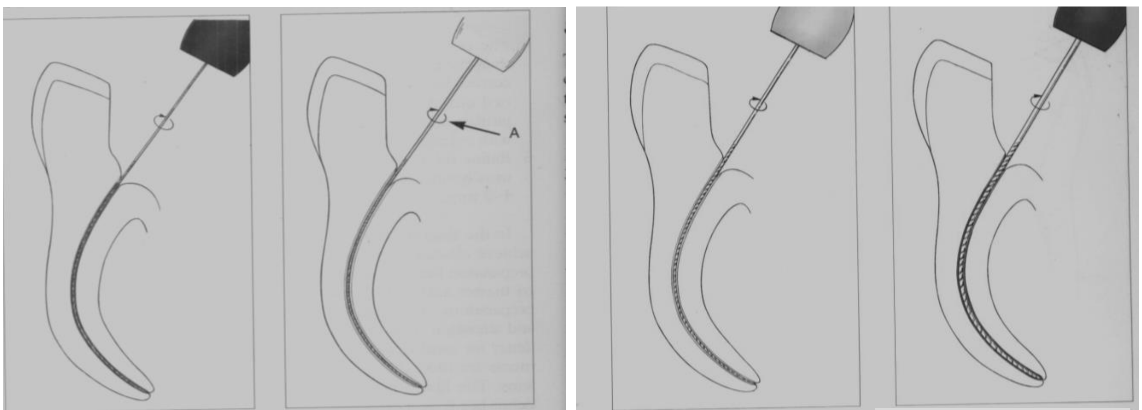
Manual or Hand instrumentation techniques:

Several methods were developed for manual root canal preparation:

1- Standardized technique: (you can follow this link below to explore a video about this technique (https://youtu.be/LpFsGlSNBkI)).

- This technique is developed by Ingle. The concept for this technique is by doing cleaning and shaping for the entire length of the canal at the same time by using the same working length (WL) definition for all instruments introduced into a root canal. Therefore, it relies on the inherent shape of the instruments to impart the final shape of the canal. It is also called ‘single-length technique’.
- In the beginning the canal is irrigated, then negotiation of fine canals is initiated with lubricated fine files in a so-called watch-winding movement until reaching to full WL. In watch winding motion, a gentle clockwise and anticlockwise rotation of file with minimal apical pressure is given.
- Canal preparation then continues with reaming or quarter-turn-and-pull motions until a next large instrument reached.
- This technique will produces a canal shape or taper that resembles the tapering of the final instrument which is called the master apical file (MAF).
- Creation of a true standardized tapered preparation is difficult in ideal straight canals and impossible in curved canals.
- A single match gutta percha point may then be used for root canal filling with inadequate space to do lateral compaction of gutta percha in such small canal tapering (0.02).



Canal negotiation by size 10 | Dentin removal by size 15. A is reaming | Dentin removal by size 20 | Dentin removal by size 25

Disadvantages of Standardized technique:

1- Chances of loss of working length due to accumulation of dentin debris.
2- Improper irrigation because of the minimal tapering of the canal.
3- Inadequate space for lateral compaction of the gutta percha which impairs good obturation.
4- Increased incidences of ledging, zipping and perforation in curved canals.
5- Because of the file is working on the entre canal space during instrumentation, this may increase the load on the file and the chance for its separation within the canal.

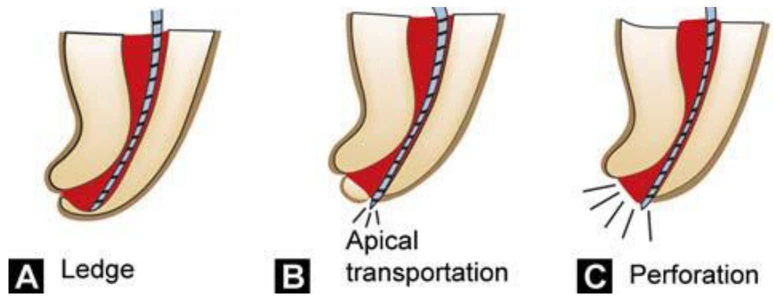


Diagram represent procedural errors

2- Step-back technique:

Realizing the funnel shape of the canal and the coronal canal diameter is larger than that produced with the standardized approach, the step-back technique was introduced by Clem and Weine in 1960. This technique relies on stepwise reduction of WL for larger files, typically in 0.5 to 1mm steps, resulting in flared shapes with 0.05 and 0.10 mm tapering, respectively. The final result is a preparation with small apical enlargement and marked taper from apical to coronal. The wide, less flexible instruments are avoided in the preparation of the apical portion of the canal. This will lessened the forces by these instruments on the canal walls, which in turn preserve the original shape of the canal. Filling with gutta-percha is made easier because more room space will be available for spreader & plugger to penetrate more apically to get maximum compaction. The technique is as follow: (Also you can follow this link to watch a video about this technique: https://youtu.be/PfkfiJ6oGIQ)

- After access of the pulp chamber and opening of the canal orifices, flood the pulp chamber with irrigant (Fig A and B).

