DIPLOMA OF PRIMARY CARE DENTISTRY

-RCSI-

PART – 1

CLINICAL SKILLS

PART 1: RESTORATIVE DENTISTRY

ENDODONTICS

C. ENDODONTICS:

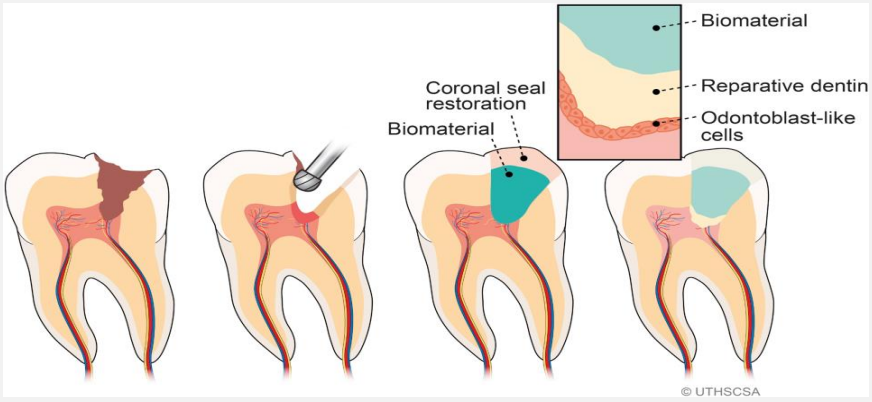
❖ Preserving pulp vitality:

- Endodontics is the study of the prevention and management of problems affecting the dentine, pulp, and periapical tissues.
- A healthy pulp is essential for:
  - Completion of root formation in immature teeth (1° dentine).
  - Continued lifelong tooth development (2° dentine).
  - Protecting against infection when there is loss of enamel/dentine integrity as a result of caries/trauma/tooth surface loss (reactionary and reparative 3° dentine).
  - Maintaining sensory/nociceptive function.
  - Maintaining elasticity of dentine.

⇒ Infection of the pulp can result in irreversible pulpitis and, if left untreated, periapical periodontitis. The overall aim of endodontic Rx is to prevent or treat periapical periodontitis by controlling infection. This is achieved by disinfecting infected teeth and sealing well thereafter.

Pulp-preserving therapies:

- These include biological caries removal, pulp protection (capping), and pulpotomy.
- Fundamentally, a vital dental pulp and the surrounding dentine (pulp–dentine complex) is a dynamic connective tissue with inherent repair properties.
- If caries is very close to the pulp or the pulp is exposed then indirect or direct pulp protection can be considered, respectively.
- Pulpotomy removes part or all of an inflamed coronal pulp to leave healthy, uninflamed radicular pulp within the root canal.
- Haemostasis must be achieved after pulpotomy (if not, then pulpectomy is required).
- Indirect pulp protection is achieved by a layer of one of multiple materials, Biodentine™, calcium hydroxide, or resin-modified calcium silicate (ThereCal LC™).
- Direct pulp protection is via calcium silicate cement (ProRoot® MTA, Biodentine™) the aim being to prevent bacterial ingress following restoration and to stimulate dentine bridge formation.



➢ Prerequisites for pulp-preserving therapies:

- These include no symptoms of irreversible pulpitis, a positive response to pulp testing, and no radiographic evidence of periapical periodontitis. The procedure is carried out under rubber dam isolation and a well-sealed adhesive restoration must be placed.

➢ Follow-up:

- Follow-up is required within 6–12 months of these procedures to check for signs/symptoms and to carry out sensibility testing and radiographic examination. If symptoms of irreversible pulpitis or signs of periapical periodontitis occur, then conventional RCT is required.
- At present, there is not enough evidence to consider pulpotomy for the final treatment of permanent teeth, but it has much potential and requires further study.

➢ The root canal system:

- The root canal system is complex and can only be viewed in two dimensions with plain-film radiography.
- The apical foramina are usually **sited 0.5–0.7mm away from the anatomical and radiographic apex**.
- The apical constriction usually **occurs 0.5–0.7mm short of the foramina**. These distances increase with age due to deposition of 2° cementum.
- Root filling to the constriction provides a natural stop to instrumentation, thus the working length should be established 1–2mm from the radiographic apex.
- Electronic apex locators are frequently used to assess the approximate position of the apical constriction and should be used in conjunction with radiographs to optimize the working length.

