Ministry of Higher Education
and Scientific Research

Procedural Errors During Endodontic Treatment

(Errors, prevention and management)

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قَالُوا۟ سُبْحَٰنَكَ لَا عِلْمَ لَنَآ إِلَّا مَا عَلَّمْتَنَآ ۖ
إِنَّكَ أَنتَ ٱلْعَلِيمُ ٱلْحَكِيمُ ﴿٣٢﴾

List of Contents

List of Figures

1. Introduction

Like any other field of dentistry, a clinician may face unwanted situations during the root canal treatment which can affect the prognosis of endodontic therapy. These procedural accidents are collectively termed as **endodontic mishaps.** [1]

Accurate diagnosis, proper case selection, and adherence to basic principles of endodontic therapy may prevent occurrence of procedural accidents. [2] Whenever any endodontic mishap occurs; inform the patient about: [3]

a. The incident and nature of mishap.

b. Procedures to correct it.

c. Alternative treatment options.

d. Prognosis of the affected tooth.

Endodontic mishaps may have dentolegal consequences. Thus, their prevention is the best option both for patient as well as dentist. Knowledge of etiological factors involved in endodontic mishaps is mandatory for their prevention. Recognition of a procedural accident is first step in its management. [4]

2.Types of endodontic mishaps:

2.1.Access cavity-related mishaps

2.1.1. Treating the wrong tooth

If there is no question about diagnosis, treating the wrong tooth falls within the category of inattention on the part of the dentist. [5]

Recognition that the wrong tooth has been treated is sometimes a result of re-evaluation of a patient who continues to have symptoms after treatment. In this instance, the error is misdiagnosis. Other times, the error may be detected after the rubber dam has been removed. In this instance, a tooth adjacent to the one scheduled for treatment was inadvertently opened. [1]

Management:

1. Appropriate treatment of both teeth: the one incorrectly opened and the one with the original pulpal problem. [6]

2. explain to the patient what happened and how the problem may be corrected. [4]

Prevention:

1. Attention to detail and obtaining as much information as possible before making the diagnosis. [7]

2. Once a correct diagnosis has been made, marking the tooth to be treated with a pen before isolating it with a rubber dam. [4]

2.1.2. Missed canals

Sometimes endodontic failure can occur because of untreated missed canals which are store house of tissue, bacteria and other irritants. [8]

Etiology:

1. Lack of thorough knowledge of root canal anatomy along with its variations. [9]
2. Inadequate access cavity preparation. [10]

Common Sites for Missed Canals: [11]

_ Maxillary premolars may have three canals (mesiobuccal, distobuccal and palatal)

_ Upper first molars usually have four canals.

_ Mandibular incisors usually have extracanal.

_ Mandibular premolars often have complex root anatomy.

_ Mandibular molars may have extramesial and/or distal canal in some cases.

Recognition missed canal can occur during or after treatment.

1. During treatment, by taking radiograph, an instrument or filling material may be noticed to be other than exactly centered in the root, indicating that another canal is present. [12]

Fig.1. Radiograph indicating the presence of a second, or missed, canal. By following the lamina dura of the root (small arrows), the eccentric position of the file (large arrow), with relation to the outline of the root, suggests the presence of a missed canal.

2.Computerized digital radiography has increased the chances of locating extra canals by enhancing the density and contrast and magnifying the image. [13]

3. The advent of high-resolution magnification has also increased the ability to locate canals. Magnifying loupes, the microscope, and the endoscope may be used to clinically determine the presence of additional canals. [14]

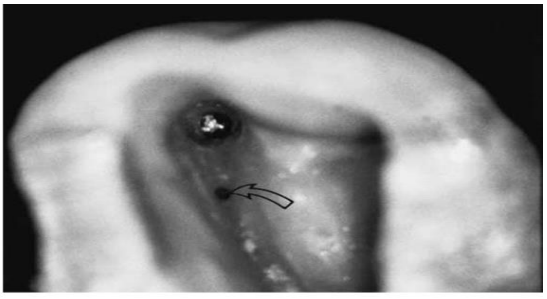

Fig.2. The second mesiobuccal canal (arrow) is readily apparent under magnification.

4. In some cases, however, recognition may not occur until failure is detected later. [15]

Management:

Re-treatment is appropriate and should be attempted before recommending surgical correction. [16]

Prevention:

1. Good radiographs take at different horizontal angulations. [17]

2. Good illumination and magnification. [18]

3. Adequate access cavity preparation. [19]

4. Clinician should always look for an additional canal in every tooth being treated. [20]

2.1.3. Damage to an existing restoration

An existing porcelain crown presents the dentist with its own unique challenges. In preparing an access cavity through a porcelain or porcelain-bonded crown, the porcelain will sometimes chip, even when the most careful approach using water-cooled diamond stones is followed. There is usually no way to predict such an occurrence. [21]

Management:

Minor porcelain chips can at times be repaired by bonding composite resin to the crown. However, the longevity of such repairs is unpredictable. [4]

Prevention:

Reove the crown before treatment to prevent damage to an existing, permanently cemented crown. Preservation of the integrity of the restoration is sometimes possible by using special devices such as the Metalift Crown and Bridge Removal System. The system allows for removal with little or no damage to the crown. After completion of root canal therapy, the crown can be recemented and the pilot hole repaired. [4]

