Rotary Endodontics

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Root Canal Preparation

- One of the most important stages in root canal treatment which includes both enlargement and shaping of the complex endodontic space together with its disinfection.
- A variety of instruments and techniques have been developed and described for this critical stage of root canal treatment.

Classification of cleaning and shaping instruments

Group I	Group II	Group III
• Manually-operated instruments • **Eg- Barbed Broaches, K type and H type instruments**	• Low-speed instruments with a latch-type attachment • **Eg- Gates Glidden and Peeso reamers**	• Engine-driven **Nickel-Titanium rotary instruments**

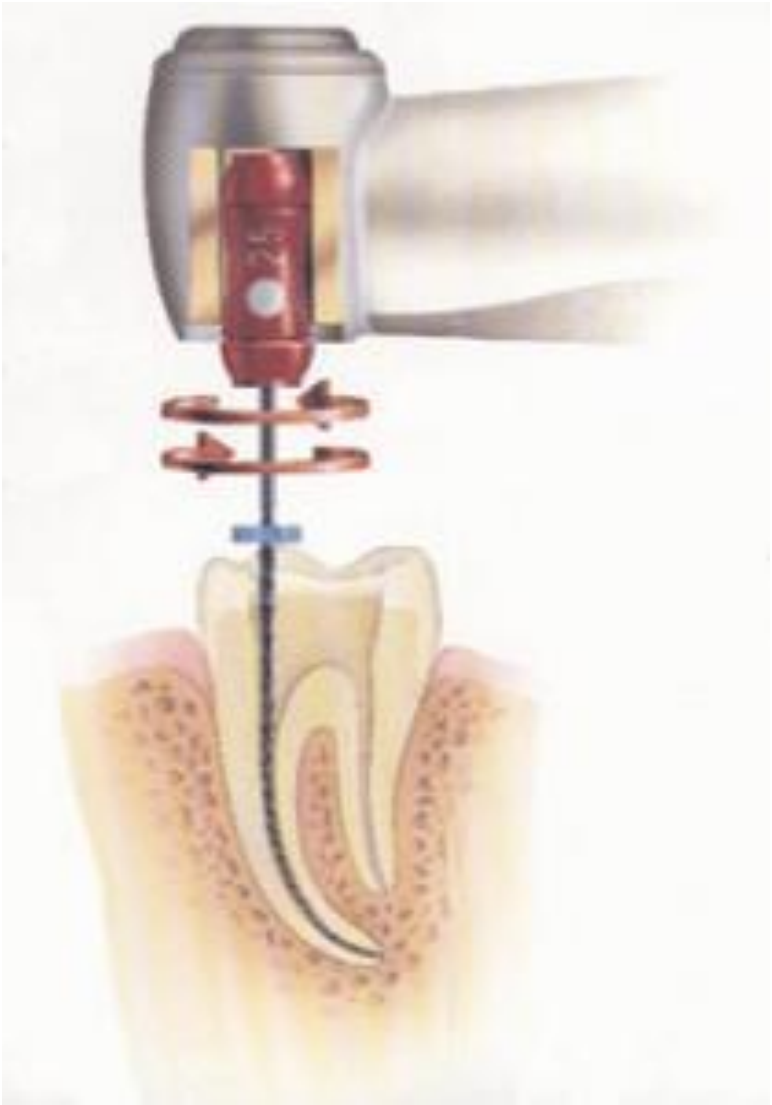
According to ISO-FDI

Classification of cleaning and shaping instruments

Group IV	Group V	Group VI
• Engine-driven instruments that adapt themselves three-dimensionally to the shape of the root canal. • **Eg- SAF**	• Engine-driven reciprocating instruments	• Ultrasonic instruments