Average working lengths (in mm)						
	1	2	3	4/5	6	7
Maxilla	21	20	25	19	19	18.5
Mandible	19	19.5	24	20	19.5	18.5
Most canals are flattened mesio-distally, but become more rounded in the apical third. Lateral canals are branches of the main canal and occur in 17–30% of teeth						
NB						
Maxillary						
4	74% have >1 canal with >1 foramen					
5	75% have 1 canal with 1 foramen					
6,7	Assume these teeth have 4 canals (2 MB; 1 P; 1 DB) until second MB canal cannot be found					
Mandibular						
1,2	>40% have 2 canals, but separate foramina are seen in only 1%					
4,5	May have 2 canals, but these usually rejoin to give 1 foramen					
6,7	Generally have 3 canals (MB; ML; D), but one-third have 4 canals (2 in D root)					

Root canal treatment Indications:

1. Pulp irreversibly damaged or necrotic &/or evidence of apical periodontitis.
2. Elective devitalization prior to further restorative Rx, like overdenture.

Root canal treatment Contra-indications:

1. Non-functional or non-restorable teeth.
2. Insufficient periodontal support.

⇒ **Aims of RCT** are the elimination of microorganisms and remaining pulp tissue by chemo-mechanical debridement of the root canal system followed by the obturation of the root canal system to create an apical and coronal seal, preventing reinfection.

⇒ **The aims of shaping** are to remove pulpal debris and microbes and produce the ideal shape and space for effective penetration of irrigant and the resistance form to allow filling of the space with root filling material.

- The prepared canal should be a continuously tapering cone from crown to apex and should maintain the original anatomy. The apical constriction and original canal length should be maintained as far as possible.
- The termination point of the preparation has been controversial. In teeth with vital inflamed pulp, bacteria are not present in the apical region of the canal and several authors recommend terminating instrumentation 2–3mm short of the radiographic apex in order to leave a clinically normal apical pulp stump. In teeth with necrotic infected pulp, bacteria may penetrate to the most apical part of the root canal. Therefore, the length of instrumentation should be the entire root canal.
- The apical width is gauged with hand files once the working length is reached.

⇒ **The aims of cleaning** are to remove bacteria and organic debris from the root canal by chemo mechanical preparation. Mechanical preparation alone does not reduce bacterial biofilm sufficiently. A classic study showed that only 50% of teeth treated with hand files and saline were free from cultivable bacteria. Therefore, antibacterial irrigation is also required to reach those parts of the root canal system inaccessibleness to mechanical instrumentation.

- Cleaning objectives are to flush out debris and eliminate microorganisms, lubricate root canal instruments, dissolve organic debris, and remove smear layer.
- The irrigant solution should have broad antimicrobial spectrum, be active against endodontic pathogen biofilms, and dissolve pulp remnants and the smear layer created by instrumentation, with no irritant effect on the periradicular tissues.

- Sodium hypochlorite is the gold standard: it is an effective irrigant as it is both bactericidal and dissolves organic debris.
- It should not be extruded beyond the apex as it can cause inflammation and tissue necrosis. The use of a side vented needle 2–3mm short of working length reduces the risk of sodium hypochlorite extrusion.
- Instrumentation of the root canal wall produces a smear layer. EDTA is a calcium ion chelating agent which dissolves the inorganic component of the smear layer which sodium hypochlorite cannot do, as it only dissolves the organic tissue.

⇒ **Aims of obturation:**

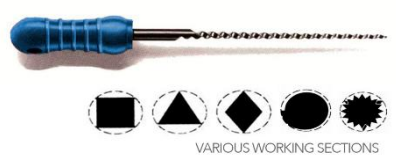
- Incarceration of residual bacteria.
- Apical seal: prevent reinfection of bacteria and ingress of inflammatory exudate into the root canal system.
- Coronal seal: prevent bacteria and tissue fluid from entering the root canal system.

Root canal treatment instruments:

1. Files:

⇒ Stainless steel files:

a. **K-type files** (K-File™, K-Flex™, K-Flexofile™):



- Usually used in a watch-winding action or with balanced force which involves using blunt-tipped (non-cutting) files and rotating clockwise to bind the flutes into the dentine and then rotating anticlockwise while applying an apically directed force to remove dentine.
- It requires practice to master but is very useful when preparing the apical part of severely curved canals.

b. **Hedström file**:

- Made by machining a continuous groove into a metal blank.
- More aggressive than K-type files.
- Use with push–pull filing motion.
- Must never be used with a rotary motion as this can increase torsional forces and increase chances of fracture.