2.1.4. Access Cavity Perforations

Undesirable communications between the pulp space and the external tooth surface may occur at any level: in the chamber or along the length of the root canal. In the process of searching for canal orifices, perforations of the crown can occur, either peripherally through the sides of the crown or through the floor of the chamber into the furcation. [3]

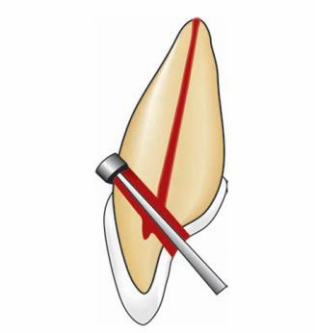

Fig.3. Perforation caused during access cavity preparation

Recognition if the access cavity perforation is above the periodontal attachment, the first sign is leakage: either saliva into the cavity or sodium hypochlorite out into the mouth, at which time the patient will notice the unpleasant taste. [22]

When the crown is perforated into the periodontal ligament, bleeding into the access cavity is often the first indication of an accidental perforation. [23]

To confirm the suspicion of such an unwanted opening, place a small file through the opening and take a radiograph; the film should clearly demonstrate that the file is not in a canal. [24]

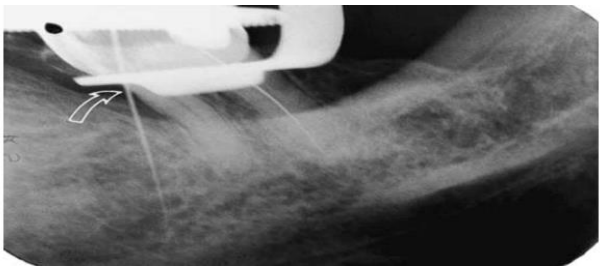

Fig.4. Placing a file in a site of suspected perforation (arrow)and taking a radiograph will show the position of the file in relation to the root. Note that in this tipped molar, the distal canal has been properly located, but the mesial orifices were missed.

Management:

1. Perforations of the coronal walls above the alveolar crest can generally be repaired intracoronally without need for surgical intervention. Cavit will usually serve to seal these types of perforations during endodontic treatment. [25]

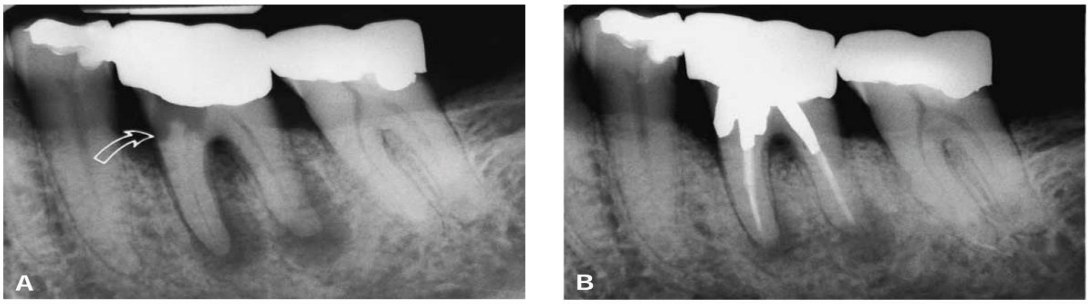

Fig.5. Supracrestal perforation repair. A, Note the perforation (arrow) made in the mesial wall during access preparation. B, Repair was done with amalgam.

2. Perforations into the periodontal ligament, whether laterally or into the furcation, management should be done as soon as possible to minimize the injury to the tooth's supporting tissues. It is also important that the material used for the repair provides a

good seal and does not cause further tissue damage, such as: amalgam, calcium hydroxide paste, glass ionomer cement, gutta-percha, or mineral trioxide aggregate (MTA). [26]

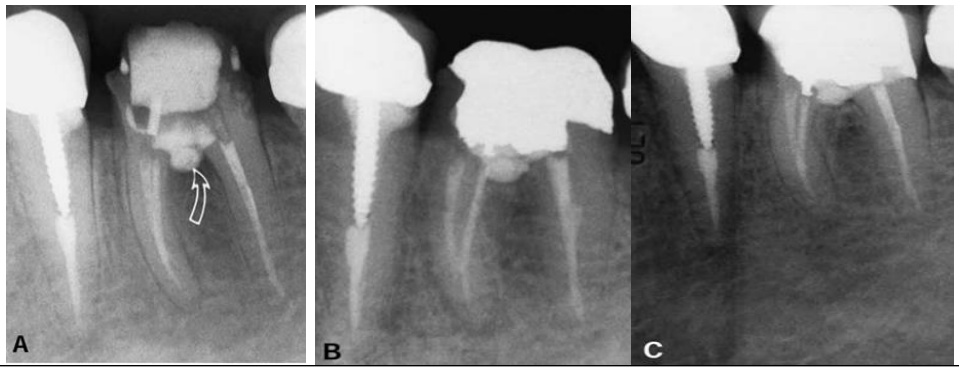

Fig.6. Furcation repair using mineral trioxide aggregate (MTA). **A**, Radiograph shows repair of perforation using MTA (arrow). **B**, Six months after repair. **C**, eighteen months after repair, intact furcation support is

Prior to repair of a perforation, it is important to control bleeding, both to evaluate the size and locations of the perforation and to allow placement of the repair material. Calcium hydroxide placed in the area of perforation and left for at least a few days will leave the area dry and allow inspection of perforation. Mineral trioxide aggregate, in contrast to all other repair materials, may be placed in the presence of blood since it requires moisture to cure. It is nevertheless preferable to control bleeding prior to repair so that the location can be more accurately determined. [27]