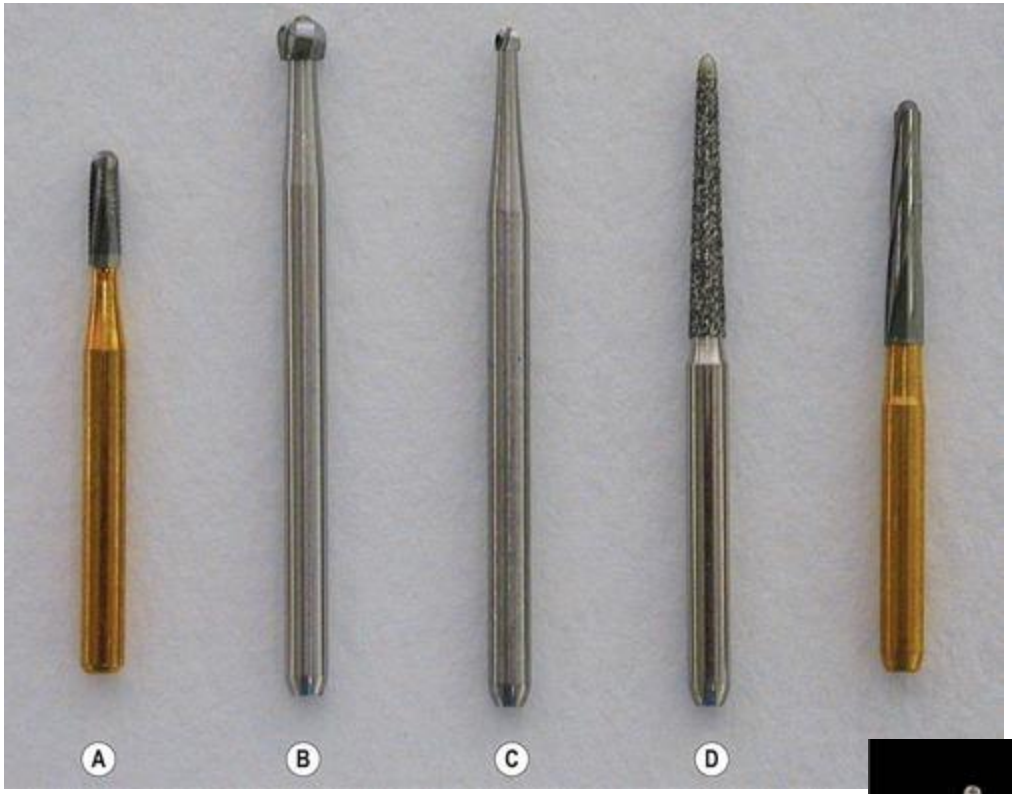
According to ISO-FDI

Group II: Low Speed Rotary Instruments

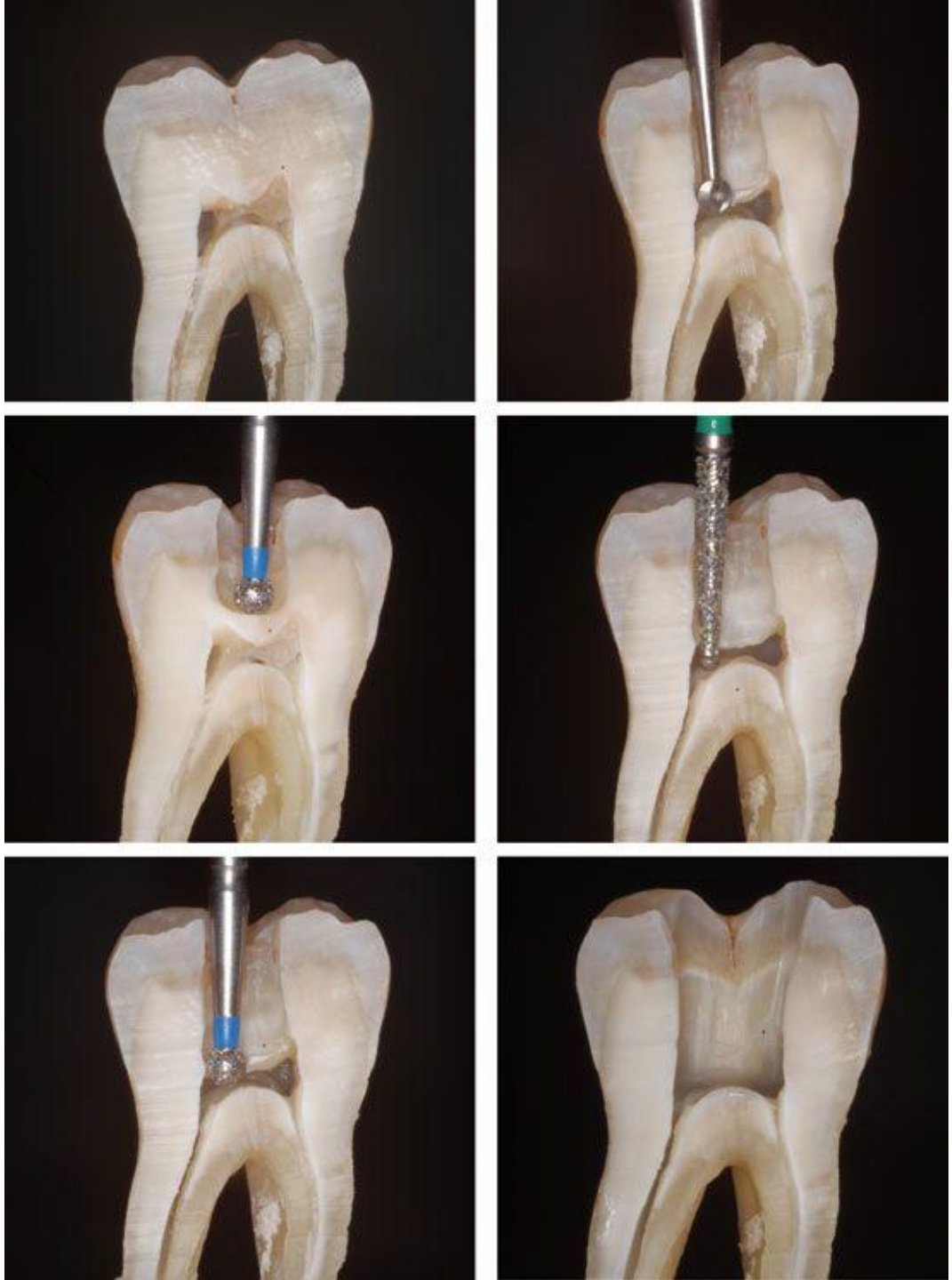


Burs

- In addition to conventional burs, ***burs with extended shanks*** for low-speed contra-angle handpieces are useful for providing good visibility during deep preparation of the pulp chamber.
- Various surgical length burs.
- The longer length of these burs allows a direct view



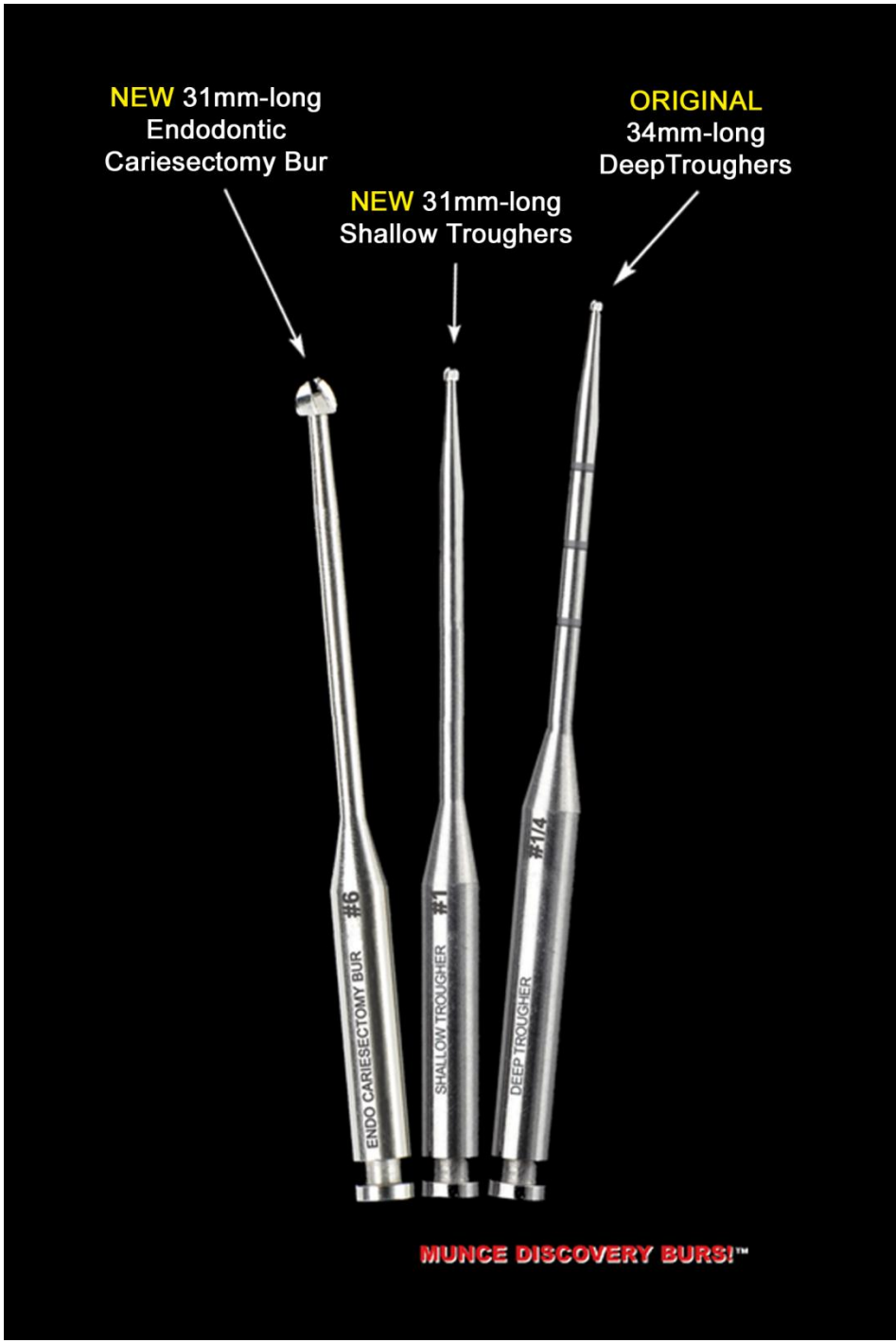
Endo Z
Endo Access
Transmetal
Long shank Round Carbide



Müller Burs

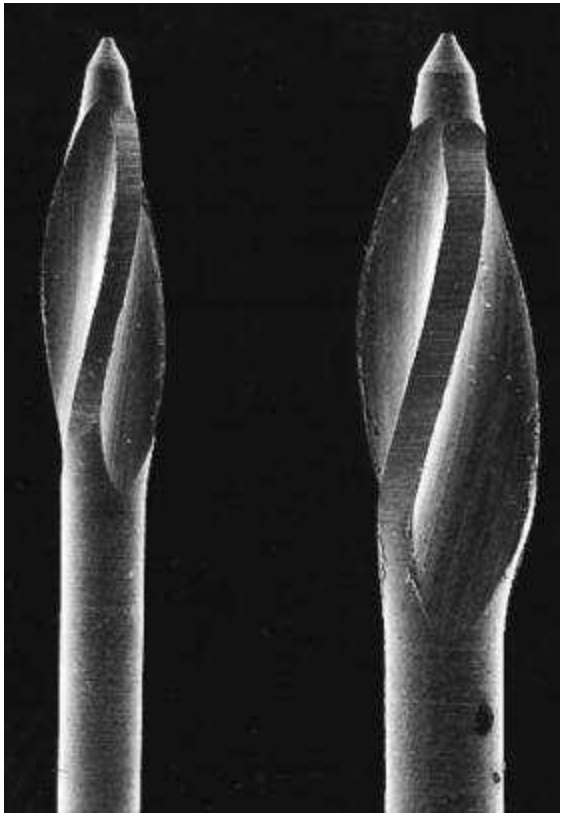
- The pulpal burs (Müller) combine a working end similar to a round bur with an especially long and elegant shaft.
- This provides excellent vision, even when working under the clinical microscope.

