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Root canal cleaning and shaping : A review

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***Abstract*---**Root canal treatment is a frequently performed dental procedure and is carried out on teeth in which irreversible pulpitis has led to necrosis of the dental pulp. The speciality of endodontics encompasses numerous elements, but the use of a variety of instruments to shape root canal systems probably challenges the clinical time of practitioners more than any other. Removal of the necrotic tissue remnants and cleaning and shaping of the root canal are important phases of root canal treatment. Treatment options include the use of hand and rotary instruments and methods using ultrasonic or sonic equipment. Rotary root canal instruments manufactured from nickel-titanium alloy have proved to be a valuable adjunct for root canal therapy. But in certain cases such as in the presence of curved root canals hand filing becomes necessary. This article aims to explore various methods and instruments used in cleaning and shaping of Root canal system.

***Keywords*---**irreversible pulpitis, rotary instruments, ultrasonic.

Introduction

Success in endodontic treatment depends on how well the pulp space is shaped and cleaned1. Research into root canal preparation has led to significant changes in instrumentation techniques. Recent designs of endodontic instruments have variable tapers giving improved shaping ability. Nickel - Titanium rotary

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instruments can be used to rapidly and safely open the main root canals creating deep space to permit full permeation of irrigant solutions.

The objective of root canal preparation are to remove all organic debris and all microorganisms from the root canal systems and to shape the walls of the root canal to facilitate further cleaning and subsequent obturation of the entire root canal space.[1] The root canal morphology is almost always associated with accessory canals, lateral canals, fins, anastomoses between canals and apical deltas. The majority of these anatomical features are not accessible to instrumentation.[2] An irrigant solution must be used which can be flushed through this system, will destroy the microorganisms and preferably and dissolve organic debris at the same time. Once shaped and cleaned the root canal system is obturated to prevent further ingress of microorganisms both apically and coronally and to entombed any remaining microorganisms to prevent their proliferation.[2]

Rationale For Treatment[1]

- PULPAL INJURY
- ISCHEMIA
- INFARCTION
- NECROSIS
- PERIRADICULAR EXTENTION OF DISEASE PROCESS

Anatomical considerations:

Vertucci's Classification[4]:

- Type I : 1-1
- Type II : 2-1
- Type III : 1-2-1
- Type IV : 2-2
- Type V : 1-2
- Type VI : 2-1-2
- Type VII : 1-2-1-2
- Type VIII : 3-3

Objectives[1]

Clinical objectives:

- " Start with the end in mind " (Yuri Kuttler oral surg '72).

Shaping facilitates cleaning[1]**:**

- By removing restrictive dentin
- Allows an effective volume of irrigant to work deeper to potentially circulate into all aspects of the root canal system

Shaping facilitates obturation[1]:

- Three- Dimensionally cleaned and shaped root canal system is ideal for compacting Gutta-percha

Biological objectives[1]:

To completely debride the pulp space of

- Pulp tissue
- Bacteria / Microorganisms
- Endotoxins

Mechanical objectives:

- Continuously tapering preparation
- Maintain original anatomy
- Maintaining the position of the apical foramen
- Foramen as small as practically possible

Principles[3]

- Outline Form
- Convenience Form
- Toilet of the cavity
- Retention Form
- Resistance Form
- Extension for prevention

Outline Form[3]:

Beginning at the enamel's edge to Resistance Form at the apical foramen. In some preparations, Retention Form may be developed in the last 2 to 3 mm of the apical canal. Usually, however, the preparation is a continuous tapered preparation from crown to root end. The entire length of the cavity falls under the rubric Outline Form and toilet of the cavity. At the coronal margin of the cavity, the Outline Form must be continually evaluated by monitoring the tension of the endodontic instruments against the margins of the cavity. Remember to retain control of the instruments; they must stand free and clear of all interference. Access may have to be expanded (Convenience Form) if instruments start to bind, especially as larger, less flexble instruments are used.