Prognosis Sinai proposed that the prognosis for a tooth with a perforation depends on the location of the perforation, the length of time the perforation is open to contamination, the ability to seal the perforation, and accessibility to the main canal. The overall success rate for perforation repairs based on 55 cases was reported by Kvinnsland et al.as 92%. Generally, it can be said that the sooner repair is undertaken, the better the chance of success. Surgical corrections may be necessary in some cases. [28]

Prevention:

1. A thorough knowledge of tooth anatomy, specifically pulpal anatomy. [29]

2. Thorough examination of diagnostic preoperative radiographs is the paramount step to avoid this mishap. [2]

3. 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. [27]

4. The presence, location, and degree of calcification of the pulp chamber noted on the preoperative radiograph. [30]

2.1.5. Crown Fractures

Crown fractures of teeth undergoing root canal therapy are a complication that can be avoided in many instances. The tooth may have a pre-existent infraction that becomes a true fracture when the patient chews on the tooth weakened additionally by an access preparation. [31]

Recognition of such fractures is usually by direct observation. It should be noted that infractions are often recognized first after removal of existing restoration in preparation of the access. When infractions become true fractures, parts of the crown may be mobile. [32]

Management:

1. when the fracture is of a "chisel type" in which only the cusp or part of the crown is involved; in such cases, the loose segment can be removed and treatment completed. [33]

2. If the fracture is more extensive, the tooth may not be restorable and needs to be extracted. [34]

Prevention:

1. Crowns with infractions should be supported with circumferential bands or temporary crowns during endodontic treatment. [35]

2. Reduce the occlusion before working length is established. [36]

2.2. Instrumentation-related mishaps

Instrumentation-related mishaps can often be associated with excessive and inappropriate dentin removal during the cleaning and shaping phase of endodontics. [37]

2.2.1. Ledge Formation

Ledge is an internal transportation of the canal which prevents positioning of an instrument to the apex in an otherwise patent canal. [38]

Etiology:

1. Caused by forcing uncurved instruments apically short of working length in a curved canal. [2]

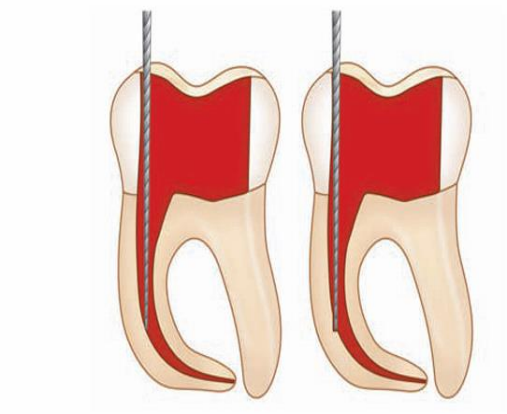

Fig.7. Ledge is formed by forcing uncurved instruments apically short of working length in a curved canal.

2. Rapid advancement in file sizes or skipping file sizes. [3]

3. Failure to make access cavities that allow direct access to the apical part of the canals. [3]

4. inadequate irrigation or lubrication. [3]

Recognition 1. Loss of tactile sensation at the tip of the instrument. [38]

2. Loose feeling instead of binding at the apex. [39]

3. Instrument can no longer reach its estimated working length. [40]

4. When in doubt a radiograph of the tooth with the instrument in place is taken to provide additional information. [41]

Management:

1. To negotiate a ledge, choose a smaller number file, usually No. 10 or 15. [42]

2. Give a small bend at the tip of the instrument and penetrate the file carefully into the canal. [43]

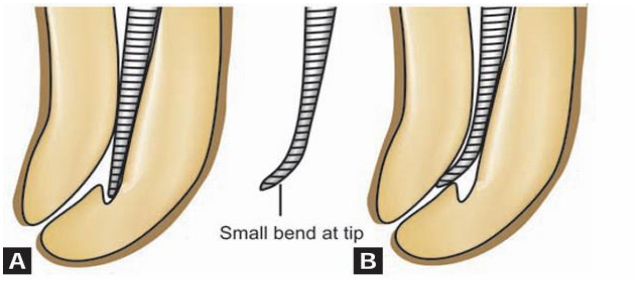

Fig. 8. (A) Formation of ledge by use of stiff instrument in curved canal; (B) Correction of ledge; ledge is bypassed by making a small bend at tip of instrument. Bent instrument is passed along canal wall to locate original canal

3. Once the tip of the file is apical to the ledge, it is moved in and out of the canal utilizing ultrashort push-pull movements with emphasis on staying apical to the defect. [43]

4. When the file moves freely, it may be turned clockwise upon withdrawal to rasp, reduce, smooth or eliminate the ledge. When the ledge can be predictably bypassed, then efforts are directed towards establishing the apical patency with a No. 10 file. [3]. Gently passing 0.02 tapered 10 file 1mm through the foramen ensures its diameter is at least 0.12mm and makes the way for the 15 file. [42]

Prevention:

1. Use of stainless steel patency files to determine canal curvature. [42]

2. Accurate evaluation of radiograph and tooth anatomy. [44]

3. Precurving of instruments for curved canals. [40]

4. Use of flexible NiTi files. [45]

5. Use of safe ended instruments with noncutting tips. [42]

6. Use of sequential filing. Avoids skipping instrument sizes. [43]

2.2.2. Canal transportation

Apical canal transportation is moving the position of canal's normal anatomic foramen to a new location on external root surface. [46]