- Establish the working length of each canal using path file which could be file # 10 (Fig C).
- Insert the next size file (# 15) into the full WL of the canal with a gentle watch-winding motion (for watch-winding motion see Fig D). Then start acting the file on the canal walls either with filling or quarter-turn-and-pull motion until the file becomes loosely moved within the canal.
- Remove the instrument and irrigate the canal.
- Place the next larger size files to the working length in similar manner and again irrigate the canal, until a clean white dentin will appear on the file tip. This file is called the MAF which is the final instrument that goes to the full working length (Fig E).
- Don’t forget to recapitulate the canal with the previous smaller size instrument. This breaks up apical debris to be easily washed away with the irrigant.
- Next use a larger file, i.e. one size larger than MAF into 0.5 to1 mm shorter than WL (Fig F). Then recapitulate the canal with MAF to full WL of the canal (Fig G) with irrigation to remove apical debris and maintain the WL.
- This process can be repeated to 3 or more, larger files until a good flaring and cleaning of the canal is obtained (Fig H, I and J). Furthermore, flaring of the coronal third of the canal can be more enlarged by using Gates Glidden rotary drills to obtain better canal cleaning coronally (Fig K and L).

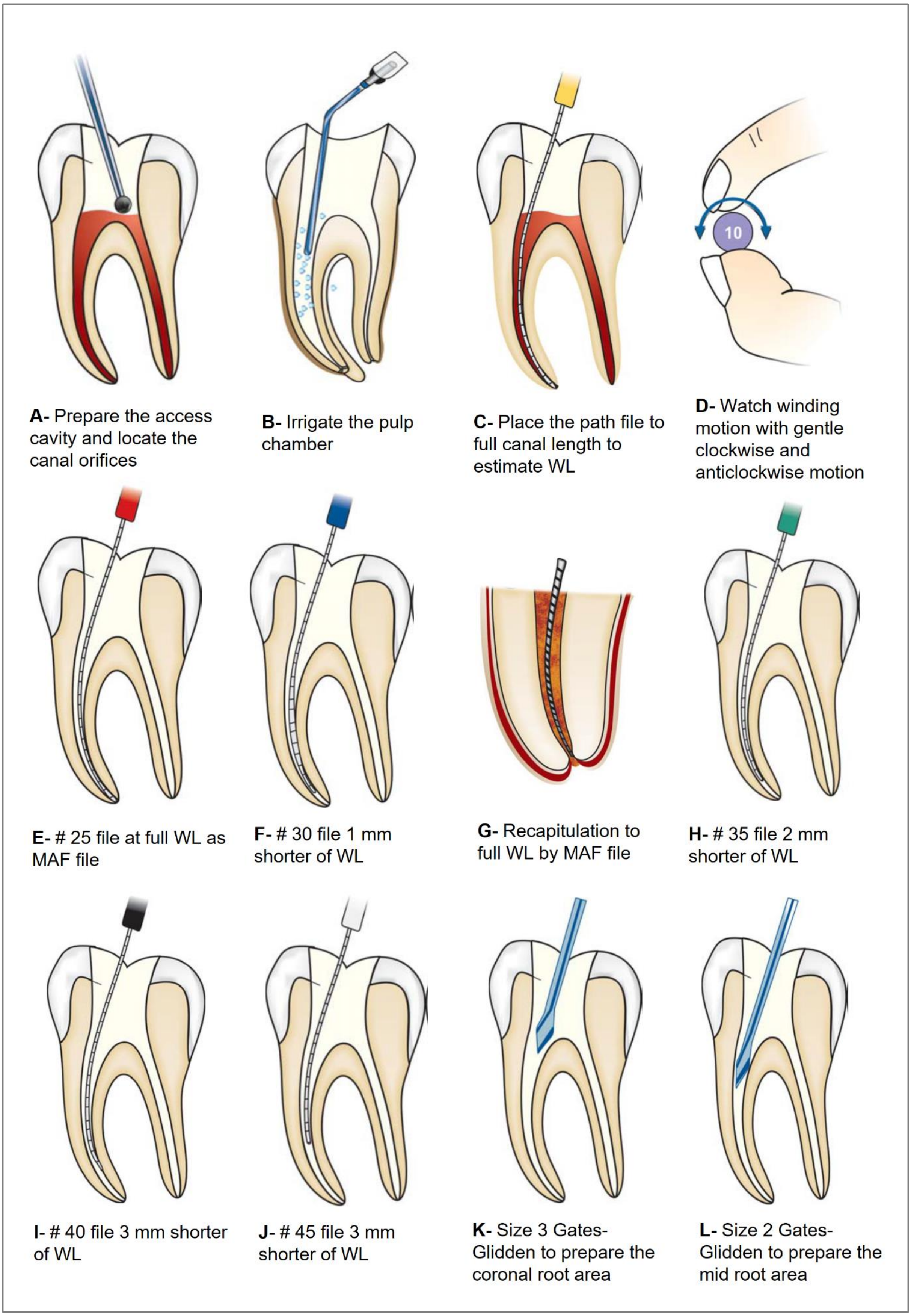


Diagram represent step-back root canal instrumentation technique.

Advantages of step-back technique:

More flaring of the canal at the coronal part with proper apical stop.

Disadvantages of step-back technique:

1. Difficult to irrigate apical region.
2. Alteration of the WL after canal flaring.
3. More chances of pushing debris periapically.
4. Time consuming.
5. Increased chances of iatrogenic errors for example ledge formation in curved canals.
6. Difficult to penetrate instruments in the canal.
7. More chances of instrument fracture.

Step-down technique:

This technique was developed to shape the coronal part (coronal pre-flaring) of the canal before instrumentation of the apical part.

The objectives of this technique is