- Munce Discovery Burs are carbide endodontic burs
- Designed to uncover hidden canals, locate separated instruments and core-out fiber posts.

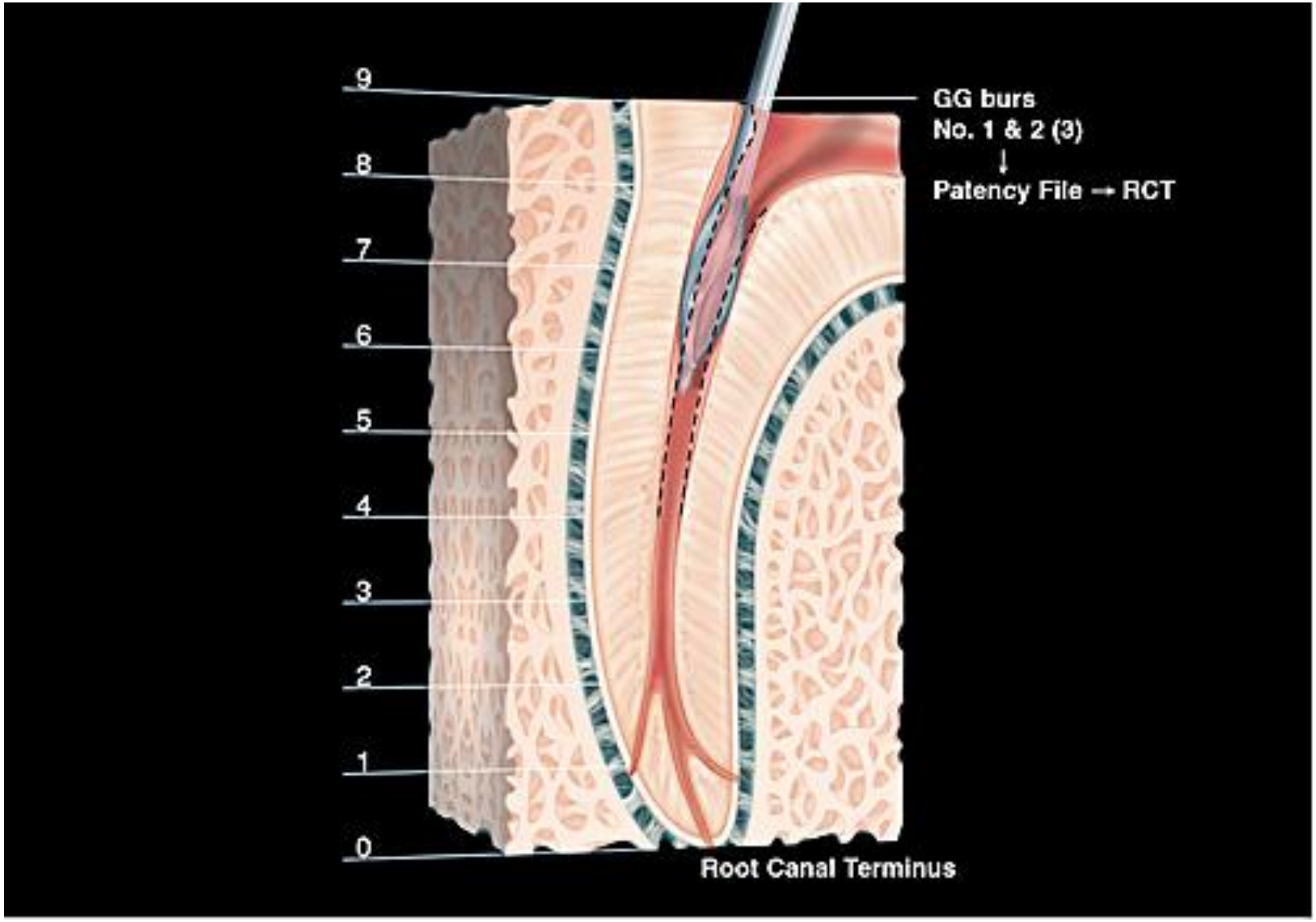


Gates Glidden Drills

- This has a ***long, thin shaft ending in a flame-shaped head with a non-cutting safe tip*** to guard against perforation.
- It is made of hardened carbon steel.
- **Uses:**
- For initial opening of the canal orifices.
- To remove the lingual shoulder in anterior teeth.
- Coronal flaring in coronal-apical (Crown-Down) technique.



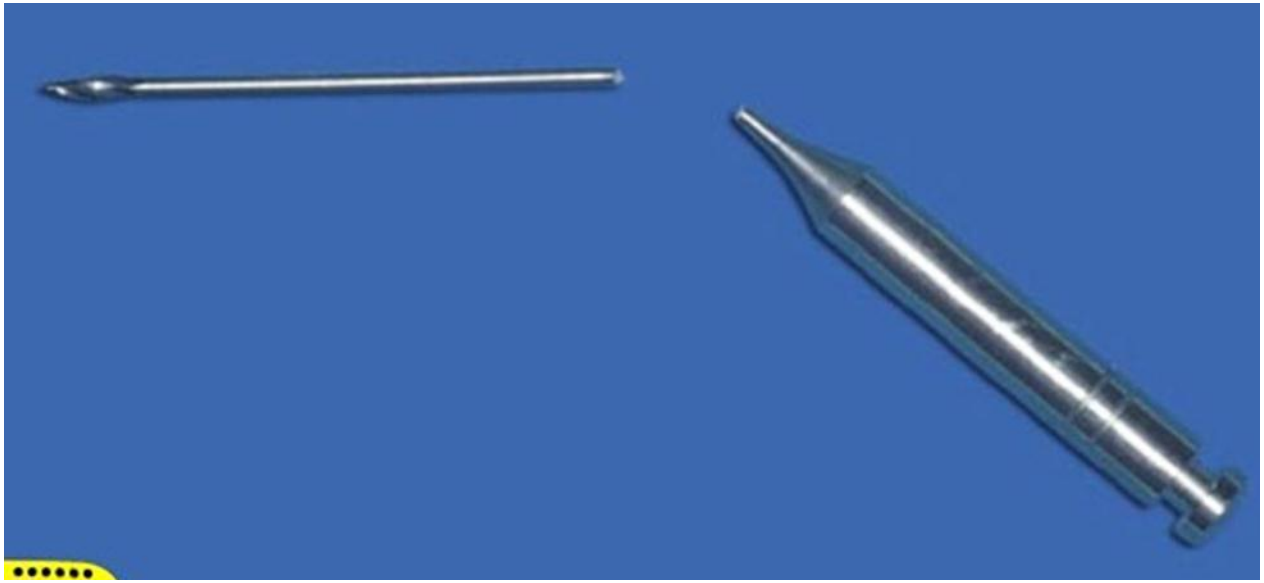
Gates Glidden Drills



Coronal Flaring

Gates Glidden Drills

- Instrument is designed to have a **weak spot** in the part of the shaft closest to the handpiece, so that, if the instrument separates, the separated part can be easily removed from the canal.



Gates Glidden Drills

- The ***flame shaped head cuts laterally and is used with a gentle, apically directed pressure***. It has a modified safe tip i.e. non-cutting tip.

- These instruments come in sizes 1 to 6.