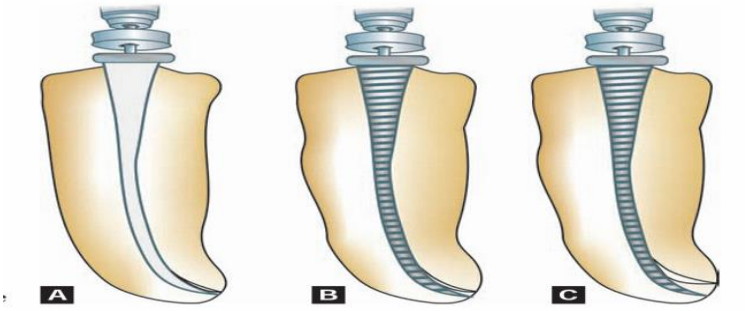

Fig.9: Type I, II and III canal transportations. (A) Minor movement of apical foramen (Type I); (B) Moderate movement of apical foramen (Type II); (C) Severe movement of apical foramen (Type III).

Classification: [3]

Type I: It is minor movement of physiologic foramen. In such cases, if sufficient residual dentin can be maintained, one can try to create positive apical canal architecture to improve the prognosis of the tooth.

Type II: It is moderate movement of the physiologic foramen to a new location. Such cases compromise the prognosis and are difficult to treat. Biocompatible materials like MTA can be used to provide barrier against which obturation material can be packed.

Type III: It is severe movement of physiological foramen. In Type III prognosis is poorest. A three-dimensional obturation is difficult in this case. This requires surgical intervention for correction otherwise tooth is indicated for extraction.

Etiology:

1. Use of large, stiff instruments to bore out a curve canal. [47]

2. Forcing instruments in curved canal. [48]

3. Failure to precurve the files. [3]

Management:

Use of vertical compaction of warm gutta-percha or thermoplastisized gutta-percha is ideal in these cases to compact a solid core material into the apical preparation without using excessive amount of sealer. [49]

Prevention:

1. Use of precurved files for curved canals. [46]

2. Use of incremental filing technique. [50]

3. Use of flexible files. [51]

4. Remove flutes of file at certain areas, e.g. file portion which makes contact with outer dentinal wall at the apex and portion which makes contact with inner dentinal wall especially in the mid root area. [52]

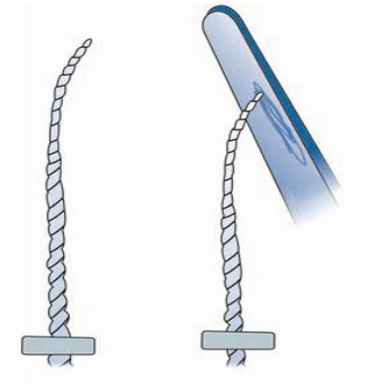

Fig.10. Modification of flutes of file.

5. By over curving in apical part of the file especially when working for severely curved canals. [53]

2.2.3. Root canal perforation

2.2.3.a.Cervical canal perforation: 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. [54]

Recognition 1. sudden appearance of blood, which comes from the periodontal ligament space. [2]

2. Rinsing and blotting (with a cotton pellet) may allow direct visualization of the perforation; magnification with either loupes, an endoscope, or a microscope is very useful in these situations. [2]

3. If direct visualization is not adequate to make a definitive identification of a perforation, it may be necessary to place a small file into the area that has been exposed and take a radiograph of the tooth. [55]

Management:

1. A small area of perforation may be sealed from inside the tooth. [56]

2. If the perforation is large, it may be necessary to seal first from the inside and then surgically expose the external aspect of the tooth and repair the damaged tooth structure; a material that has been recommended for this is Geristore. [57]

Prognosis must be considered to be reduced in these types of perforations, and surgical correction may be necessary if a lesion or symptoms develop. [27]

2.2.3.b.Mid-root perforation: Lateral perforations at midroot level tend to occur mostly in curved canals, either as a result of perforating when a ledge has formed during initial instrumentation or along the inside curvature of the root as the canal is straightened out. The latter is often referred to as canal "stripping" and results in a fairly long perforation that seriously compromises the outcome of treatment. [4]

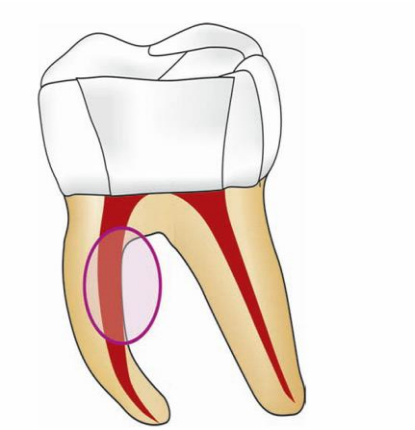

Fig.11. Strip perforation occurs more commonly on inner side of curve.

