Journal of Multidisciplinary Dental Research

Review Article

Prevention of endodontic perforation - A review article

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ARTICLE INFO

Article history:
Received 29.04.2021
Accepted 06.08.2021
Published 04.10.2021

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https://doi.org/10.38138/JMDR/v7i1.8

ABSTRACT

Endodontic perforation is an iatrogenic error which results in the communication between the crown and the oral cavity/root and the periodontal ligament space and bone. It's the most common type of endodontic mishap occurs while negotiating canals.

The primary cause of endodontic perforations is poor knowledge of the internal anatomy of the tooth. Other factor includes calcification, rotation, malposed tooth, and resorption. The diagnosis of root perforation is pivotal for treatment and good prognosis. Prime diagnosis of perforation was done by Clinical and radiographic examination. Cone-beam computed tomography play an important role for the diagnosis perforation, even with other materials superimposing the defect. This article mainly focuses on prevention of endodontic perforations.

Keywords: Perforation; Straight line access; Illumination; Access

1 INTRODUCTION

"Root canal perforation is a technical accident that results in communication between the crown or the root canals and the periodontal space capable of affecting prognosis of endodontic treatment-Estrella. [(1)]

Root perforations were the second greatest cause of failure accounting for 9.62% of all unsuccessful cases. It has been reported that 47% of perforations were noted or created during endodontic treatment, 53% were due to prosthodontic treatment, and that maxillary teeth (74.5%) were more often affected than mandibular teeth (25.5%). [(2)]

Most commonly, endodontic perforation occurs during negotiating calcified canals or reduced volume of pulp chamber due to reparative dentin formation as a result of constant aggressions/tissue aging. This leads to calcification of coronal crown which complicates the location of and access to the apical region. [(3)] Secondly lack of knowledge and observation of dental anatomy in pre-operative radiograph. Radiographs reveals degree of axial inclination, curvature, calcifications, pre existing perforations.

Other causes of perforations include aggressive use of instruments in cleaning and shaping (rigid SS instruments in curved canal), post space preparation, retreatment procedures such as silver points, instrument and gutta percha retrieval. [(4)]

Perforation results in a communication with the external structures like oral cavity, and periodontal ligament, it acts as a channel for ingression of micro organisms from oral cavity to tooth or from tooth to periodontium in which eventually leads to loss of tooth. Not all perforation causes irreversible inflammation and failure. However, when a bacterial infection and/or an irritative restorative material(non biocompatible) is placed on the perforation, healing will not take place properly due to continuous irritation. [(5)] When perforations are not treated or unnoticed growth of attachment epithelium to the perforation site can occur, especially when it occur in the crestal area by or perforation in furcation of multi-rooted teeth. [(4)]

The diagnosis is difficult because most perforations are not identified immediately and not adequately treated. Specific diagnosis of endodontic perforation in endodontically treated teeth is tough because of the absence of clinical signs and symptoms and the limited capacity of periapical radiographs 2D (IOPA) to diagnose these

perforations. However, proper diagnosis of perforations will help in selecting the proper treatment, and favourable prognosis.[4] There are different instruments and techniques to diagnose perforations. These includes electronic apex locator, Dental operative microscope, endoscope, optical coherence tomography .However, perforations in already filled root canals are harder to diagnose because above mentioned aids are based on visualization of the empty root canal.[6,7] Cone-beam computed tomography (CBCT) scans were efficiently used as diagnostic tool in the endodontic treatment. It provides several advantages for the diagnosis and treatment planning of endodontic perforation over the conventional radiographs.[7]

2 CLASSIFICATION

Perforations are usually classified by size, location, type, length of time before repair, and degree of bone destructions.[8] ref Tables 1, 2 and 3

Table 1:

Based on procedures of RCT	
Perforation occurs during access opening	• Cervical perforation • Furcal perforation • Lateral perforation
Perforation occurs during cleaning and shaping	• Strip perforation Apical perforation
Perforation occurs during post space preparation	• Mid root perforations • Lateral perforations[4,6]

Table 2:

Based on time
• Fresh (on the same day of endodontic treatment)
• Old (are associated with previously untreated accidental operative procedures where a bacterial infection is most common)

Table 3:

Based on position
• Coronal (coronal to the crestal bone).
• Crestal (at the level of epithelial attachment and crestal bone).
• Apical (apical to the epithelial attachment and crestal bone).
• Lateral

2.1 *Causes of endodontic perforation*

- Lack of knowledge of internal anatomy-Failure to analyse the root canal location, i.e. not aligning the bur to the long axis of the canal in rotated tooth leads to perforation.[9]
- Due to pulp chamber calcifications of pulp camber stars from the coronal part and reduces towards the root surface (classic feature) due to aging process, irritant stimuli, trauma. Calcification leads to identifying the canals more difficult.[10]
- Diameter of the tooth-Narrow width of the tooth at the cervical area are more prone for perforation i.e. cervical constriction of mandibular central incisors, narrow mesio-distal thickness of cervical area of premolar increase the occurrence of perforation.[2]
- Due to enlargement of canals with instruments-Instrumentation of root canal without preparing "straight line access" causes excess removal of dentin in the furcal wall making it as a dangerous zone leading to strip perforation. this kind of perforation generally occurs in teeth that have a figure-eight shape in cross section, pre-coronal flaring of canals using gates-gliden irrespective the size accordance to the root canal width leads to mid root perforation.[4]
- Not assessing proper working length-Instrumentation beyond anatomic working length causes apical perforation.
- Not pre-curving of the instrument-Not precurving the instrument before using in the curved root canals leads to transportation of canal, false path for instrumentation leads to mid root perforations.
- Due to post space preparation-Not assessing the radio graph and remaining dentin thickness or inserting the peeso on the resistant path of canal causes post space perforation.[11]

2.2 *Prevention of perforation*

To have knowledge about the internal anatomy of tooth, variations in the root canal system, proper visualization and placement of access cavity margins in tooth to be operated is mandatory for quality endodontic treatment. Not well-established access cavity will complicate the treatment outcome leading to complications.[12] By clinically modifying the following factors perforation can be prevented

- Access approach
- Inclination of the root
- Illumination and visualization
- Prevention of post space perforation
- Micro guided access

3 ACCESS APPROACH

3.1 *Maxillary anteriors*

The traditional access preparation is approached from the palatal aspect so the exit of perforation made from this angle, will be on the labial aspect of the root. The perforation site is approximately located at the buccal crestal bone. Straight line access is not achievable in anterior teeth if access was made from palatal side, this traditional approach allows straight line access least achievable in maxillary central incisors .It

seems appropriate that the access cavity must modified to a more incisal approach to reduce the chance of perforation. [2]

3.2 Mandibular anteriors

Lower Anterior like mandibular incisors, canine is wider in the labiolingual than mesiodistally and it is the smallest teeth in the oral cavity. Traditional endodontic technique for mandibular incisor teeth, states to make access approach from lingual than to adopt an incisal approach. The reason behind this lingual approach on anterior teeth was to cover the color of the post endodontic restorative materials of past era like silicate cements which are not aesthetically acceptable. [12] But recent, improvements in the aesthetic materials like the introduction of bonded composite resins. Incisal access approach relates to the anatomy of the mandibular incisors with more than 40% of these teeth having two separate canals. Lingual access approach may hinder the identification of the lingual canal. [2]

3.3 Access cavity preparation in the posterior teeth

It should relate the pulp chamber to the normalised occlusal morphology. Most commonly teeth requiring endodontic treatment in the posterior region will be having extensive caries or heavily restored and the occlusal anatomy may have no significance to the location of the underlying pulp chamber. Intra orally, it takes more knowledge to observe the external outline of the tooth at the level of the CEJ which is rarely involved by caries or other dental procedures. The pulp chamber is at the centre of the tooth at this level. The axial planes of pulp chamber relates the external morphology of the tooth at the level of the cemento enamel junction(CEJ). [13]

4 INCLINATION OF ROOT

4.1 In maxillary anteriors

Not properly evaluating the palatal inclination of the roots in the maxillary incisors leads to labial root perforation. To prevent disorientation of bur during access cavity preparation, consideration of the anatomy of the tooth with its clinical finding intraorally is necessary. This should be analysed adjunctively with pre-operative radiographs. If the tooth possesses difficulties like, rotation, dilacerations, which make access preparation more difficult and beyond the limits. [2]