Sizes

No. 1 - 0.50 mm
No. 2 - 0.70 mm
No. 3 - 0.90 mm
No. 4 - 1.10 mm
No.5 - 1.30 mm
No.6 - 1.50 mm

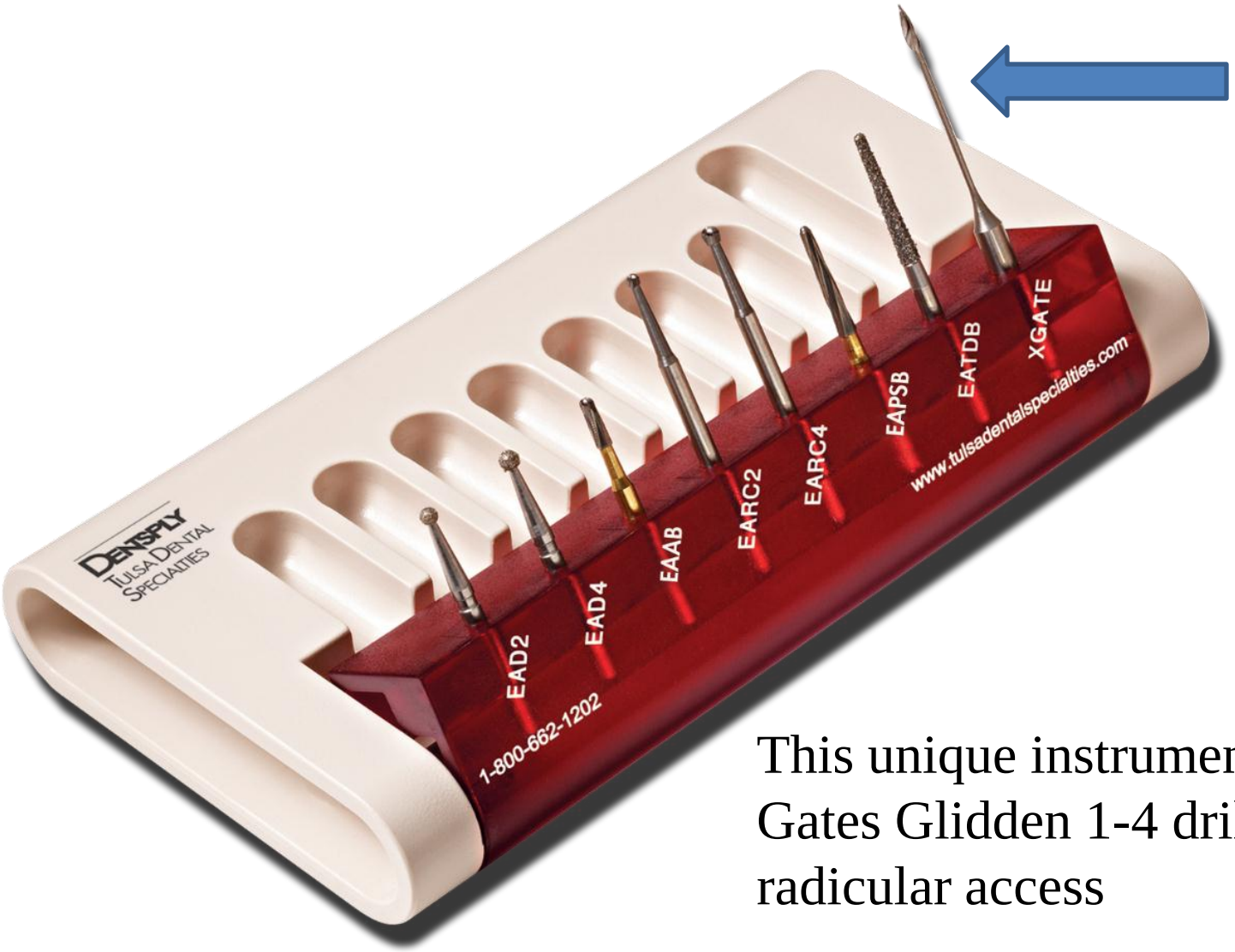
Speed – 750-1500 rpm.

Length- 28mm, 32mm.

FLEXOGATES

- **Flexogates (Dentsply/Maillefer; Tulsa**) are Modified Gates-Glidden NiTi instrument designed for apical preparation**.**
- It consist of a smooth, flexible shank which is circular and is small in cross section.
- Flame shape head and Non cutting tip
- Weak spot at the neck
- Landed design

X-Gates Drill



This unique instrument replaces the Gates Glidden 1-4 drills and is ideal for radicular access

PEESO REAMER

- It has long sharp flutes with a safe tip connected to a thick shaft.
- It is most often used in preparing the coronal part of the root canal for a post and core.
- It cuts laterally and hence may cause perforation if used injudiciously.
- These instruments are also available in no.1 to 6.

Sizes

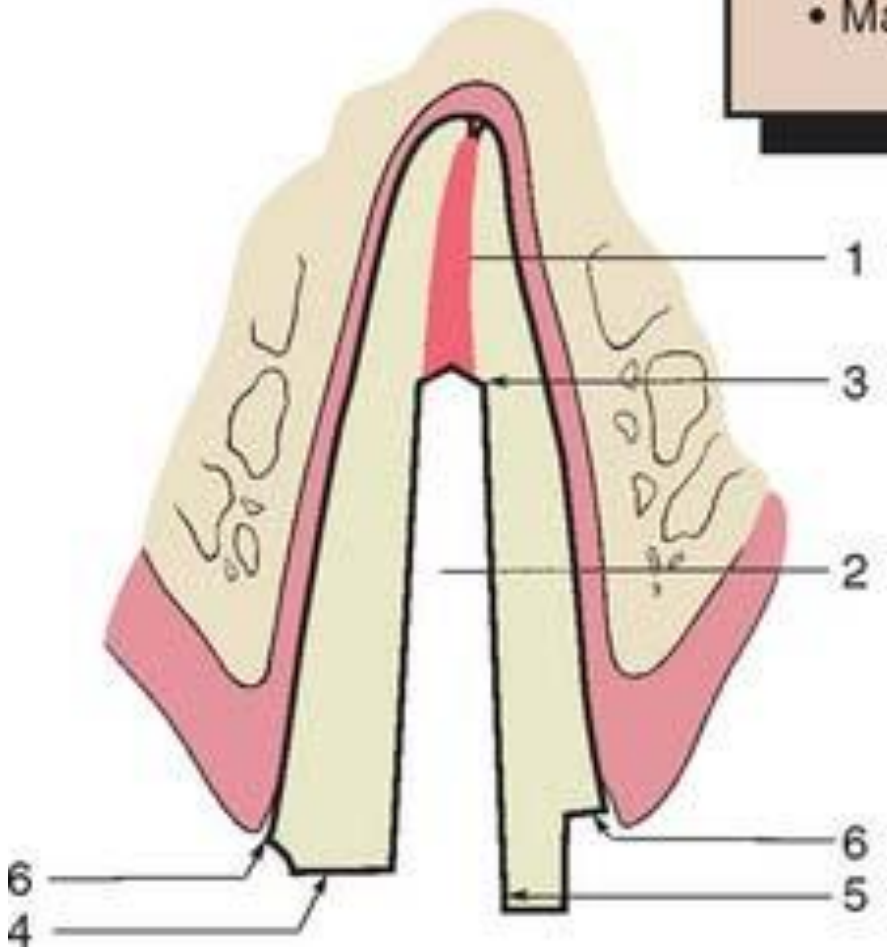
No. 1 - 0.70 mm
No. 2 - 0.90 mm
No. 3 - 1.10 mm
No.4 - 1.30 mm
No.5 - 1.50 mm
No.6 - 1.70 mm

Speed – 750-1500 rpm.