Stripping is easily detected by sudden appearance of haemorrhage in a previously dry canal or by a sudden complaint by patient. [58]

Management:

Successful repair of a stripping or perforation relies on the adequacy of the seal established by repair material. Access to mid root perforation is most often difficult and repair is not predictable. Mineral trioxide aggregate (MTA) or Calcium hydroxide can be used as a biological barrier against which filling material is packed. [59]

Prevention:

1. Use of precurved files for curved canals. [60]

2. Using anticurvature filling, i.e. more filling pressure is placed on tooth structure away from the direction of root curvature and away from the invagination, thereby preventing root thinning and perforation of the root structure. [61]

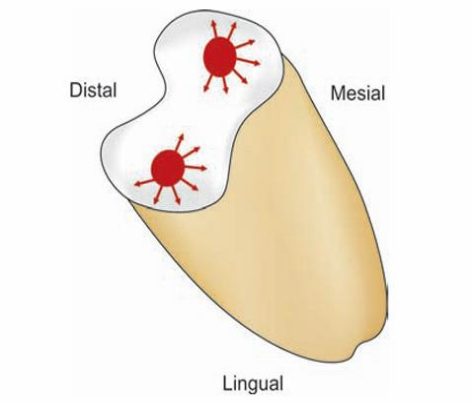

Fig.12. Anticurvature filling. Here more filling pressure is placed on tooth structure away from invagination.

2.2.3.c. Apical root perforation: Apical root perforation can occur:

• When instrument goes into periradicular tissue, i.e. beyond the confines of the root canal. [62]

Fig.13. Radiograph showing apical root perforation, i.e. instrument is going beyond confines of root canal.

• By overuse of chelating agents along with straight and stiffer large size instruments to negotiate ledging, canal blockage or zipping, etc. [62]

Management:

These types of perforations can be repaired both surgically as well as nonsurgically. But one should attempt nonsurgical repair before going for surgery. MTA is choice of material for perforation repair. [63]

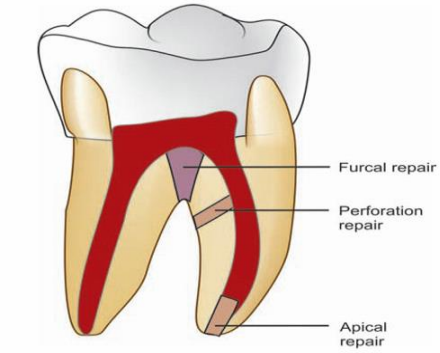

Fig.14. Use of MTA for repair of perforation.

Technique: [63]

• Apply rubber dam and debride the root canal system.

• Dry the canal system with paper points and isolate the perforation site.

• Prepare the MTA material according to manufacturer's instructions.

• Using the carrier provided, dispense the material into perforation site. Condense the material using pluggers or paper points.

• While placing MTA, instrument is placed into the canal to maintain its patency and moved up and down in short strokes till the MTA sets. It is done to avoid file getting frozen in the MTA. Place the temporary restoration to seal chamber.

• In next appointment, one sees the hard-set MTA against which obturation can be done.

Prevention:

1. proper working lengths must be established and maintained throughout the procedure. [28]

2. In curved canals, the flexibility of files with respect to size must be considered. [64]

3. Cleaning and shaping procedures straighten the canal somewhat and effectively decrease the working length by as much as 1 to 2 mm, requiring compensation. [2]

4. the working length should be verified with an apex locator after completion of cleaning and shaping steps. [43]

2.2.4. Instrument separation

Instrument breakage is a common and frustrating problem in endodontic treatment which occurs by improper or overuse of instruments especially while working in curved, narrow or tortuous canals. Most commonly, files and reamers are involved in these types of procedural mishaps. [65]

Etiology:

1. Variation from normal root canal anatomy. [66]

2. Over use of damaged instruments. [67]

3. Over use of dull instruments. [67]

4. Inadequate irrigation. [66]

5. Use of excessive pressure while inserting in canal. [68]

6. Improper access cavity preparation. [66]

Management:

When an instrument fracture occurs, take a radiograph to evaluate:

1. Curvature and length of canal. [69]

2. Accessibility of instrument. [69]

3. Location of separated instrument. [70]

4. Type of broken instrument that is whether stainless steel or NiTi. [70]

5. Amount of dentin present around the instrument. [71]

Fig.15. Curved, narrow and tortuous canals are more prone for instrument fracture.

2.2.4.a. File Bypass Technique: [72]

- The key to bypass a file is establishing straight line access and patency with small instruments. The initial attempts should be made with number 6 or 8 file.

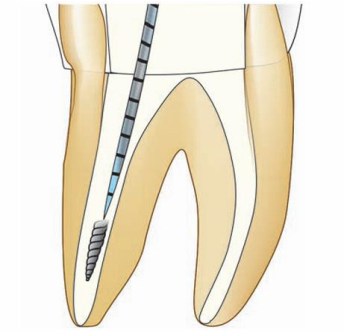

Fig.16. Straight line access to instrument is primary requirement.

- In order to get past the broken instrument fragment, a small sharp bend should be given at the end of the instrument.
- Insert the file slowly and carefully into the canal. When the negotiation occurs past the fragment, one will find a catch. Do not remove file at this point. Use a small in and out movements along with copious irrigation of the root canal.
- While doing these movements, sometimes file may kink, and one may not be able to place the file in the canal to the same length. In such cases, use new file with similar bend and repeat the above procedure.
- Once the patency with a No.15 instrument is achieved, go to K reamers. Use a "place pull/rotate/withdrawal" movement rather than a filing motion. By this motion two things may occur:
  - The reamer will be deflected by the fragment and then there is need to find a consistent path of instrument insertion that is probably different than the initial path.
  - Every time one rotates the reamer, there will be a "clicking" sound as the flutes brush up against the file fragment. This is normal.
- One must avoid placing an instrument directly on top of the broken file. This can push it deeper resulting in loss of patency. If the file is visible at this point, it is

possible to use a small tipped ultrasonic instrument or ¼ turn withdrawal-type handpiece to dislodge and remove it.

