaned, shaped and packed if this has not already been accomplished.

Prognosis : Prognosis is considered to be reduced in this type of perforations and surgical correction is necessary if a lesion or symptoms develop.

Prevention : Reviewing each tooth's morphology prior to entering its pulp space. Additionally, radiograhically verifying one's position in the tooth can turn one back on tract before it is too late.

Mid Root Perforations : Lateral perforations at mid root level tend to occur mostly in curved canal either as a result of perforating when a ledge has formed during initial instrumentation or stripping which is most common

Recognition

1) Sudden appearance of hemorrhage in a previously dry canal.
2) Sudden complaint by the patient.
3) Paper points placed in canal can confirm presence of location of perforation.
4) Apex locators.
5) Optical microscopes can be used for visualization.

Correction

When managing deeper defects that are positioned on lateral walls of canals, vision is enhanced when direct access exists or can be safely created. Generally perforations that occur secondary to overzealous canal instrumentation are sterile and do not require modification using microinstrumentation procedure.

In middle one-third perforations with a small defect, if the bleeding can be arrested and the canal dried, the perforation can then be sealed and repaired during 3-D obturation. However if the defect is large and there is nuisance moisture or if the canal cannot be definitely dried, the perforations must first be repaired before3-D obturation. Repair of strip perforation has been attempted both surgically and non-surgically. Access to mid-root perforation is most often difficult and repair is not predictable. Various materials has been used. Calcium hydroxide has been used to stimulate a biologic barrier against which to pack filling material, but usually filling material ends up into the perforation area. A majority of techniques propose a two-step method wherein the root canal are first obturated and then the defect is repaired surgically. Removal of the excess GP using a hot spatula and cold burnishing the perforation site was reported by Allam.[24] Use of amalgam, GP and calcium hydroxide was reported by Biggs et al.[50], and the GIC were reported by Lundergan.[25] All have reported limited success.

MTA is the material of choice in cases where moisture control is difficult. MTA is mixed and carried into the field and managed in accordance with the technique as discussed earlier. Upon reappointment, MTA will invariably be hard and the clinician can proceed with the required treatment.[13],[18],[25]

Prognosis:

Stripping and direct lateral perforation of root has reduced prognosis. Loss of tooth structure and integrity of the root wall can lead to subsequent fractures or microleakage owing to inability to properly seal the perforation.

Prevention:

To overcome the problem of stripping caused by students. university of South California developed a technique termed as anticurvature filing,[26] stressing the importance of maintaining mesial pressure on the enlarging instruments to avoid the delicate danger zone of the distal wall. A similar technique was advocated at Ohio State University.

Apical Perforations:

Perforation in the apical segment may be the result of file not negotiating a curved canal or not establishing accurate working length and instrumenting beyond the apical confines. Perforation of a curved root is the result of "ledging" "apical transportation" or apical zipping.

Recognition:

1) Sudden complain of pain during treatment
2) Canal becomes flooded with hemorrhage'
3) Lose of tactile resistance of the confines of the canal space
4) Apex locators can be used.
5) A paper point inserted to the apex will confirm a suspected perforation.
6) Extension of the largest file beyond the radiographic apex is also a sign.

Corrections:

Various treatment options are considered based on the location and width of the perforation.

1) Lateral opening is considered like a new foramen, one is now dealing with 2 foramina, one natural and other iatral. Obturation of both of these foramina and of the main body of the canal requires the vertical compacting techniques with heat-softened GP. Often surgery is necessary if a lesion is present apically.
2) The canal is negotiated for the physiologic terminus. The file is gently worked to negotiate the physiologic pathway, establish patency and pave the way for the successively large instrument. The next sequentially large, precurved file

is then inserted and carried apical to the perforation but not necessarily to length. This holding file "maintains the pathway of the true canal and prevent if from being blocked during subsequent repair. Proroot (MTA) is material of choice for repairing deep perforation, especially when a dry environment and technical access are not possible.

3) In a perfectly straight canal if instrument used exceeds the correct working length. This destroys the resistance form of the root canal preparation at the CDJ making it difficult to control the apical extensions of the root canal filling.

a. The treatment includes re-establishing tooth length short of the original length and then enlarging the canal with larger instruments, to that length.

b. Careful adaptation of the primary filling point, often blunted is imperative.

4) Creating an apical barrier is another technique that can be used to prevent overextension during root canal filling. Materials used for developing such barriers include dentin chips, calcium hydroxide powder, proplast, hydroxyapatite and MTA.

Prevention:

Weine et al have recommended the use of a flared preparation to reduce the incidence of elbow formation in the apical portion of the canal. Apical transportation has been shown to be a common undesirable result from the instrumentation of curved canals. Cimis et al.reported that 46% of curved canal exhibited various degree of apical transportation after instrumentation. Briseuo and Sounabend evaluated the ability of endodontic instruments to remain in the central axis of the canal.

Conclusions:

Perforation defects may be repaired by nonsurgical or surgical techniques. Diagnosis, prognosis, and management of perforations provides information for avoiding, detecting, and treating of such defects.

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