1- To permit straight access to the apical region of the canal by eliminating coronal interference

2- To remove the bulk of necrotic tissue and microorganisms before apical shaping to minimize extruded debris through the apical foramen during instrumentation.

3- To allow deeper penetration of irrigant deeply into the apical part of the canal. In addition, it provide coronal escape way for debris extrusion from the apex.

4- The WL is less likely to change with less chance of zipping near the apical constriction.

Procedure: (you can follow this link to watch a video about this technique: https://youtu.be/uLAstzZeSc0)

- Preparation of two coronal root canal thirds using Hedstrom files of size #15, #20, and #25 to 16 to 18 mm or where they bind. These files are used with circumferential filing motion on the canal walls.
- Thereafter, increasing the coronal flaring of the canal by using Gates-Glidden drills size 2, 3, and 4, in sequential order and 1mm shorter length between each file.

- Followed by canal WL estimation, then instrumentation of the remaining apical part of the canal. This includes using small K-file # 15, 20 and 25 to prepare the apical seat.
- Combining the two parts, step-down and apical shape, by stepwise decreasing of WL of incrementally larger files. Frequent recapitulation with a #25 K-file to WL is advised to prevent blockage.

Disadvantages of step-down technique:

It is only time consuming technique.

Balanced force technique:

This technique was introduced by Roane and Sabala in 1985, after the development of new file ‘Flex-R file’. This file has “safe tip design” with a guiding land area behind the tip which allows the file to follow the canal curvature without binding in the outside wall of the curved canal. While the old K-type files have pyramidal tips with cutting angles which can be quite aggressive with clockwise rotation. This technique can be described as positioning of instrument with a counterclockwise rotation with apical pressure for shaping canal followed by preloading the instrument with canal debris through clockwise rotation then pulling.

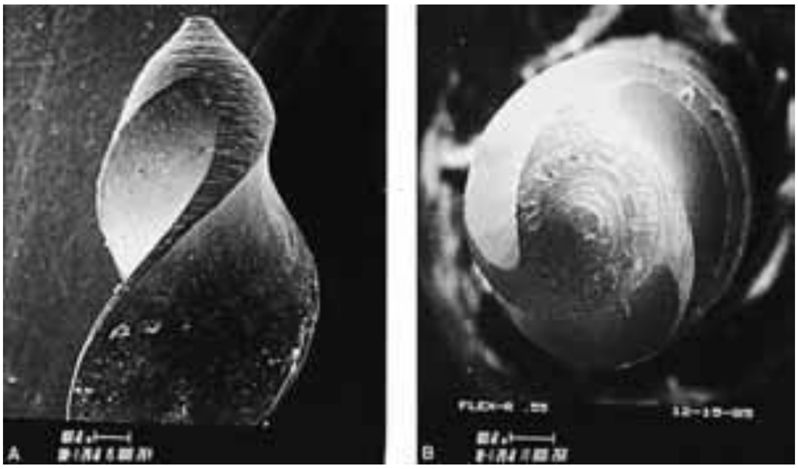


Fig shows Flex-R file with non-cutting tip.