2.2.4.b. Instrument Retrieval: [73]

- In order to attempt file removal, exposure of fragment is mandatory. Modified Gates-Glidden can also be used to expose the instrument.
- Gates-Glidden is modified by removing their bottom half and thus creating a flat surface.
- The crown down technique using Gates-Glidden burs is carried out. Once it is accomplished, use modified Gates Glidden to enlarge the canal to a point where instrument is located; this way a platform is created which enable to visualize the broken fragment. It creates a flat area of dentin surrounding the file fragment.

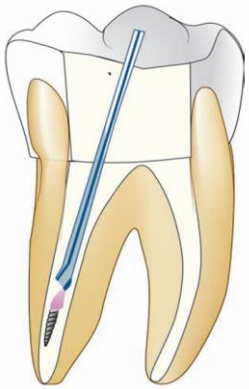

Fig.17. Gates-Glidden modified to form a platform which enables to visualize broken fragment.

- Thereafter, small tipped ultrasonic instruments can be used around the instrument and eventually vibrate the file out of the canal.

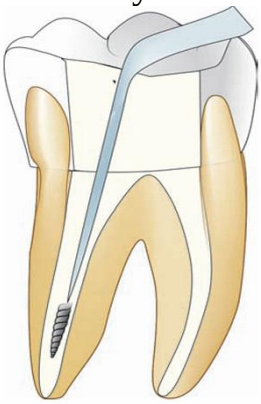

Fig.18. Use of ultrasonic instrument to remove fractured instrument.

- The tip is used in a counter clockwise motion to loosen the file.
- Irrigation combined with ultrasonics can frequently flush it out at this point.
- If sufficient file is exposed, an instrument removal system can be used.

Some special instruments used for retrieval of separated instrument: [74]

- Wire-loop technique.
- Masserann kit.
- Endo-extractor.
- Instrument removal system.
- Nonsurgical mechanical removal system.
- Surgical removal of broken instrument.

Prognosis of separated instrument depends upon following factors: [3]

- Timing of separation.
- Status of pulp tissue.
- Position of separated instrument.
- Ability to retrieve or by pass the instrument.

Separated instruments are not the prime cause of endodontic failure but separated instruments impede mechanical instrumentation of the canal, which may cause endodontic failure. [75]

Prevention:

• Examine each instrument before placing it into the canal. One should always discard instrument when there is: [76]

– Bending of instruments.

– Corrosion of instrument.

– Excessively heating of instrument.

• Always use the instruments in sequential order.

• Never force the instrument into the canal.

• Canals should be copiously irrigated during cleaning and shaping procedure.

• Always clean the instrument before placing it into the canal. Debris collected between the flutes retard the cutting efficiency and increase the frictional torque between the instrument and canal wall. [77]

2.2.5. Canal blockage

When a canal suddenly does not permit a working file to be advanced to the apical stop, a situation sometimes referred to as a "blockout" has occurred. Buchanan pointed out that "blockage occurs when files compact apical debris into a hardened mass." He further noted that "fibrous blockage occurs when vital pulp tissue is compacted and solidified against the apical constricture. [1]

Recognition occurs when the confirmed working length is no longer attained. Evaluation radiographically will demonstrate that the file is not near the apical terminus. [78]

Management:

1. When a blockage occurs, place a small amount of EDTA lubricant on a fine instrument and introduce into the canal. Use a gentle watch winding motion along with copious irrigation of the canal to remove the dentin chips or tissue debris. [42]

2. If this does not solve the problem, endosonics may be used to dislodge the dentin chips by the action of acoustic streaming. [79]

3. Whatever happens, do not force the instrument into the blockage as it may further pack the dentinal debris and worsen the condition. Moreover, forcing instruments may cause the perforation of the canal. [42]

Prevention:

1. Remove all the caries, unsupported tooth structure, restorations before completion of the access cavity preparation. [80]

2. Keep the pulp chamber filled with an irrigant during canal preparation. [78]

3. Intracanal instruments must always be wiped clean before they are inserted into the canal system. [80]

4. Recapitulation must be done during instrumentation. [81]

2.3.Obturation-related mishaps

2.3.1. Under Filling/Incompletely Filled Root Canals

Under filling, i.e. more than 2mm short of radiographic apex. [82]

Etiology:

1. Inaccurate working length determination. [83]

2. Inadequate irrigation and recapitulation during biomechanical preparation which can lead to accumulation of dentin chips and tissue debris, and thus canal blockage. [84]

3. If ledge is there which can be due to: [42]

- Large stiff files in curved canals.
- Inadequate straight-line access to canals apices.
- Inadequate irrigation.
- Skipping the file sizes during biomechanical preparation.
- Packing dentin chips, tissue debris in apical portion of the canal.

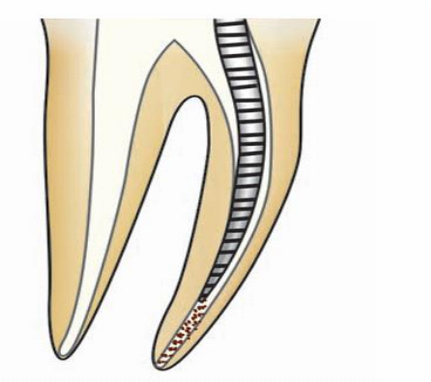

Fig.19. Accumulation of dentin chips and tissue debris resulting in incomplete instrumentation.