Outline Form and Toilet of the Cavity:[3]

Meticulous cleaning of the walls of the cavity until they feel glassy-smooth, accompanied by continuous irrigation, will ensure, as far as possible, thorough débridement. One must realize, however, that total débridement is not possible in some cases, that some "nooks and crannies" of the root canal system are virtually impossible to reach with any device or system. One does the best one can, recognizing that in spite of microscopic remaining debris, success is possible.

Success depends to a great extent on whether unreachable debris is laden with viable bacteria that have a source of substrate (accessory canal or microleakage) to survive—hence the importance of thorough douching through irrigation, toilet of the cavity.

Retention Form:[3]

In some filling techniques, it is recommended that the initial primary gutta-percha point fit tightly in the apical 2 to 3 mm of the canal. These nearly parallel walls (Retention Form) ensure the firm seating of this principal point. Other techniques strive to achieve a continuously tapering funnel from the apical foramen to the cavosurface margin. Retention Form in these cases is gained with custom-fitted cones and warm compaction techniques. These final 2 to 3 mm of the cavity are the most crucial and call for meticulous care in preparation. This is where the sealing against future leakage or percolation into the canal takes place. Coronally, from the area of retention, the cavity walls are deliberately flared. The degree of flare will vary according to the filling technique to be used—lateral compaction with cold or warm gutta-percha or
vertical compaction of heat-softened gutta-percha.

Resistance Form:[3]

Resistance to overfilling is the primary objective of Resistance Form. Beyond that, however, maintaining the integrity of the natural constriction of the apical foramen is a key to successful therapy. Violating this integrity by overinstrumentation leads to complications:

(1) acute inflammation of the periradicular tis-sue from the injury inflicted by the instruments or bac-teria and/or canal debris forced into the tissue,
(2) the inability to com-pact the root canal filling because of the loss of the lim-itingapical termination of the cavity—the important apical stop.

Establishing Apical Patency:[3]

Bearing in mind that canal preparations should ter-minate at the dentinocemental junction, slightly short of the apex, one is left with a tiny remaining portion of the canal that has not been properly cleaned and may contain bacteria and packed debris. It is this section of the canal that is finally cleaned, not shaped, with fine instruments—No. 10 or 15 files. The fact must also be established that the apical foramen does not always lie at the exact apex of the root. Most often, canals exit laterally, short of the radi-ographic apex. This may be revealed by careful scrutiny of the film with a magnifying glass or by placing a curved exploratory instrument to the exact canal length and repeating the radiograph examination. The extension of the cavity preparation through-out its entire length and breadth is necessary, howev-er, to ensure prevention of future problems. Peripheral enlargement of the canal, to remove all of the debris, followed by total obturation is the primary preventive method. Instruments and filling material should terminate short of the cementodentinal junction, the

narrowest width of the canal, and its termination at the foramen. This point is often 0.5 to 1.0 mm from the apex[3]

Armamentarium

Hand instruments:

- Kerr - Reamers
- K - Files
- Hedstroem files (H - files)

Hybrid instruments

Instruments with short cutting segments

- Canal master u
- Flexogates
- Heliapical and apical

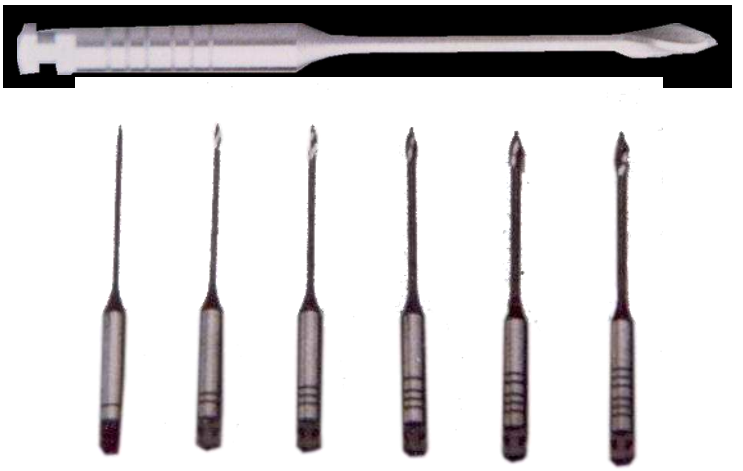
Rotary contra angle hand piece:

- Gates Glidden drill
- Peeso reamer
- Rotary H-type, U–type, K–type
- Nickel titanium instruments:
- Profile series, Quantec 2000, Hero 642, Light speed, Progressively tapering (GT)
- Reciprocating hand piece:
- Giromatic, Canal finder system
- Vertical stroke handpiece:
- Canal leader 2000
- Random motion hand piece
- Excaliber

Ultrasonic and sonic systems[3]
Lasers

Gates Glidden Drills[3]

- It is the main rotary instrument used for the pre-enlargement of the coronal 2/3rd.
- It has a flame shaped cutting head and comes in a box of 6 instruments
- They have tip diameters from 0.5 – 1.5 mm
- They are used in speeds from 750 – 1000 rpm
- They should be used in a brushing motion like a painter's brush to carve away restricted dentin from the orifice.[3]



Peeso – Reamers[3]

- Most often used in preparing coronal portion of the root canal for recieving a post core
- Safe–ended
- Tip – Diameter: 0.7 – 1.7
- Used in a brushing motion

Irrigants:[3]

Sodium Hypochlorite 2.3% - 5%
Chlorhexidine 0.2%
Ethylelne Diamine Tetra Acetic acid (EDTA)17%

Functions of irrigants :

- ❖ Antimicrobial activity
- ❖ Flushing action - debridement of the canal system
- ❖ Dissolution of necrotic and vital tissues
- ❖ Lubrication
- ❖ Removal of smear layer
- ❖ Bleaching action

Removal of pulp tissue:

- ♦ Barbed broaches (Smooth Broaches rarely used)
- ♦ Used in slightly widened canals (# 20)
- ♦ Inserted until it contacts dentin in pulp space, slightly withdrawn, then rotated till it entangles pulp tissue, and removed.[3]

The Standardized Technique[3]: *(Ingle 1967)*

Each instrument is placed to the full working length

- Canal enlarged until clean white dentin shavings are seen on the apical few mm of the instrument
- Filling continued for a further 2 or 3 sizes

Disadvantages:

In curved root canals

- Ledging, zipping, elbow formation, perforation and loss of working length owing to compaction of dentin debris

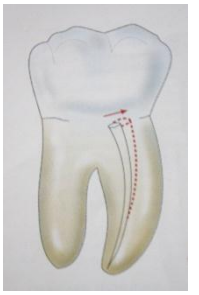
Instrument manipulation[1]**:**

Watch winding and circumferential filing (Filing and reaming)[1]:

It is done in a continuous back and forth rotation with slight apical pressure each slight turn engages the flutes of the file in the canal wall and removes dentin. Only fine files are advanced to the apex in this way as there is a danger of compacting pulpal debris ahead of the file which may result in blockage.
Once it reaches the desired length, a push- pull filing action is to be used moving the file circumferentially around the canal walls.[1]

Disadvantages

- Tendency to preferentially file the inside wall of the curved canal
- If a file engages the coronal part of the root canal the apical flutes may remain passive resulting in under prepared canals



Anti – curvature filing[6]:

- In multi-rooted teeth filing is always done away from the danger zone in the ratio 3:1.
- Its usually performed in the direction corresponding to the name of the canal.[6]

Recapitulation:

- Use of a smaller instrument to remove debris produced during instrumentation.
- Prevents pushing debris beyond the apex and apical plug formation.