4.2 Precautions for posterior teeth

Pre consideration should be given to the orientation of the tooth intraorally before the placement of the rubber dam. Mandibular molar teeth are often tilted lingually. Maxillary molar teeth are be tilted buccally, additional confounding factors are mouth opening, presence of old restorations, Airotor head size this factors will alter the path of Airotor handpiece orientation, in such cases the access preparation can be done without having the rubber dam in place so that the different angulations can be tried relative to the teeth, or several tooth isolation by use of rubber dam will allow to gain proper access and have all the benefits of dental dam. [14]

In case of(NRSC)non surgical retreatment extra-coronal restorations will change the angulation of root to the crown or rotations or occlusal morphology of the tooth, so that the position of the pulp chamber or canals will vary. Accessibility and visualization in access modified tooth through a metal crown or restoration is very tough, with the aid of a microscope making identification of canals in the same tooth is more complicated. [15] The removal of old restoration/crown is indicated only in the presence of secondary caries or ill marginal fit so there will be isolation problem in defending the poor access.

The Furcation Perforation is the most commonly occurred perforation in the pulp chamber floor of a molar tooth. It occurs while doing access cavity preparation in tooth which the normal anatomy is often severely distorted or poor knowledge of anatomy. With the use of bitewing radiograph can have good view which can be used to locate and assess the pulp chamber and floor. This makes it possible to take a measurement of the distance from the external surface of the restoration or tooth to the level of the floor of pulp. After measurement of this distance it reduces the chance of a perforation occurrence. [8]

5 ROLE OFILLUMINATION AND MAGNIFICATION IN PREVENTION

Accessibility of root canals using illumination and magnification are important factors in determining the location and extension of the chamber. Pulp chamber dentin is always darker in colour than the remaining dentin. [2] The reparative dentine or calcifications are lighter in colour than the pulpal floor. This colour difference creates lines of demarcation where the walls and the floor of the pulp chamber meet. Sudden changes in colour when searching for a canal are indication of near perforation.Reparative dentine is commonly found in teeth which have undergone trauma, teeth in aged patients or where tooth with previous history of extensive metallic restorations or attrition. Once the access cavity outline has been prepared following the anatomic guidelines for the tooth to be treated. Then usage of operating microscope and endo z bur, ultrasonic tips to remove circumferential dentine to differentiate the colours between axial wall dentine and secondary dentine and pulp calcification. [16]

6 PREVENTION DURING CANAL INSTRUMENTATION

The ideal requirement of shaping the canal is a continuously tapering preparation, largest diameter coronally

and narrowest diameter at apex, maintaining the original canal anatomy, and keeping the apical foramen as small as practically possible.[13] This pattern is achieved with hand files (K-files,H-Files,reamers)in conjunction with rotary-driven instruments. A major reason for iatrogenic errors in the canal preparation are aggressive force during canal preparation, especially with a rotary driven instrument or stainless-steel instrument of larger size.[2] A poorly placed access cavity margins will aggravate the problem by increasing friction of the instrument into the dentinal wall. The introduction of 'Step Back 'technique of canal preparation was advocated to reduce large stiff instruments to the apical third of the root canal.[17] Numerous rotary nickel titanium instruments can efficiently create preparation satisfactory and minimising iatrogenic errors like perforations. Even with the use of modern rotary nickel titanium instruments, the preparation of a path hole using hand instrumentation is essential prior to the insertion of the rotary instruments to prevent Ledging and leads to a smooth path. Failure to establish this guide path can result in deflection of the rotary instrument on its own path through the root and resulting in a perforation, Even using more modern instrumentation techniques and instruments. Gates Glidden drills are widely used for pre-coronal flaring of two-thirds of most root canal systems. However, the use should have GG drills should be limited to the straighter parts of the root canal or away from the curvature and root concavities in multi rooted teeth. Anti curvature technique of root canal preparation in which the file is directed away from the furcation area in a molars and premolars has been shown to reduce the chances of potential root perforation. The method can be applied when using rotary nickel titanium instruments. Irrespective of metallurgy all instruments have a straightening effect on a curved canal.[17]