Management:

re-treatment: removal of the old filling followed by proper preparation and obturation of the canal. [85]

Prognosis depends on the presence or absence of a periradicular lesion and the content of the root canal segment that remains unfilled. If a lesion is present or the apical canals have necrotic or infected material in them, the prognosis diminishes considerably without re-treatment. [4]

2.3.2. Overfilling of the Root Canals

Overfilling of the root canals is filling more than 2mm beyond the radiographic apex. [82]

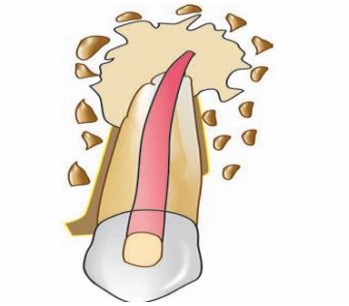

Fig.20. Overfilling of canal causes irritation of periapical tissues.

Etiology [3]

1. Overinstrumentation of the root canal.
2. Inadequate determination of the working length.
3. Incompletely formed root apex.
4. Inflammatory apical root resorption.
5. Improper use of reference points for measuring working length.

Management:

1. An attempt to remove the overextension is sometimes successful if the entire point can be removed with one tug. Many times, however, the point will break off, leaving a fragment loose in the periradicular tissue. [4]

2. If the overextended filling cannot be removed through the canal, it will be necessary to remove the excess surgically if symptoms or radicular lesions develop or increase in size. [86]

Prognosis if the overextended filling provides an adequate seal, treatment may still be successful. [87]

Prevention of over and underfilling:

1. Accurate working lengths and care to maintain them will help prevent overextensions. [88]

2. Techniques that create apical barriers with calcium hydroxide, dentin chips, or MTA may be useful in younger patients with wider root canal systems or in teeth with apical resorption. [89]

3. Incorporation of two simple steps into one's root canal treatment technique can significantly decrease the chance of aberrant fillings; first, confirmation and adherence to canal working length throughout the instrumentation procedure and, second, taking a radiograph during the initial phases of the obturation to allow for corrective action, if indicated. [89]

2.3.3. Vertical Root Fracture

Vertical root fracture can occur at any phase of root canal treatment that is during biochemical preparation, obturation or during post placement. This fracture results from wedging forces within the canal. These excessive forces exceed the binding strength of existing dentin causing fatigue and fracture. [90]

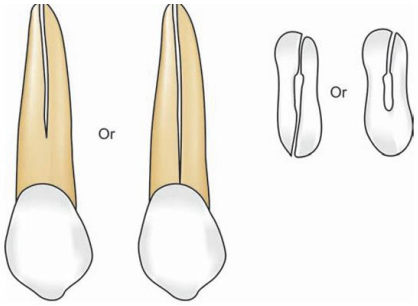

Fig.21. Vertical root fracture.

Recognition [91] 1. The sudden crunching sound, similar to that referred to as crepitus in the diseased temporomandibular joint.

2. pain reaction on the part of the patient, is a clear indicator that the root has fractured.

3."teardrop" radiolucency may appear in the radiograph of a long-standing vertical root fracture and may be associated with only minor symptoms of soreness in the tooth.

4. To confirm the diagnosis of a vertical fracture, exploratory surgery is a good way to visualize the fracture, but finding a deep periodontal pocket of recent origin in a tooth with a long-present root canal filling is most suggestive of a vertical fracture.

Fig.22. Vertical root fracture. Arrows surround the typical "halo" radiolucency often seen in vertical root fractures. Note the enormous "screw-type"post.

Management:

1. extraction in most of the cases. [92]

2. In multirooted teeth root resection or hemisection can be tried. [93]

Prevention:

1. Avoid overpreparation of the canal. [94]

2.Use less tapered and more flexible compacting instruments to control condensation forces while obturation. [94]

3. Posts should not be used unless they are necessary to retain a tooth. [95]

2.4. Miscellaneous

2.4.1. Irrigant-Related Mishaps

Various irrigants have been used in the chemomechanical preparation of the root canal system. Saline, hydrogen peroxide, alcohol, and sodium hypochlorite are among those most commonly used. The fear of toxicity of sodium hypochlorite as an irritant of periradicular tissue has tended to deter its use. [96]

An unfortunate sequence of events is triggered after the solution is injected into the root canal system and forced into the periradicular tissues. With alcohol or sodium hypochlorite, an immediate inflammatory response followed by tissue destruction ensues. [97]

Fig.23. Gross swelling caused by inadvertent injection of 5.25% sodium hypochlorite periradicular to a maxillary premolar.

Recognition: 1. The patient may immediately complain of severe pain. [98]

2. swelling can be violent and alarming. [98]

3. The initial response stage may be characterized by swelling, pain, interstitial hemorrhage, and ecchymosis. [99]

- The effects on the patient will, of course, depend on the type of solution used, the concentration, and amount of exposure. [100]

Management: [101]

1. Because of the potential for spread of infection related to tissue destruction, it is advisable to prescribe antibiotics in addition to analgesics for pain.

2. Antihistamines can also be helpful.

3. Ice packs applied initially to the area, followed by warm saline soaks the following day, should be initiated to reduce the swelling.