Techniques of cleaning and shaping[1]:

The mechanical objectives of canal preparation can be fulfilled using a variety of instruments. The *concepts* of canal preparation endure, where as the instruments, strategies and techniques used for cleaning and shaping constantly *evolved.* Clinical performance is enhanced use of the best technologies with a high level of teamwork and organization.[6]

coronal 2/3rds preparation

scouting the coronal 2/3rds:[1]

No: 10 and 15 hand files (0.02 taper) are used to scout the coronal 2/3rds.
Scouting instruments provide the following important information (Ruddle C.J):

- Cross sectional diameter of the canal
- Whether the canal is open, partially restricted or calcified
- Straight line access presence or absence-critical as it simplifies all subsequent instrumentation procedures
- Pulp space anatomy (five commonly encountered anatomic forms- canals that merge curve, recurve, dilacerate or divide)

Instrument is inserted into the canal and passively pushed apically with its handle gently rocking back and forth (15° CW & 15° CCW)
This results in apical file movement :

- ✓ In straight canals the file may slide to working length

- ✓ In canals that are more curved, narrow or exhibit interradicular divisions, rate of taper of the instrument often exceeds the rate of taper of the canal. Consequently apical file movement is limited

If the scouting file encounters restriction, when the file is snug, the file should be pulled 1-2mm. The pull stroke will ensure that the instrument cuts away form the terminus towards the region of the canal having an increasingly larger cross sectional diameter. This cutting cycle is repeated around 5-6 times.[1]

Coronal 2/3rds preparation:[1]

- ☞ Step-back technique
- ☞ Step-down technique

Advantages of preenlarging using files and GGs:

- Smaller instruments can be more easily and more deeply with in the root canal space, were they cut on pull stroke
- In crown-down technique instrument cut on the push stroke which may push pulp stones fibrotic tissue and debris deeper into the root canal space
- Coronal 2/3rds of canal be easily move and relocated away for furcal danger and toward the greatest bulk of dentin when GGs are used in step back technique

Apico-Coronal Preparation:[3]

Step back technique (Mullaney et al 1979):[3]

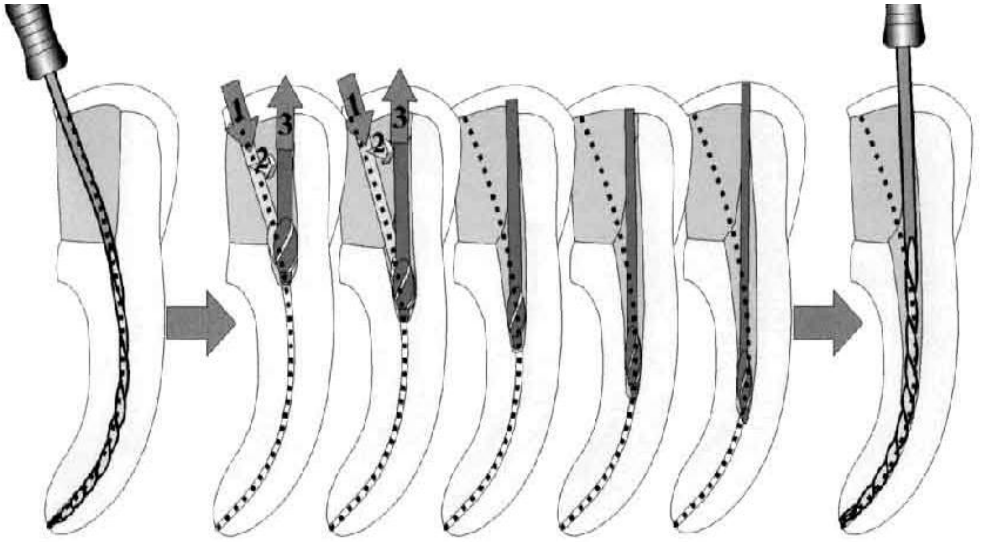
- Apical preparation first. enlarged to a master apical file size 25 or 30
- Subsequently larger instrument then inserted 1mm less into the canal to get a uniform taper
- In between placing each larger instrument recapitulation is done with master apical file

Corono- Apical Preparation[3]

Step down technique[3]

First suggested by Schilder in 1974.
Goerig 1982 named and described the technique in detail.