⇒ Nickel titanium (NiTi) files:

- NiTi files are popular as they are much more flexible, even with increase diameters.
- Benefits also included decreased preparation time and files required to complete preparation, and operator and patient fatigue.
- Unlike conventional hand files which have a constant taper of 0.02 (2%), they have a **range of tapers (0.05–0.12) and often have matched GP cones**.

- NiTi files are vulnerable to fracture due to cyclic fatigue and torsional stress. They should be used with care in very (especially coronally) **curved canals.**
- They are designed to be used following the production of a negotiable glide path that has been created by small hand files.
- Frequent irrigation is important and recapitulation with a small hand file between each rotary file helps maintain a glide path and avoid blockages with dentine mud/debris.

2. **Ultrasonic instrumentation**:
   - These can be used for shaping but are less effective than other methods.
   - Useful for activating irrigant during canal cleaning, for assisting with loosening of posts/crowns prior to removal, removing instruments, identifying canal orifices, and for apical surgery.

3. **Spiral root fillers**:
- These may be used to deposit paste materials within the canal, but are liable to number, therefore the novice should use them by hand.
- Alternatively, coat a file with the paste and spin it by hand in an anticlockwise direction to deposit the paste in the canal.

4. **Gates–Glidden burs**:
- These are bud-shaped with a blunt end and are used, at slow speed, for preparing the coronal two-thirds of the canal.
- An 'orifice opener' works in the same fashion and is generally considered less aggressive and less prone to endodontic misadventure.

5. **Silicone stops**:
- These are used to indicate the working length.
- Some have a notch or mark to indicate the direction of a curvature.
- This is especially useful when using pre-curved SS files to establish a guide path or negotiate ledges and blockages.

6. **Finger spreaders**:
- These are used to condense the cones of GP during canal obturation with the cold lateral condensation techniques.
- May be sized to match the GP accessory cones.

Root canal treatment materials:

1. **Irrigants:**

- These are required to flush out debris and lubricate instruments.
- Dilute sodium hypochlorite is generally considered to be the best irrigant as it is bactericidal and dissolves organic debris.
- The normal concentration is 2.5% available chlorine.
- Chelating agents which soften dentine by their demineralizing action are particularly helpful when trying to negotiate sclerosed or blocked canals (EDTA paste, File-Eze®).
- Organic acid (citric acid) can also remove inorganic material.

		Females	Males	Total
Which irrigants do you use?	H2O2	56 (65.1%)	52(52.5%)	108 (58.4%)
	Sodium hypochlorite	25 (29.1%)	29 (29.3%)	54 (29.2%)
	Normal saline	2 (2.3%)	12 (12.1%)	14 (7.6%)
	Chlorhexidine	1 (1.2%)	1 (1.0%)	2 (1.1%)
	Local anesthesia	2 (2.3%)	5 (5.1%)	7 (3.8%)

- The overall effect is optimized by agitating and alternating the irrigants.

2. **Canal medication:**

- Non-setting calcium hydroxide paste (Hypocal™, Ultracal®) is used as an inter-appointment medicament.
- It can be very effective in treating an infected canal where there is a persistent inflammatory exudate from the periapical tissues.

3. **Antibiotic/steroid paste (Odontopaste®):**

- This is useful if anaesthesia of a hyperaemic pulp is not successful.
- Dressing with zinc oxide based Odontopaste® decreases inflammation and may allow pulp extirpation under LA during the next visit. It contains calcium hydroxide, the broad-spectrum antibiotic clindamycin hydrochloride, as well as a steroid-based anti-inflammatory agent, triamcinolone acetonide.

4. **Iodine-containing pastes (Vitapex®, Calcipast-I ®):**

- These are useful in retreatment cases as certain organisms are resistant to calcium hydroxide.

5. **Filling material:**

- GP, an isomer of latex extracted from tropical trees, comes the nearest to meeting the requirements of an ideal filling material. It is supplied in cones which come in two main forms: master cones, sized to match the master apical file, and accessory cones, sized to match the finger spreaders.
- Some systems advise that only one cone is required **(single cone obturation techniques)**; however, this does create a relatively high proportion of sealer in the obturation and not all canals will be a uniform cone shape.

6. Sealers:

- A wide variety is available. Calcium hydroxide materials (Sealapex™) and the eugenol-based sealers (Tubliseal™) are popular.
- Other sealers based on resin (AH Plus®) and GI (Ketac™ Endo) are available.
- Calcium silicate sealers are also used (BioRoot™ RCS, TotalFill®) and have shown good biocompatibility.