4. The use of intramuscular steroids.

5. In more severe cases, hospitalization and surgical intervention with wound debridement, may be necessary.

6. Monitoring the patient's response is essential until the initial phase of the reaction subsides.

Prognosis is favorable, but immediate treatment, proper management, and close observation are important. The long-term effects of irrigant injection into the tissues have included paraesthesia, scarring, and muscle weakness. [1]

Prevention [102]

1. passive placement of a modified needle.

2. No attempt should be made to force the needle apically.

3. The needle must not be wedged into the canal, and the solution should be delivered slowly and without pressure.

4. Special endodontic irrigating needles such as the Monoject Endodontic Needle with a modified tip and side orifice.

5. In the event that sodium hypochlorite is inadvertently injected into the maxillary sinus, immediate lavage of the sinus through the same root canal path way of at least 30 mL of sterile water or saline should prevent damage of the sinus lining.

2.4.2. Tissue Emphysema

Subcutaneous or periradicular air emphysema is, fortunately, relatively uncommon. Tissue space emphysema has been defined as the passage and collection of gas in tissue spaces or fascial planes. [103]

The common etiologic factor is compressed air being forced into the tissue spaces.Two procedures in endodontics, if carried out improperly, have the potential to cause a problem. [104]

* First, during canal preparation, a blast of air to dry the canal.

* second, during apical surgery, air from a high-speed drill can lead to air emphysema.

Recognition [105] 1. The usual sequence of events is rapid swelling, erythema, and crepitus.

2. Hayduk et al. regard crepitus as pathognomonic of tissue space emphysema and therefore easily distinguished from angioedema.

3. Although pain is not a major complaint, dysphagia and dyspnea have been reported.

4. Unlike irrigant extrusion reactions, tissue space emphysema remains in the subcutaneous connective tissue and usually does not spread to the deep anatomic spaces.

5. Migration of air into the neck region could cause respiratory difficulty, and progression into the mediastinum could cause death.

There are several diagnostic signs of mediastinal emphysema. [106]

- First, a sudden swelling of the neck is seen.

- Second, the patient may have difficulty breathing and his voice will sound brassy.

- Third, the characteristic crackling can be induced when the swollen regions are palpated.

- Finally, the mediastinal crunching noise is heard on auscultation, and air spaces are seen in anteroposterior and lateral chest radiographs.

Management:

Treatment recommendations vary from palliative care and observation to immediate medical attention if the airway or mediastinum is compromised. Broad-spectrum antibiotic coverage is indicated in all cases to prevent the risk of secondary infection. [107]

Prevention: [108]

1. Using paper points to dry root canals.

2. If the air syringe is to be used, Jerome suggested horizontal positioning over the access opening, using the “Venturi effect” to aid in drying the canal.

3. In surgical procedures, once a flap is reflected, apical access can be made with the slow-speed or high-speed handpieces that do not direct jets of air into surgery sites.

2.4.3. Instrument Aspiration and Ingestion

Aspiration or ingestion of a foreign object is a complication that can occur during any dental procedure. [109]

Aspiration of instruments can occur during endodontic therapy if accidentally dropped in the mouth. It occurs especially in absence of rubber dam. [109]

Recognition 1. In these cases, is perhaps better termed "suspicion" because sometimes aspiration may not be recognizable. [110]

2. If an instrument aspiration or ingestion is apparent, the patient must be taken immediately to a medical emergency facility for examination, which should include radiographs of the chest and abdomen. [111]

Management: [112]

1. in the dental operatory is limited to removal of objects that are readily accessible in the throat.

2. High-volume suction, particularly if fitted with a pharyngeal tip, can be useful in retrieving lost items.

3. Hemostats and cotton pliers can also be used.

4. Once aspiration has taken place, timely transport to a medical emergency facility is essential. The dentist should accompany the patient there.

Prevention:

1. Can best be accomplished by strict adherence to the use of a rubber dam during all phases of endodontic therapy. [113]

2. If a rubber dam clamp is placed on the tooth to be treated before rubber dam placement, aspiration of a loosened clamp can be avoided by attaching floss to the clamp before placement. [114]

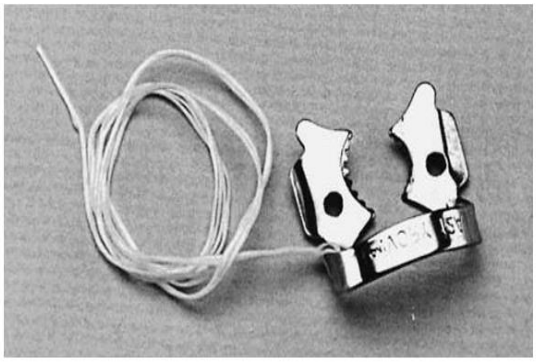

Fig.24. Routine placement of floss around the rubber dam retainer will allow retrieval in the event that the patient aspirates it.

3. Conclusion

Endodontic failure still occurs despite technological advancements in the field of dental instrumentation and materials. Endodontic procedural errors are not the direct cause of treatment failure. The technological boom in endodontics has provided the methods and instruments that allow successful treatment of teeth with calcified chambers, calcified canals, severe root curvature, ledging, resorptive defects, perforations and canal blockage due to separated instruments. With enhanced magnification by operating microscope, direct lighting, use of ultrasonics, NiTi instruments, multiple delivery systems for obturation, almost all procedural errors during endodontic therapy can be minimized or prevented/ successfully treated with predictable prognosis.

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