Principle- coronal aspect of the root canal is prepared and cleaned before the apical part
Apical preparation using gates glidden, smaller hand instruments to the apex.[3]



Crown-down pressureless technique (Marshall & Pappin):[3]

- Similar to step-down technique
- Used in rotary systems, protaper, GT hand instruments
- Minimal or no pressure on the instrument as it is manipulated in the canal

Hybrid / Double flare technique:[3]

- Coronal enlargement done first using hand instruments
- Apical preparation done by step-back technique

Advantages:

- ☞ Straighter access to the apical region
- ☞ Eliminates dentin interferences in the coronal 2/3rd, apical instrumentation accomplished quickly and efficiently
- ☞ Reduces risk of extruding material through the apical foramen
- ☞ Better penetration of irrigant solution
- ☞ Reduces risk of zipping (Leeb, JOE1983).[3]

Hand instrumentation

Hand instrumentation is best accomplished with the balanced forced technique
Certain modification to the balanced force technique include:

- safe ended NiTi files from no 35-60
- limit use of straight portion in canals that exhibit abrupt curvatures or dilacerations
- caution in he apical 2-3mm of canals exhibiting complex anatomy

Balanced - Force Technique:[1]

Phase I- file insertion
Handle of the file is reciprocated in a back and forth motion until it snuggly fits

Clockwise rotation in 45-90° - cutting blade moves deeper into to the canal and engages dentin

Phase II- file cutting

Two simultaneous (balanced) forces are applied – counter clock wise rotation with simultaneous apical push. After first cutting the instrument is extended into the canal as in phase I and another phase II cutting cycle is repeated

Phase III- flute loading

The cut dentin lies partially in the inter blade spaces of the file and partially in the canal apical to the instrument. The debris is removed from the canal by rotating the file handle clock wise by simultaneously pulling the instrument coronally. When performed properly the position of the file tip never advances apically because the tendency of the file to be drawn in to the canal is balanced by the force of the file being lifted out of the canal. The file is removed after 2-3 rotations.[1]

Advantages

File cutting occurs essentially at the apical extent of the file
Safe ended file tip stays centered in the root when activate in phase II file cutting

Determination of correct width of preparation

- Still controversial
- Minimal instrumentation to size #20 - #25 is adequate for pulp tissue removal (Grossman)[7].
- Apical Preparation – Three sizes greater than the initial apical file (IAF) Weine.[8]

Procedural Accidents

Definition:

Procedural accidents in endodontics are those unfortunate occurrences that happen during treatment, some due to inattention to detail, and others totally unpredictable.
Complex pulp space systems acknowledged to exist biologically, but technically inaccessible can now be uncovered with the use of surgical microscopes and Ni-Ti instruments.[3]

A. Loss of working length
B. Ledging, zipping, elbow
C. Separated instruments
D. Perforation
E. Over instrumentation
F. Canal blockage

Loss Of Working Length

It is a very common and frustrating error usually noted on a master cone radiograph.