Procedure:

1. In balanced force technique, preparation is completed in a step-down approach. The coronal and mid-thirds of a canal are flared with GG drills, beginning with small sizes as described previously.

2- After that, the balanced force hand instrumentation begins in the apical preparation by placing, cutting, and removing instrument using only rotation motion. First file which binds short of working length is inserted into the canal and rotated clockwise a quarter of a turn. This movement causes flutes to engage a small amount of dentin.

3. Now file is rotated counterclockwise with apical pressure at least one third of a revolution. It is the counterclockwise rotation with apical pressure which actually provides the cutting action by shearing off small amount of dentin engaged during clockwise rotation.

4. Then a final clockwise rotation is given to the instrument which loads the flutes of file with loosened debris and the file is withdrawn.

5. Balanced Force instrumentation initiated from the belief that the apical area should be shaped to sizes larger than were generally practiced. The original Balanced Force concept then refers to apical control zones by, for example, first using sizes #15 and #20 files to the periodontal ligament (i.e., through the apical foramen) and then reducing the working depth by 0.5 mm for subsequent sizes #25, #30, and #35. The apical shape is then completed 1 mm short using sizes #40 and #45 under continuing irrigation with NaOCl.

Advantages of balanced force technique

Lesser chances of creating a ledge, blockage or canal transportation.

Crown-down (pressure-less) technique

The crown-down instrumentation concept based on the canal shaping technique moving from the crown toward the apical portion of the canal. This concept was the introductory for the most recent rotary instrumentation technology.

Procedure: (please follow this link to watch a video about the steps of this technique: https://youtu.be/qfBYMA2_evQ)

1. After preparing the access opening and locating the canal, flood the pulp chamber with irrigation solution and start pre-flaring of the canal orifices. This can be done by using hand instruments, Gates-Glidden drills or the nickle-titanium rotary instruments. After that a glide-path for each canal have to be obtained from the canal orifice till the apical foramen by using # 10 or 15 file.

2. Coronal preparation of the canal can be started with Gates-Glidden drills. The crown down approach begins with larger Gates-Glidden first (Fig A) (size 4 or 5), followed by smaller diameter Gates-Gliddens are worked into the canal with additional mm to complete coronal flaring. A care should be taken to avoid carrying all the Gates-Glidden drills to same level which may lead to excessive cutting of the dentin.

3. Frequent irrigation with sodium hypochlorite and recapitulation with a smaller file (usually No. 10 file) to prevent canal blockage.

4. After establishing coronal and mid root enlargement, explore the canal and establish the working length with small instruments (# 10 or 15 file) (Fig B).

5. Introduce larger files to coronal part of the canal and prepare it (Fig C and D). Subsequently introduce progressively smaller number files deeper into the canal in sequential order and prepare the apical part of the canal (Fig E).