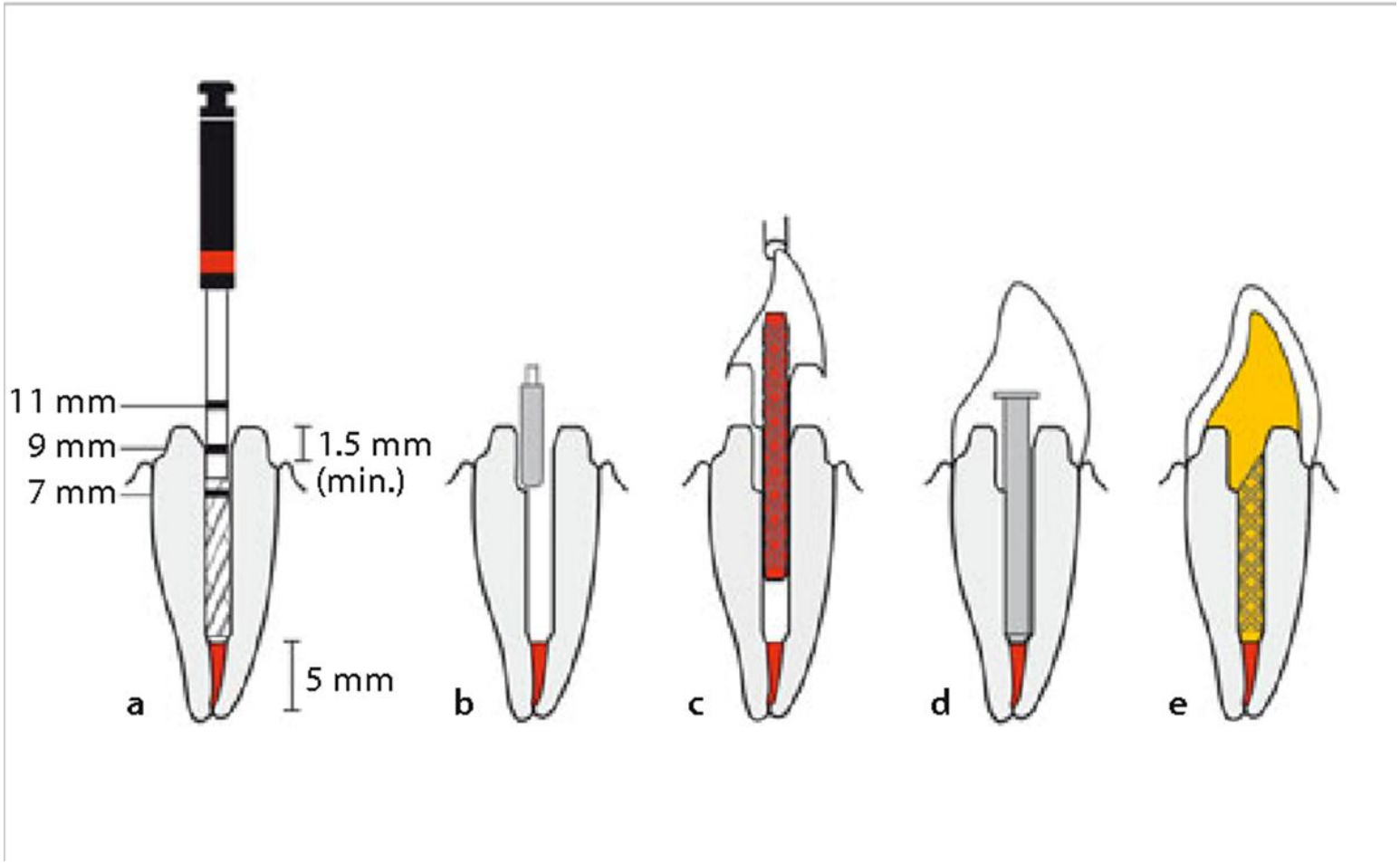
Length- 28mm, 32mm, 38mm.

POST SPACE PERPARATION

- Apical seal
- Minimal enlargement
- Length
- Stop
- Antirotation
- Margin extension

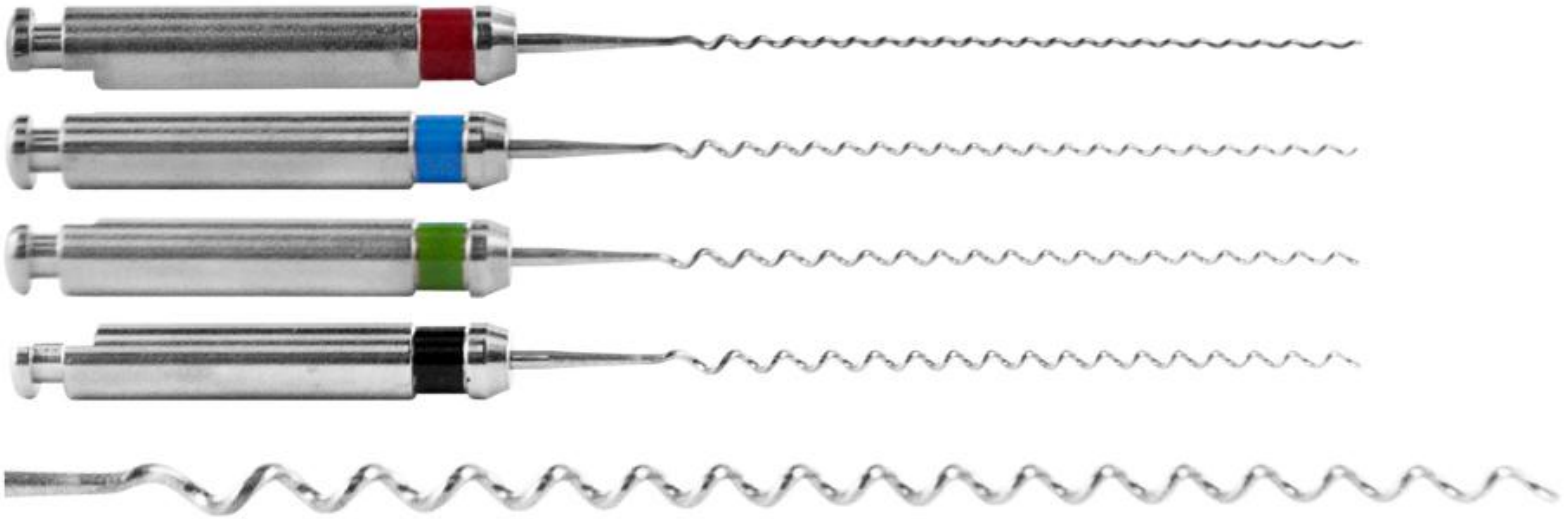


POST SPACE PERPARATION



Lentulo Spirals

- Paste Filler
- Small flexible instrument to place sealer/ Intra canal medicament in the canal
- Used with caution, snaps easily



Lentulo Spirals

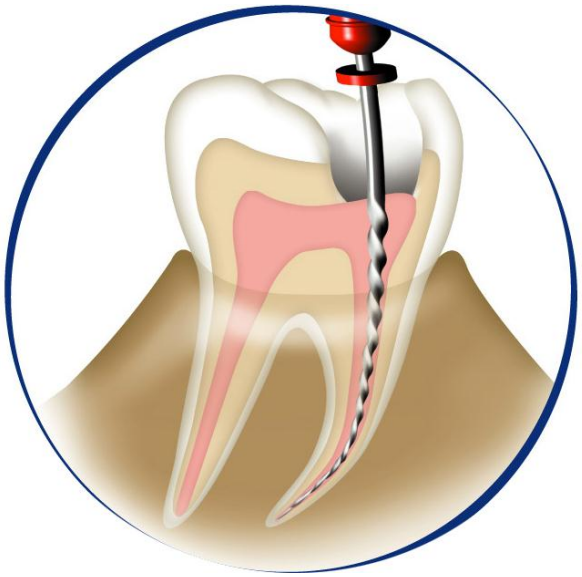
Size	
25	●
30	●
35	●
40	●
25-40	

Failure

Group III: Engine-driven Nickel Titanium Rotary Instruments

Disadvantages of Stainless Steel instruments

- Increased number of instruments and steps
- Increase time for canal preparation
- Each resultant shape is different
- Obturation is time consuming
- Increased chances for canal transportation
- Coronal enlargement burs cause excessive dentin removal



ROTARY REVOLUTION

Changes in files

- Material (SS to Ni Ti)
- Design (working end size, tip, taper, blank, rake angle, helical angle & pitch)

Changes in Handpiece

- Speed (gear reduction)
- Torque control

NICKEL-TITANIUM

- The greatest innovation in endodontic instrumentation in recent times – more than 25 years
- Instruments are entirely fabricated by a machining process, in contrast to the twisting of tapered wire blanks used for the traditional manufacturing of stainless steel instruments.
- Widespread popularity of nickel-titanium (NiTi) rotary instruments arises from the relatively low elastic modulus of the nickel titanium alloy, which permits use of these instruments in curved root canals that would present considerable difficulty for stainless steel instruments .