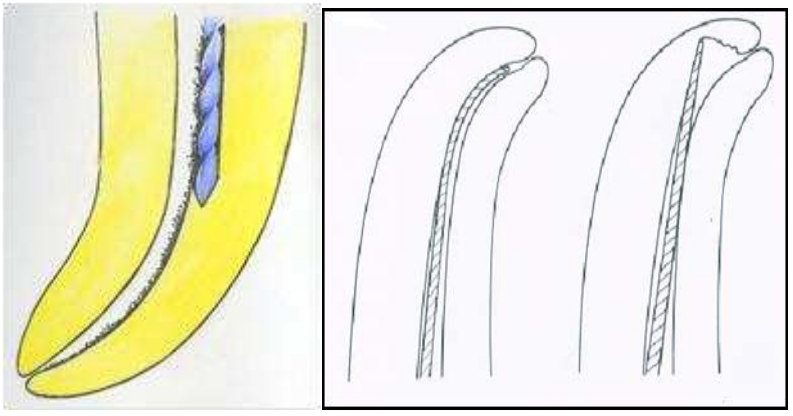
- It is actually secondary to the other procedural errors.[3]

Ledging

Any deviation from the original canal curvature results in the formation of a ledge.

Causes

- Inadequate access cavity preparation
- False estimation of pulp space direction
- Failure to pre-curve SS instruments
- Failure to use instruments in a sequential manner
- Attempt to retrieve separated instruments
- Attempt to prepare calcified canals.[3]

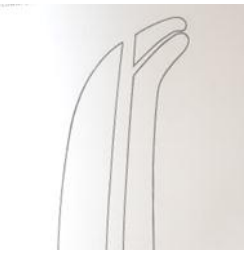


Zipping Or Elliptication

Transportation or transposition of the apical portion of the canal.[3]

Perforation

- An artificial opening in a tooth or its root , created by boring, piercing , cutting or pathologic resorption, which results in a communication between the pulp space and the periodontal tissues
- Incidence 3-10%
- Causes
  - Caries
  - Resorptive defects
  - Iatrogenic events[3]
  -



Strip Perforation:

Caused by over-instrumentation in the danger zone

Classification Based On The Location Of Perforation[3]

- Cervical
- Mid – root
- Apical

Classification Based On The Factors That Affect The Prognosis: Fuss/ Trope et al[3]

Good Prognosis	Poor Prognosis
Fresh Small Apical	Old Large Crestal

Diagnosis Of Perforation**:**[3]

- Electronic Apex locators
- Surgical microscopes
- Radiographs
- Paper points
- Bleeding
- Pain
- Loss of tactile sensation

Management

- ☞ Non surgical
- ☞ Surgical

Goals Of Management

- Attain haemostasis
- Placement of internal matrix
- Placement of a restorative material

Internal Matrix

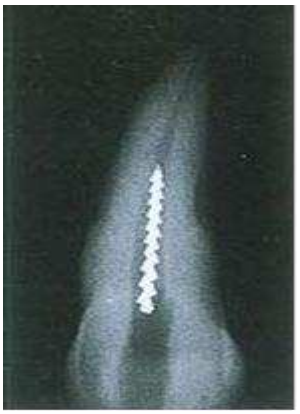
- Collaplug or collatape
- Calcium hydroxide
- Gel foam
- Hydroxyapatite
- Calcium phosphate
- Tricalcium phosphate
- Demineralised freeze dried bone

Perforation Repair Materials[4]

- MTA - latest, attaches to cementum, long setting time
- Glass ionomer- good flow
- Composite- curing is a problem at mid root level
- Zinc oxide eugenol - irritates the tissues
- IRM- less eugenol - less irritation
- Super EBA- less eugenol than IRM
- Gutta percha - for apical perforation
- Amalgam- not used any more

Separated Instruments[4]

The incidence of separation is 2-6%



Classsification:[4]

T.Sotokowa classified the types of damage of instruments.