7. Calcium hydroxide:

- This is useful in endodontics due to its antibacterial properties, and which then allows the body to form a calcific barrier also known as a dentine bridge.
- The former is thought to be due to a high pH and also to the absorption of carbon dioxide, upon which the metabolic activities of many root canal pathogens depend. It is also proteolytic.
- Nonsetting calcium hydroxide is used as an inter-visit medicament in two-stage RCT.
- In setting form, it was previously used for apexification and treatment of perforations but is now largely superseded by MTA.
- It is effectively placed with a Lentulo spiral filler or a cannula-based system to reduce risk of extrusion.

8. Mineral trioxide aggregate:

- MTA is a calcium silicate cement, originally developed as a root-end filling material.
- It is biocompatible and can set in the presence of moisture. It is the material of choice in apexification procedures and can be used as a pulp-capping agent.
- It creates a physical barrier and releases calcium hydroxide when it is setting. It can be difficult to handle and can cause grey discoloration when used as a root canal filling (RCF) material or pulp-capping agent, this is thought to be due to the presence of bismuth oxide.
- Other biocompatible products have been developed (ProRoot MTA®, MTA Angelus®, Biodentine®).

Root canal preparation:

Preparation for treatment:

A. Magnification and illumination: with loupes or an operating microscope are of great benefit.
B. Pre-operative radiograph: A pre-operative radiograph must show the full length of the root(s) and 2–3mm of the periapical region.
C. Local anaesthesia: LA should be given if required.

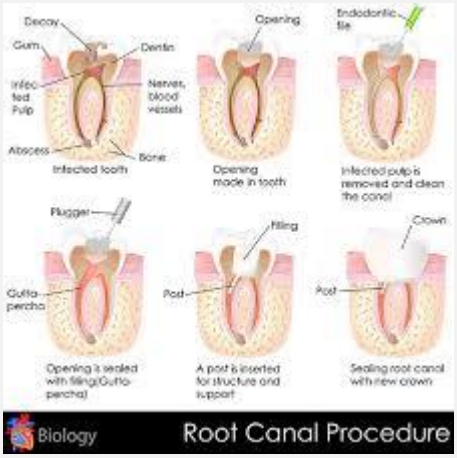
D. Preparation of tooth:
- Before starting RCT all caries must be removed from the tooth and an interim restoration placed to allow placement of a rubber dam, prevent ingress of bacteria from the mouth, and provide a stable reference point for measurement of working length.
- This may mean removal of existing full coverage restorations (with the patient's consent) in order to ensure the tooth is free from caries or fracture. It will also establish whether the tooth can be predictably restored.
- If not, then there is no point in carrying out RCT.