NICKEL-TITANIUM

- This super elastic property of nickel-titanium alloy (**Nitinol)** was discovered by **William F. Buehler** at the **US Naval Ordnance Laboratory in the early 1960s**.
- The name ***Nitinol*** was derived from the elements that make up the alloy, nickel and titanium, and “nol” for the Naval Ordnance Laboratory.
- The alloy used in endodontics is commonly referred to as 55 **NiTiNOL**.
- It contains about 55 wt% Ni and 45 wt% Ti and substituting some Ni with less than 2 wt% Co, nearly the same number of Ni and Ti atoms are combined, being reflected in the term *equiatomic*.

US Naval Ordnance Laboratory

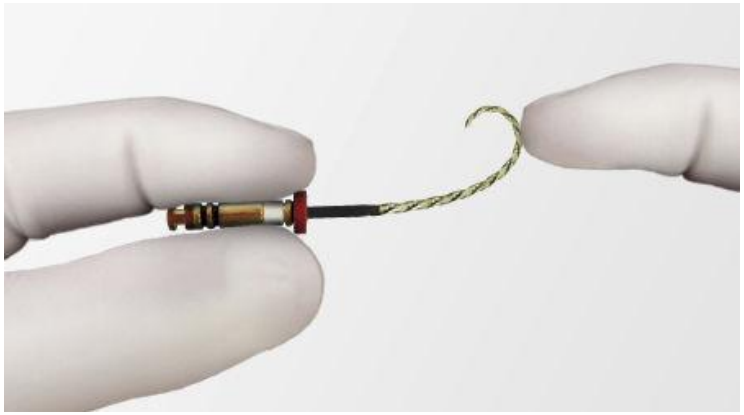
Features of Ni-Ti

a) Shape memory

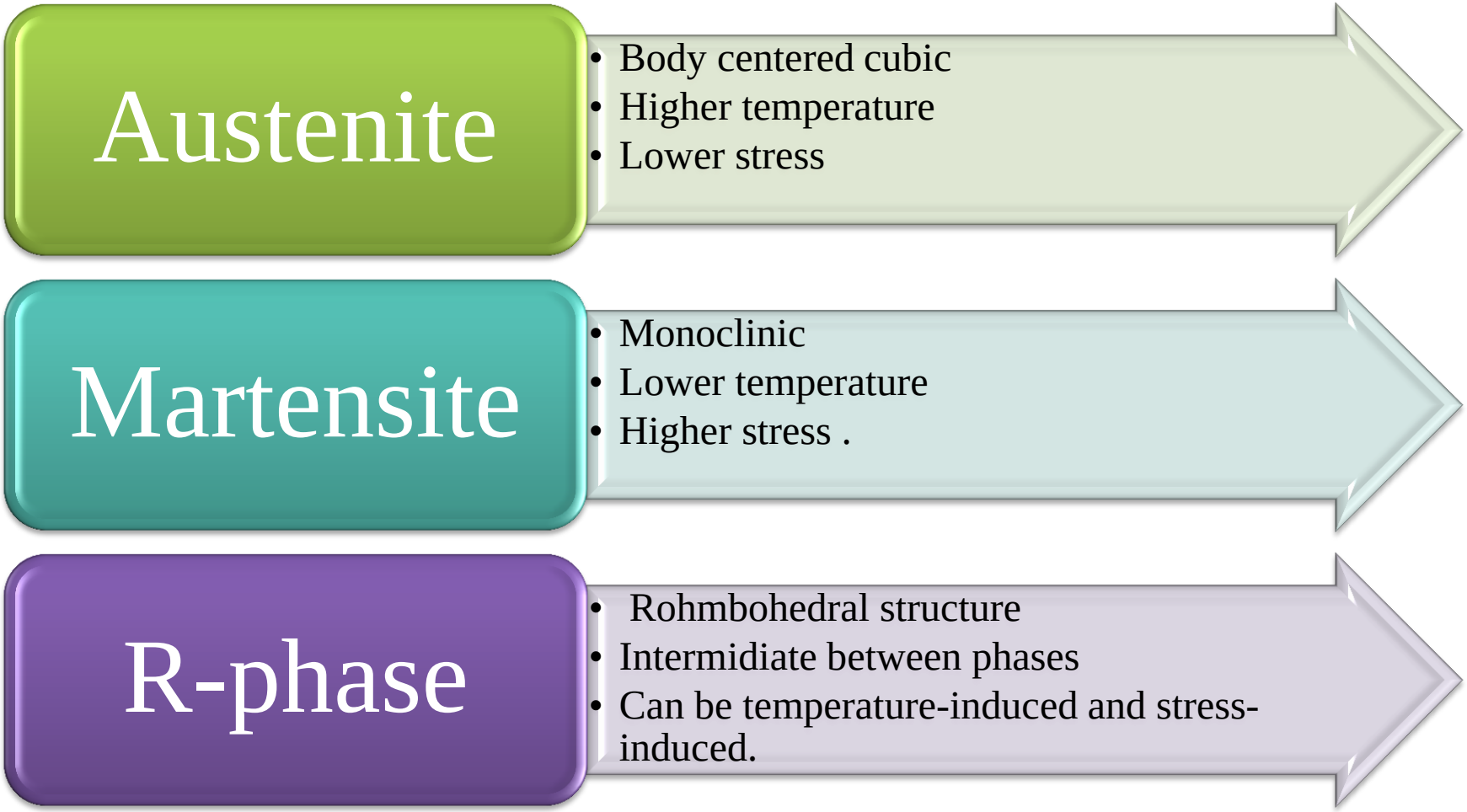
- The NiTi file comes back to its original straight form without showing any sign of lasting deformation.