6. Final apical preparation is prepared and finished along with frequent irrigation of the canal system.

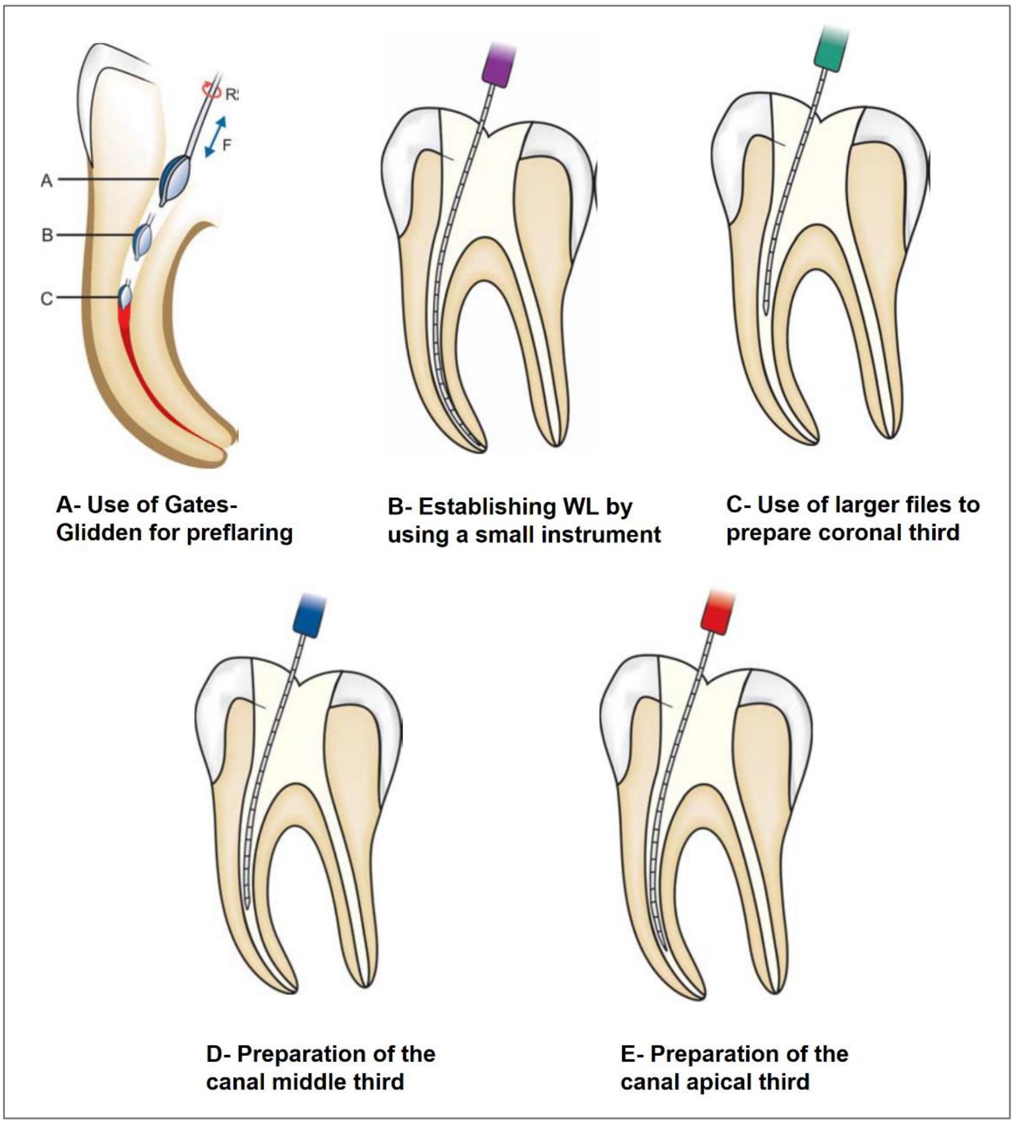


Diagram presenting Crown down (pressure-less) technique

Biological Advantages of crown down technique:

1. Removal of tissue debris coronally, thus minimizing the extrusion of debris periapically.
2. Reduction of postoperative sensitivity which could result from periapical extrusion of debris.
3. Greater volumes of irrigants can reach in canal irregularities in early stages of canal preparation because of coronal flaring.
4. Better dissolution of tissue with increased penetration of the irrigants.

Clinical advantages of crown down technique:

1. Enhanced tactile sensation with instruments because of removal of coronal interferences.
2. Flexible (smaller) files are used in apical portion of the canal; whereas larger (stiffer) files need not be forced but kept short of the apex. This decrease the chance for canal ledging, transportation and perforation.
3. Straight line access to root curves and canal junctions.
4. Provides more space for irrigants.
5. Enhance canal debridement and decrease frequency of canal blockages.
6. Desired shape of canal can be obtained that is narrow apically and wider coronally. This provides better room for gatta percha compaction to obtain proper three dimensional obturation of the root canal.

Root Canal Irrigation

- Studies have shown that mechanical instrumentation, whether using manual or rotary instruments, can not sufficiently debride and disinfect root canals.
- Every root canal system has spaces that cannot be cleaned mechanically.
- The only way for cleaning webs, fins and anastomoses is through the effective using of irrigation solutions (See Fig 1).