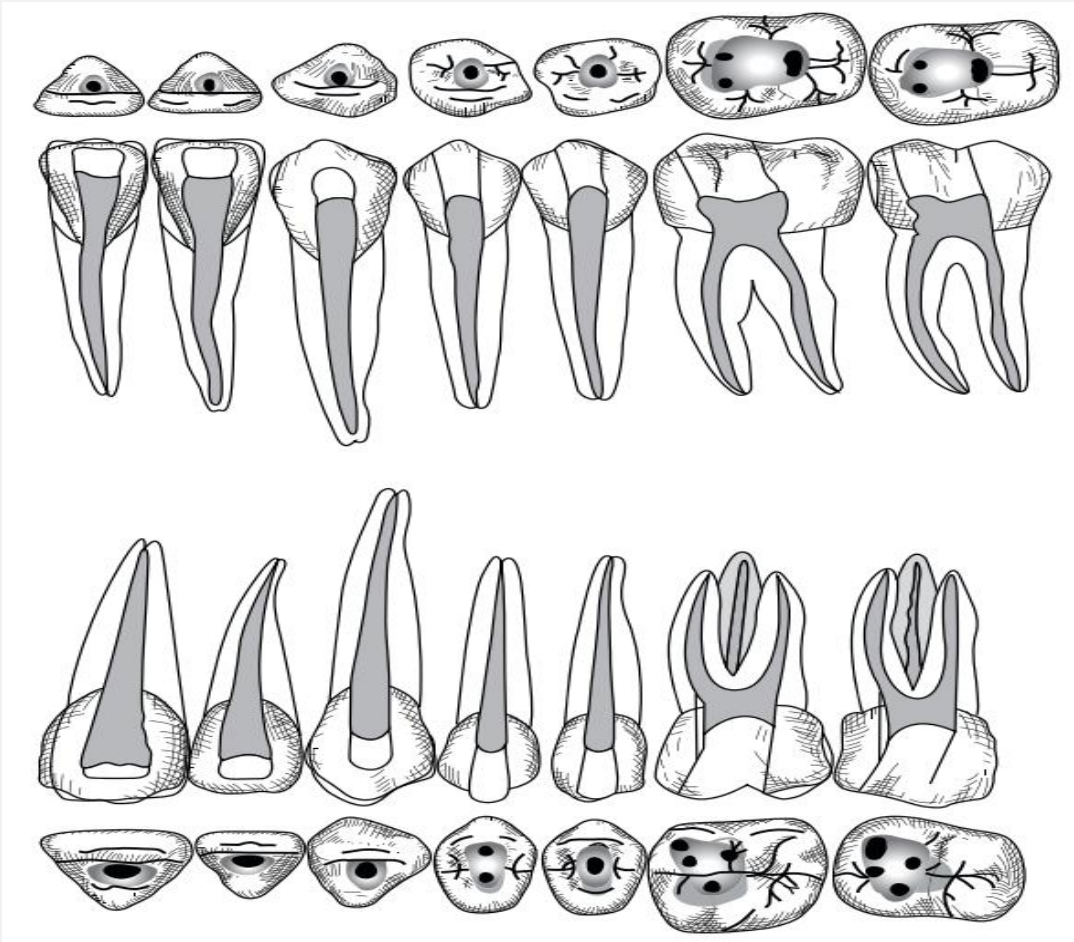
E. Isolation:
- A rubber dam is mandatory to prevent inhalation or ingestion of small root canal instruments, maintain an aseptic environment, and protect patient from toxic materials.
- The seal may be optimized with use of OraSeal®/OpalDam®.

F. Access:
- The aim is total removal of the pulp chamber roof.
- This allows unimpeded, smooth-walled access with instruments to the coronal third of root canals.
- Careful removal of dentine needs to be balanced with conservation of as much sound tooth tissue as possible.
- Initial access is made at a point where the pulp chamber roof and floor are furthest apart (usually the pulp horns).
- This can be done using tungsten carbide burs or diamond burs.
- Diamond burs are used to cut through ceramic and newer generations of diamond burs can be used to cut through ceramic and reduce the possibility of fracturing of the ceramic crown.
- Following initial penetration, a non-end cutting bur can be used for removal of the rest of the pulp chamber roof without damaging the floor.
- When completed the access cavity should have a smooth funnel shape.
- Proprietary access cavity burs are available.

G. <u>Identification of root canal orifices:</u>

- This is achieved by careful examination of the pulp chamber floor with an endodontic explorer. Magnification and additional illumination are helpful.
- Knowledge of tooth morphology is essential. Developmental lines on the dark pulp chamber floor can form useful landmarks.
- If a single canal is located towards one side of the root there may be a second, hidden canal on the other side.
- 3° dentine can narrow orifices and tends to be white in colour.
- Gates–Glidden burs, NiTi orifice shapers, and non-end-cutting burs can be used carefully to create straight line access.
- Ultrasonic endodontic tips can assist with the removal of 3° dentine and the identification of canal orifices.





⇒ Then the root canal is prepared with progressively smaller instruments, this principle is adhered to whether hand or rotary techniques are used.

⇒ The advantages of this are that it:

- Effectively decrease the curvature in the coronal part of the root canal, allowing straighter access for files to the apical region. Therefore decrease the likelihood of apical transportation (zipping).
- Allows improved access for the flow of irrigant solution within the canal.
- Decrease the likelihood of apical extrusion of infected material as most of the canal debris is removed before apical instrumentation takes place. Important because the majority of bacteria in an infected root canal are located in the coronal region.

➢ Whether using hand or rotary instruments, adequate access is required and the choice of technique, instrument, and final preparation size have to be decided for each root canal system.