b) Super/Pseudo elasticity

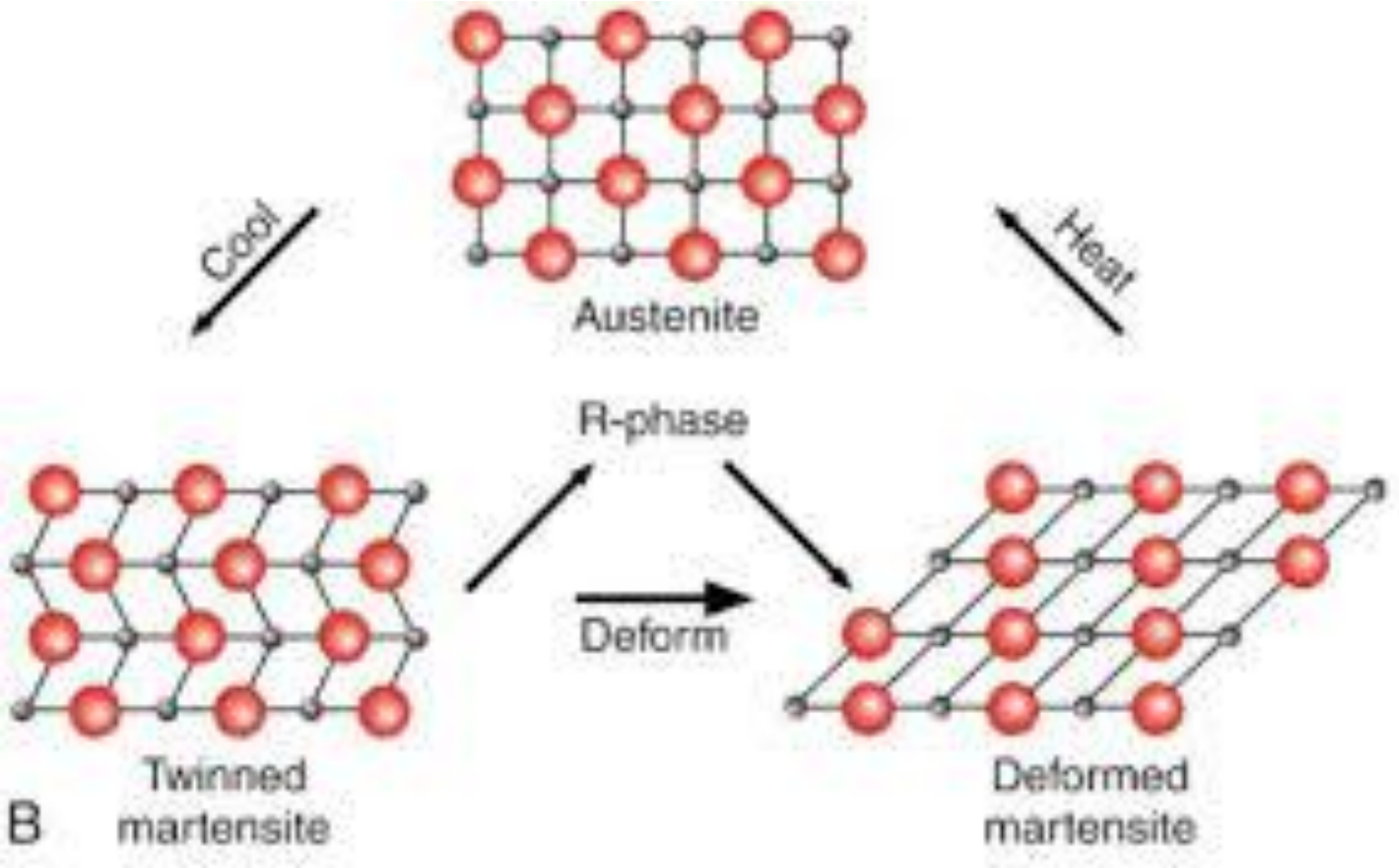
- The ability of resisting stress without permanent deformation and going back to the initial lattice form.



NiTi Phases

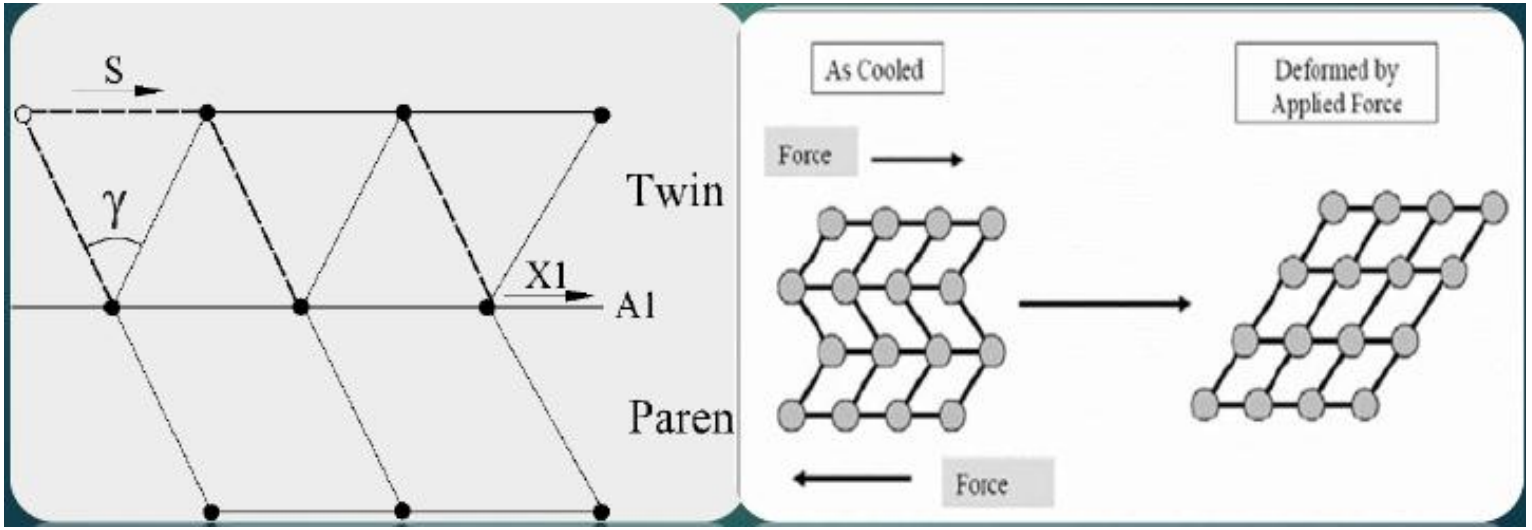

Austenite
Body centered cubic
Higher temperature
Lower stress
Martensite
Monoclinic
Lower temperature
Higher stress .
R-phase
Rohmbohedral structure
Intermidiate between phases
Can be temperature-induced and stress-induced.

Phase Transformation in NiTi

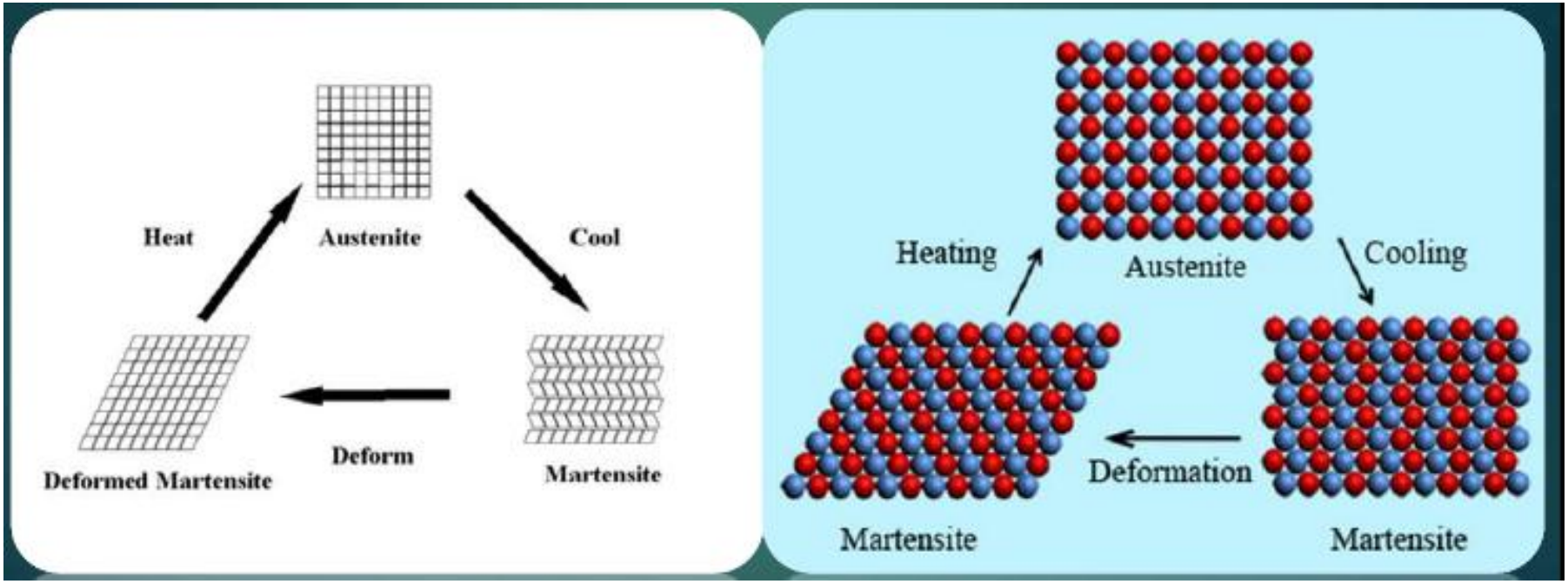


Twining

- Is the deformation that divide lattice into two symmetric parts at an angle(the rearrangement of atomic planes without causing slip, or permanent deformation. It is able to undergo about 6–8% strain in this manner)