7 PREVENTION OF POST SPACE PERFORATION

Post space preparation accounts for 53% of all perforations. It is postulated that with the increased use and predictability of bonding in dentistry, the need to place metal posts into roots should be diminishing.[2] The indications for post placement vary greatly between anterior and posterior teeth, if an anterior root canal filled extensively damaged tooth is to go for a crown, a post is often indicated because of less amount of remaining coronal structure and flexural forces acting on anterior tooth. The pulp chambers in anterior teeth are generally too small for adequate retention and resistance for a core without a post.by more incisal approach to access the tooth during the endodontic procedure, less tooth structure is removed reducing the need to place post. Selecting the post size conservatively to the tooth size so that the post diameter is no larger than one third the mesial distal width of the root reduces the chance of perforation. There are two main way in which a root may be perforated during post space preparation :

- A deviated preparation which is where the post space deviates(when the path of instrument does not coincide with the path of canal) away from the long axis of the root and perforates the lateral aspect of the root canal.
- Parallel-sided preparation is advanced without stopping at the specific length apically and does not take the tapering and the diameter into consideration.

For e.g., if in the case of a maxillary central incisor, with improper removal of lingual shoulder. When a GG drill is advanced deep into the root canal. Due to the fullness of dentin in lingual aspect The GG will be glided against the labial wall of root dentine as it advances down the canal. The further down the GG in canal advances, the higher the resisting of force will cause more labial root dentine will be removed, the chances of a perforation in the labial aspect is greater.[11]

The preparation and placement of a post add up a particular degree of risk to the post endodontic procedure. These factors include that perforation during preparation and also include an high risk of root fracture post restoration, especially where the diameter of the post is larger than the diameter of tooth. It is therefore important to consider the alternative options to postplacement. Endodontically treated molar teeth on the other hand rarely require a post, unless there is extensive loss of coronal tooth structure. In order to reduce the chance for a perforation during post-space preparation. The preparation should follow the long axis of the root in accordance to the canal(should always follow the path of least resistance). Removal of the coronal and mid- root gutta percha with heated and hand instruments will help provide a pilot hole for the post drills to follow.[1] By inserting a heated instrument into the gutta percha, the material will be softened considerably, some of the material will adhere to the instrument on its removal creating a hole into which the initial Peeso drill can be inserted and progressed. The surrounding gutta-percha will also have been softened by heating and will therefore provide less resistance to the pilot drill. If resistance is encountered, the softening process can be repeated until the ideal post length is achieved. Preparation of the post space with an engine driven rotary instrument can be done in a counter-clockwise direction to reduce the aggressive cutting potential of these drills and pushing the gutta percha more apically. Posterior teeth cause problems from a post-placement view. Access may be restricted, directing the preparation away from the canal if so alternative means of achieving core retention such as pins, slots and grooves which have been shown to work equally well in posterior. The roots will exhibit curvature and there are associated root concavities which cannot be detected either clinically or radiographically.[11,18]

8 GUIDED ENDODONTICS

With the help of the software (co Diagnostix TM, Dental Wings Inc., Montreal, Canada) adjunct with a CBCT scan. Subsequently, a template is produced by means of a 3D printer. This template guides a minimally invasive drill to the calcified root canal.it works by limiting the depth, width, angulation of the access cavity preparation. [19]

9 CONCLUSION

Procedural error in endodontics is unavoidable in certain physiological conditions like calcific metamorphosis, it is clear to see from the above mentioned points by focusing on certain areas during the treatment process, we can reduce the potential problems. For anteriors It is suggested that by taking a more incisal starting point in access preparation will reduce the potential for a labial perforation and retain more tooth structure, facilitate true straight-line access improving the quality of our root treatment and facilitate the post space preparation if and when required. Usage of bitewing radiograph to determine the location of the pulp chamber supplement with a clinical examination of anatomic crown will reduce the chances of perforation. Clinician should always remember that teeth with pulpal calcifications or total pulpal obliteration are significantly more difficult to treat and account for 42% of the perforations that occur during root canal treatment. By using some form of illumination and magnification (preferably an operating microscope) clinician should be able to differentiate between the root dentine, the floor of the pulp chamber and calcified deposits within the pulp chamber. Importantly perforation not always leads to endodontic failure unless it is not treated immediately. The clinician should have the knowledge about proper diagnosis and treatment modalities for perforation for successful outcome. Hence however knowledge the clinician have, the experience and skill of the dentist will influence the treatment outcome.

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