➢ **Sequence of canal preparation**: the root canal orifices are identified and the canals prepared as follows:

a. Initial negotiation:

- Coronal two-thirds of canal is negotiated with an ISO size 10 or 15 file in a watch-winding movement and then flooded with sodium hypochlorite.
- EDTA lubricant is also helpful. In very fine canals, one may need to start with an ISO size 6 or 8 first.
- Files should be worked gently to the coronal two-thirds with sequentially larger files up to ISO size 20, this creates a **'glide path'.**

b. Coronal % flaring:

- After creating a glide path, the coronal two-thirds is flared.
- This can be achieved using proprietary 'orifice shaper' files or a combination of SS hand files or NiTi hand or rotary files or Gates–Glidden drills.
- Files with sequentially d taper or diameter are used in a crown-down approach. Copious irrigation is needed throughout and frequent recapitulation with an ISO size 10 or 15 hand file to prevent blockage.

c. Apical negotiation:

- Next, the remaining one-third of the canal can be negotiated up to ISO size 15 to develop a glide path to allow the entire length of the canal to be prepared.
- Working length determination This is defined as the distance from a fixed reference position on the crown of the tooth to the apical constriction of the root canal.

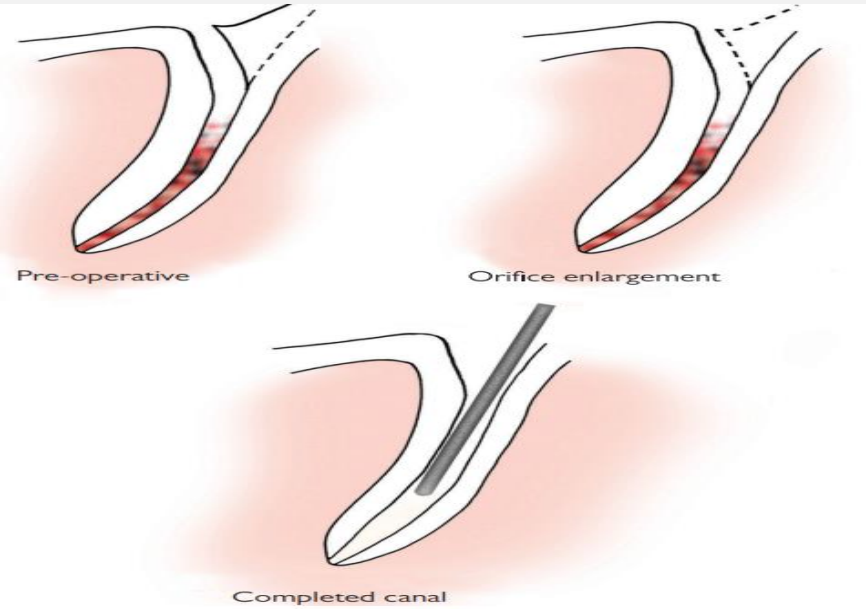
- The apical constriction is normally 0.5–2mm short of the radiographic apex of the tooth.

⇒ There are two methods of establishing the working length:

1. **A radiograph:** a file fitted with a silicone stop and of sufficient size is inserted into the canal to the estimated working length prior to taking the radiograph.

2. **An electronic apex locator**: this works by measuring electrical impedance with an electrode attached to a file in the root canal; when the file reaches the apical foramen the device emits an audible or visible signal.

- Working length is determined by subtracting 0.5mm from the length indicated by the device, this allows thorough cleaning, and preservation of the constriction facilitates a good apical seal while reducing extrusion of infected debris.
- Ideally, both methods of working length determination should be used in each case. It is advisable to prepare 1mm from the zero reading of an apex locator on lower 5s and 7s as the apices are potentially very close to the inferior dental nerve (IDN).



d. Apical third preparation:

- Preparation to the correct working length and apical width is done next.
- The size of the apical width is determined by 'gauging' the root canal at the apex by passively inserting SS files to working length.
- Generally, apical preparation should be at least ISO size 25 to facilitate adequate irrigation.
- The aim is to produce a tapered preparation which blends into the coronal preparation.

- If using SS hand files, this is achieved in two stages (creation of apical enlargement and apical taper) in a modified double-flare technique.
- If using NiTi hand or rotary files, the manufacturers generally have finishing files to produce the desired apical size and taper. Canal patency must be maintained at all times during preparation. This is helped by copious irrigation and frequent recapitulation with small files.

e. Patency filing:

- This involves passive placement of a small (< size 10) ISO file 0.5–1.0mm through the apex.
- The advantage is to prevent blockage at the apex by build-up of debris. T
- he disadvantages is that if the file is pushed through further than 1mm, extruded infected debris may cause a flare-up.

- Finally, smear layer removal is achieved by irrigating with EDTA and a final rinse of NaOCl.
- The root canal is dried with paper points.
- Balanced force filing This is performed at 90° clockwise followed by 270° anticlockwise using a k-flexofile.
- Its benefit is to remove dentine equally on all walls.