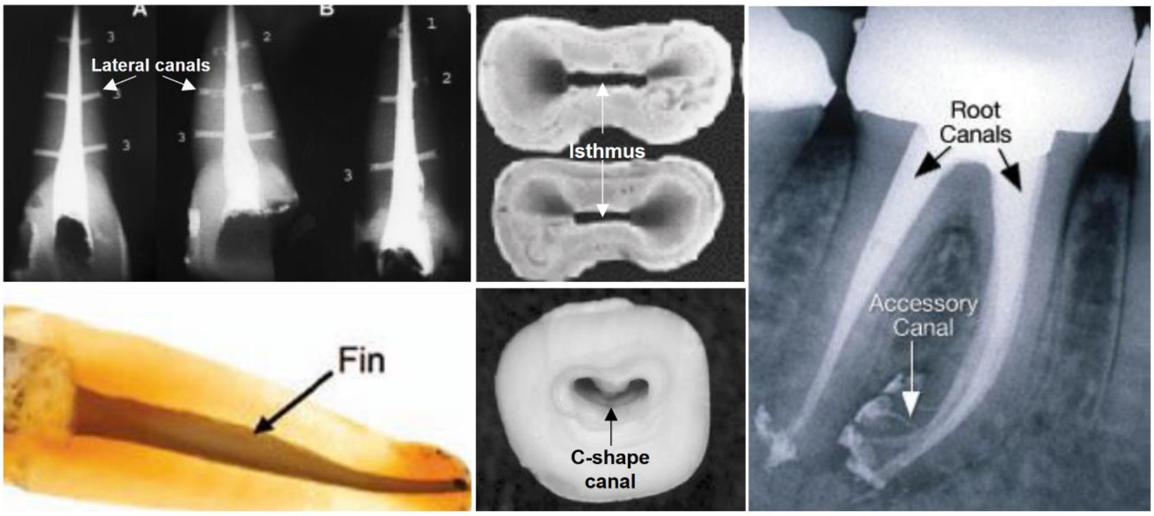


Figure 1: Variations in root canal anatomy

Requirements of ideal irrigant solution:

1- Have a broad spectrum antimicrobial activity.

2- Be able to effectively sterile the canal (or at least disinfect them).

3- Have the ability to dissolve necrotic tissue and debride the canal.

4- Lubricant solution.

5- Low level of toxicity.

6- Have low surface tension to be able to penetrate into inaccessible areas.

7- Prevent the formation of smear layer during or after instrumentation.

8- Inhibiting bacterial toxins such as endotoxin.

Functions of irrigants

1- Removal of dentinal shavings by physical flushing to prevent their packing at the apical region of the root canal.

2- Canal wetting material which effectively increase the efficacy of root canal instruments. Instruments are less likely to break when the canal walls are lubricated by irrigant.

3- Irrigants act as a solvent for necrotic tissue, so they loosen debris, pulp tissue and microorganisms from irregular dentinal walls.

4- Irrigants facilitate the removal of debris from inaccessible regions of root canals.

5- Most irrigants have germicidal and antibacterial properties.

6- Irrigants also have bleaching action to lighten teeth discolored by necrotic pulp tissue, caries or restorative material.

7- Irrigats facilitate the removal of smear layer and opening of the dentinal tubules.

Factors that modifying the activity of irrigating solution

There are several factors that can be controlled to increase the efficacy of irrigant solutions:

1- Concentration: the dissolving capacity of some irrigation solution, such as sodium hypochlorite, can be increased with higher concentration (5.2 rather than 2.5%). However the cytotoxicity of higher concentrations is extremely higher.

2- Contact: the irrigant must contact the intracanal substrate (organic tissue, or microbes) to be effective, otherwise it won't be able to dissolve or flushout the debris. Therefore, it is critical that the canal diameter should be mechanically enlarged to facilitate the delivery of the irrigant solution up to the apical region of the prepared canal.

3- Presence of organic tissue: the organic tissue must be removed mechanically or chemomechanically to increase the efficacy of intracanal irrigation. This can be obtained by simultaneous use of instruments and irrigating solutions.

4- Quantity and frequency of the irrigant used:

- More irrigation causes better tissue debridement.
- Each time a flush of fresh potent irrigant plays an action.

5- Gauge of irrigating needle: usually the 27 or 28 irrigation needle is preferable for better penetration into the canal.

6- Surface tension of irrigation solution: the lower surface tension, the better wettability and the more penetration into narrowest areas of the canals, and even into the dentinal tubules.