Type I	-	Bent instruments
Type II	-	Stretching or straightening of twist contour without bending
Type III	-	Peeling or tearing off of metal at the edges without bending or straightening
Type IV	-	Partial reverse twisting of instruments
Type V	-	Cracking along the file axis
Type VI	-	Fracture of the instrument

Causes of breakage:

- Torsional fatigue
- Flexural fatigue

Management:

- Bypass
- Retrieval

Ultrasonic Tips

For loosening the instrument prior to its retrieval

Ultrasonics[5]

Endosonics refers to endodontic treatment by Sonic, supersonic or subsonic systems (Martin and Cunnigham) Synergistic system- canal preparation and cleaning, irrigation and disinfection and canal packing and filling are all accomplished with the same group of instruments

Uses

- Mainly for Cleaning - excellent
- Retreatment
- Retrieval of silver points, posts, cements and unwanted material in the canal

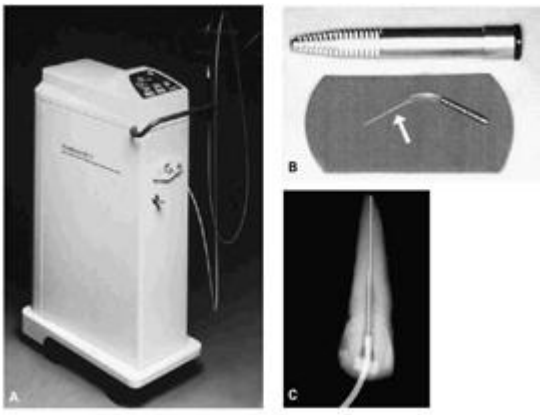
Disadvantage

Shaping using larger files (no 30) zipping was always seen (Chenail et al 1985)

Lasers[5]

Laser stands for Light Amplification by Stimulated Emission of Radiation
Lasers emitting in the ultraviolet, visible (ie, argon laser—488 and 514 nm), and near infrared (ie, neodymium:yttrium-aluminum-garnet [Nd:YAG] laser—1.064 μm) are weakly absorbed by dental hard tissue, such as enamel and dentin
Excimer lasers (193, 248, and 308 nm) and the erbium laser (~3.0 μm) are strongly absorbed by dental hard tissues.[5]

Lasers in Endodontics:



In 1971, at the University of Southern California, Weichman and Johnson were probably the first researchers to suggest the use of lasers in endodontics

The technique requires widening the root canal by conventional methods before the laser probe can be placed in the canal. The fiber's diameter, used inside the canal space, ranges from 200 to 400 μm, equivalent to a No. 20-40 file.[6] However, the performance of this equipment, concerning safe and effective wavelength and energy levels related to temperature rise, morphologic changes, and microbial reduction, should be well documented before it becomes a current method of treatment.[6]

Noninstrumentation Root Canal Cleansing:

Based on the premise that "Optimal cleansing of the root canal system is a prime prerequisite for long term success in endodontics," Lussi and his associates at the University of Bern, Switzerland, introduced devices to cleanse the root canal "without the need of endodontic instrumentation."[7] More recently, they have improved the device and reported that the "smaller new machine produced equivalent or better cleanliness results in the root canal system using significantly less irrigant (NaOCl)." This cleanses the canal but, of course, does nothing to shape the canal.[7]

Smear layer management

When the blades of any file engage and cut dentin a smear layer of organic and inorganic debris forms on the walls of the preparation. If the smear layer is removed then a tighter interface between the obturation materials and dentin walls is possible. If the smear layer is left, then the root canal system is thus incompletely sealed and the potential for microleakage and subsequent failure increases significantly.[8]

EDTA and Ultrasonics

Aqueous 17% EDTA flooded into well -shaped preparations for minute has been shown to remove and eliminate the smear layer.[8] Piezo electric ultrasonic energy has been used in enhancing debridement and debris removal.

EDTA and microbrushes

Microbrushes have been introduced recently to optimally to finish root canal preparation. Can be used in either rotary or ultrasonic hand pieces.[9]

Conclusion

Endodontist has a wide array of instruments and techniques at his disposal. Ni-Ti Rotary instruments need the practitioners' expertise and one should use them in-vitro prior to clinical use.Even the best of intruments have its limitations in the hand of an inexperienced pactitioner. Experienced endodontist should choose tried and tested instruments and techniques for best results.

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