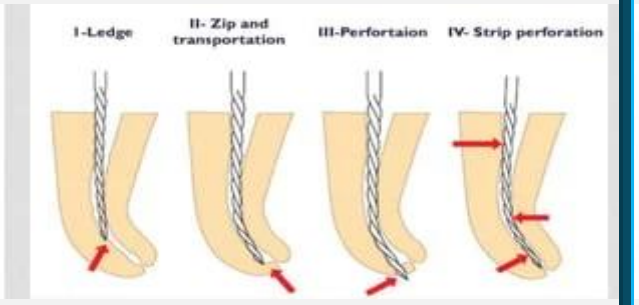
f. Inter-appointment medication:

- The objective is to prevent growth and multiplication of microorganisms between visits.
- Materials used are non-setting calcium hydroxide or iodine-containing pastes.
- It is essential to place an effective temporary restoration to prevent contamination of the canal system between visits.

Common errors in canal preparation:

- Incomplete debridement and missed anatomy: for example, working length short and missed canals.
- Lateral perforation: This often occurs because of poor access or bur angulation.
- Apical perforation and overpreparation: this makes filling difficult. Ledge formation This can be very difficult to bypass.
- Apical transportation (zipping): A file will tend to straighten out when used in a curved canal and straightening can transport the apical part of the preparation away from the curvature. The use of flexible files reduces the likelihood of this happening.
- Elbow formation: When apical zipping happens, a narrowing often occurs coronal to this in the canal such that the canal is hourglass in shape. This narrowing is termed an elbow.

- Strip perforation: This is a perforation occurring in the inner or furcal wall of a curved root canal, usually towards the coronal end.



- Anticurvature filing: This was developed to minimize the possibility of creating a 'strip' perforation on the inner walls of curved root canals. It is used in conjunction with other techniques or preparation, and the essential principle is the direction of most force away from the curvature. Filing ratio is 3:1 outer wall: inner wall.

  - Establishing straight line access reduces the chances of errors occurring.
  - NiTi rotary instruments reduce creation of blocks, ledges, transportations, and perforations by remaining centred within the natural path of the canal.
  - The newer generation of controlled memory wire M wire, gold wire, and blue wire nickel titanium reduces the transportation of the root canal during preparation.

Root canal obturation:

⇒ To provide a 3-D hermetic seal to the root canal to:

- Prevent the ingress of bacteria or tissue fluids which might act as a culture medium for any bacteria that remain in the root canal system, called a coronal seal.
- Incarcerate any microbes remaining in the root canal system.
- Prevent reinfection of the root canal system.
- Prevent diffusion of inflammatory exudate into the canal, called an apical seal.

⇒ Materials:

- **Core materials:**
  a. GP: a form of latex derived from tropical trees.
  b. Resin-based core materials.

  - Both types are supplied as master/accessory points for placement with lateral condensation and as pellets for thermoplastic, vertical condensation techniques.
  - The proposed advantage of adhesive (Resilon™) obturation systems is decreased risk of root by creating a 'monoblock' of dentine and obturation materials but clinical studies to back this up are lacking. It is very difficult to bond atubular root dentine.

- **Sealers:**
  - These fill the space between the root canal wall and core material and between GP points and fill accessory and lateral canals.
  - A wide variety is available:
    - ZOE-based sealers (e.g. Tubliseal™).
    - Calcium hydroxide-based materials (e.g. Sealapex™).

- Resin-based sealers (e.g. AH Plus®), RealSeal® for use with Resilon®.
- Gutta flow is a material based on RoekoSeal® with powdered GP added.
- Bioceramic sealers (TotalFill® Endo sequence).
- Glass ionomer based (e.g. Ketac™Endo).

- **Techniques:**
  - There is no evidence that any technique is superior in terms of promoting healing.

1. Cold lateral compaction:

- The technique involves placement of a master point chosen to fit the apical section of the canal.
- Obturation of the remainder is achieved by compaction of smaller accessory points.
- The steps involved are as follows:

✓ Select a GP master point to correspond with the master apical file instrument. This should fit the apical region snugly at the working length so that on removal a degree of resistance or '**tug-back' is felt.**
✓ Take a radiograph to confirm that the point is in the correct position.
✓ Coat walls of canal with sealer using a small file.
✓ Insert the master point, covered in cement.
✓ Condense the GP laterally for 20sec with a finger spreader set.
✓ Excess GP is cut off with a hot instrument at the base of the pulp chamber and the remainder packed vertically into the canal with a cold plugger to 1mm below the amelo-cemental junction.