7- Level of penetration of the irrigant: Maximum actions of irrigant occurs on coronal part of root canal whereas minimal on apical end.

8- Age of irrigant: Freshly prepared solution is more effective than older one.

Irrigant solutions:

There are several irrigation solution that are currently used in root canal chemomechanical debridement nowadays (See Figure 2). But none of these irrigats fulfil all the required criteria. The main irrigants include sodium hypochlorite, chlorhexidine and ethylene diamine tetraacetic acid. A combination of several irrigants can be used to get maximum action.

Some of the commonly used irrigation solutions

Chemically non-active solution

- Water
- Saline
- Local anesthetic

Chemically active materials:

- Alkalis: Sodium hypochlorite 0.5-5.25 percent
- Chelating agents: Ethylene diamine tetra acetic acid (EDTA)
- Oxidizing agents: Hydrogen peroxide, carbamide peroxide
- Antibacterial agents: Chlorhexidine, Bisdequalinium acetate
- Acids: 30 percent hydrochloric acid
- Enzymes: Streptokinase, papain, trypsin
- Detergents: Sodium lauryl sulfate

Figure 2: A list of the currently used irrigant in root canal treatment.

Normal saline:

Normal saline as 0.9% W/V is commonly used irrigant in endodontics. It is very mild in action and can be used in adjunct to chemical irrigant. It causes gross debridement and lubrication of the root canal. Normal saline basically acts in flushing action. It can also be used as a final rinse for root canals to remove the chemical irrigant left after root canal preparation.

Advantages: it is a biocompatible solution with no adverse effect even if extruded periapically, because its osmotic pressure is the same as that of the blood.

Disadvantages:

- It has no dissolution, disinfectant and antimicrobial properties.
- Too mild to thoroughly clean the canal.
- Does not remove sear layer.

Sodium hypochlorite (NaOCl):

NaOCl encompasses many desirable properties of the main root canal irrigant and has therefore been described as the most ideal irrigant solution. It can be used with different concentrations (0.5 to 6%) but the recommended concentration in many studies is 5.25%. Commercially available household bleach (Clorox) contains 6.15% NaOCl.

- NaOCl dissolve organic material such as pulp tissue, collagen, organic material in smear layer and bacteria. With lower concentrations (0.5%) it dissolve only necrotic tissue, however in higher concentrations dissolve both necrotic and vital which is not always a desirable property.
- NaOCl possess a broad-spectrum antimicrobial activity against endodontic microorganisms and biofilms, including microbiota difficult to eradicate from root canals, such as *Enterococcus, Actinomyces,* and *Candida* organisms. This depends on its concentration and the contact time. With higher concentration and longer contact time its antimicrobial action increase.
- NaOCl minimally remove dentin debris or smear layer. Therefore, the use dentin demineralizing agent (EDTA) is recommended post instrumentation to eliminate smear layer and enhance cleaning of difficult-to-reach areas such as dentinal tubules and lateral canals.
- When using NaOCl over extended periods of time during treatment, it has an undesired side effect by decreasing the flexural strength and modulus of elasticity of dentin. Therefore it has to be flushed out by using normal saline after the end of instrumentation visit.
- NaOCl also has bleaching action by the function of the hypochlorite ions which is important in whitening the discolouration caused by pulp necrosis or endodontic and restorative material such as some endodontic sealers, and amalgam restoration. However, NaOCl cause bleaching in contact with clothes, so cautions have to be taken during its use.

- Although NaOCl is nontoxic during intracanal use, it could cause serious tissue damage if it injected periapically especially with higher concentration. This is associated with severe pain, swelling and periapical bleeding. Medication like antibiotics, analgesics, antihistamine should be prescribed accordingly. In addition to these, reassurance to the patient is the prime consideration. Thus irrigation with NaOCl should always be performed passively especially in cases with larger apical diameters and needles with very small diameter.

Advantages of NaOCl:

1- It has antibacterial and bleaching action.
2- It help in canal debridement by dissolution of the organic debris.
3- It cause lubrication of canals
4- Economical.
5- Easily available.

Disadvantages:

1- Because of high surface tension, its ability to wet dentin is less.
2- Irritant to tissues, if extruded periapically, it can result in severe cellular damage.
3- If comes in contact, it cause inflammation of gingiva because of its caustic nature.
4- It causes clothes bleaching in contact.
5- It has bad odor and taste
6- Vapours of NaOCl can irritate the eyes.
7- It has a corrosive effect to instruments.

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