➢ Single cone obturation techniques are very popular with matched GP points, corresponding to the file size/shape used.

2. Warm GP techniques:

- As for cold lateral compaction but uses a warm spreader after the initial cold lateral condensation.
- Special heat carriers can be used with a flame or a special electronically heated device.

3. Vertical compaction:

- The GP is warmed using a heated instrument and then packed vertically.
- A good apical stop is necessary to prevent apical extrusion of the filling, but with practice a very dense root filling can result.
- Time-consuming.
- The System B™ heat carrier has simplified this technique.

⇒ After completing obturation, a good **coronal seal** must be achieved by placement of an ideal restorative material on the pulp chamber floor and canal orifices and placement of a definitive restoration.

Some endodontic problems and their management:

1. Pain following instrumentation:
   - This is usually due to instruments or irrigants, or to debris being forced into the apical tissues.
   - Occasionally, an acute flare-up of a previously asymptomatic tooth occurs following initial instrumentation so pre-warn patients.

2. Pulp stones:
   - Pulp stones in the pulp chamber can usually be flicked out.
   - If they occur in the canal, use EDTA and a small file to dislodge them.

3. Fractured instruments:
   - The success of removal depends on root canal anatomy and type and design of the number of instruments and location of the portion.
   - **The fractured file may be bypassed**.

4. RCT of teeth with immature apices:
   - The length of the root can be obtained by using radiographs, an electronic apex locator, or making a hook from a K-type file.
   - Preparation often involves activation of Irrigants due to the width of the root canal.
   - The apex is often filled with a bioceramic cement or MTA to aid in apexification and then the canal filled using warm GP.
   - Revascularization is also a Rx modality for non-vital teeth with incomplete root formation

5. Perforations:
   - These can be iatrogenic or caused by resorption.
   - Dressing with non-setting calcium hydroxide may help to arrest the resorption and promote formation of a calcific barrier.
   - Increasingly, MTA is being used for the repair of perforations and in surgical endodontics as a retrograde filling material with excellent results.

⇒ Management of traumatic perforations depends upon their size and position:

- Pulp chamber floor: if small, can cover with MTA or a bioceramic material, but if large, hemisection or extraction may be necessary. MTA can also be used.
- Lateral perforation:

∇ If near the gingival margin, can be incorporated in the final restoration, a diaphragm post and core crown.

∇ If in the middle third, the remainder of the canal may be cleaned by passing instruments down the side of the wall opposite the perforation.

∇ Then the canal can be filled with GP, using a lateral compaction technique to occlude the perforation as well.

∇ Larger perforations may require a surgical approach and in multirooted teeth hemisection or extraction may be unavoidable.

- Apical third:

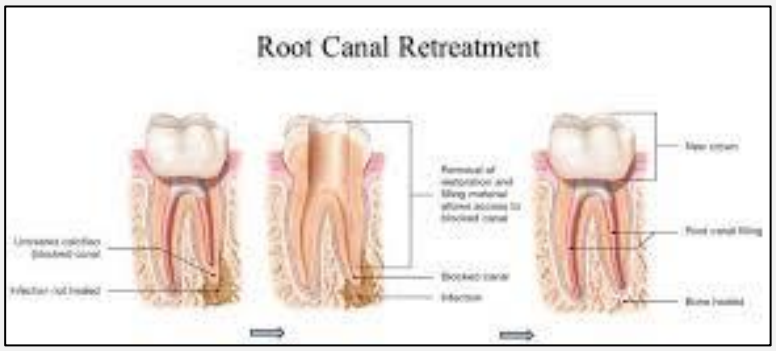
- It is usually worth trying a vertical compaction technique to attempt to fill both the perforation and the remainder of the canal.
- If this is unsuccessful, periradicular surgery will be required.

6. Ledge formation:

- If this occurs, return to a small file curved at the apex to the working length and use this to try and file away the ledge, using EDTA or RC Prep™ as a lubricant.

Retreatment:

- Endodontic causes of unfavourable outcome are mainly due to reinfection or persistent infection due to missed or inadequately treated canals. Retreatment involves removal of the original RCF.
- Microflora in endodontically treated teeth with persistent infection differs from that of untreated, infected teeth; Enterococcus faecalis and Candida albicans are found more frequently in retreatment cases.
- Where the root canal is not accessible for retreatment (post crown), surgical endodontics may be required.



The End