High temperature → detwinning → Shape memory

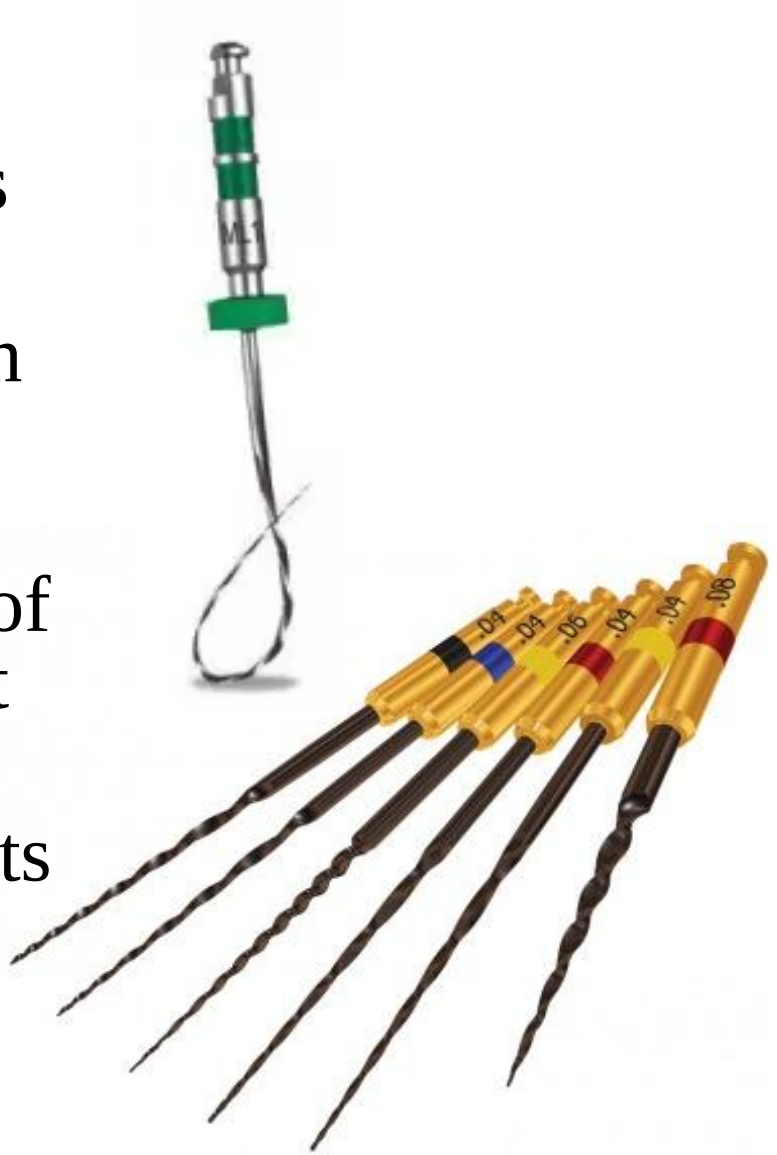


Properties of NiTi and stainless steel

PROPERTY	NiTi	Stainless steel
DENSITY (g/cm3)	6.45	8.03
Biocompatibility	EXCELLENT	FAIR
Elastic modulous Approx.	48 Gigapascal	193 Gigapascal
Recovered Elongation %	8 %	0.8%
Torqueability	EXCELLENT	POOR
Ultimate tensile strength Approx	1240 Megapascal	760 Megapascal

Advantages over stainless steel:

- NiTinol files have 2-3 times more flexibility than stainless steel (Walia et al 1988).
- Superior fracture resistance in clockwise and counter clockwise torsion.
- NiTinol can retain the shape of the curved canal and does not straighten like stainless steel.
- Ni-Ti undergoes large amounts of elastic deformation when compared to Stainless steel.



Disadvantages compared to Stainless Steel:

- Cutting efficiency of NiTinol is only 60% than that of matching S.S. file.
- Does not give any signs of fatigue before they fracture.
- More expensive.

Strategies of surface treatment

1- Plasma immersion ion implantation

2- Cryogenic treatment

3- Electropolishing

4 -Physical vapour deposition (PVD)

5–Electrical discharge Machining (EDM)

Surface treatment NiTi Why?

1- To enhance cleaning surface of Ni Ti instrument

2- Minimize defect, increase surface hardness and flexibility

3- Enhance cutting efficiency

4- Increase resistance to cyclic fatigue

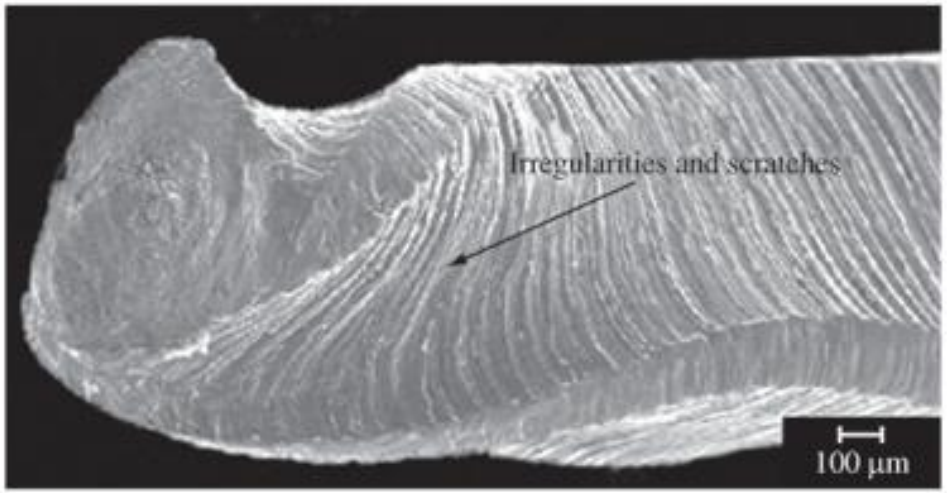
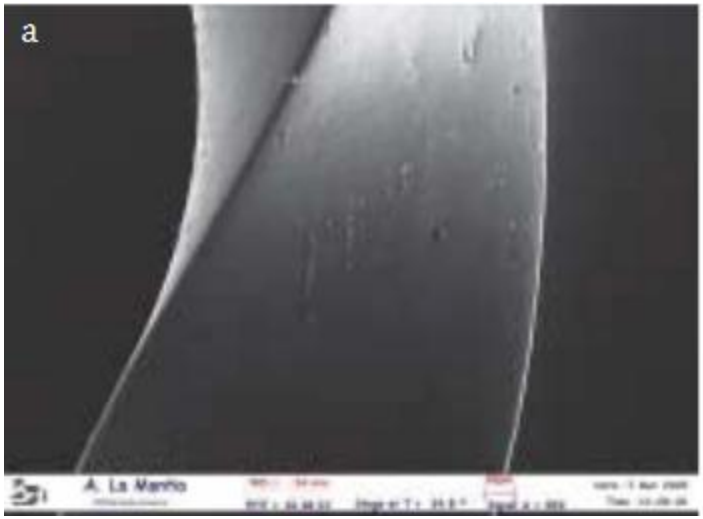
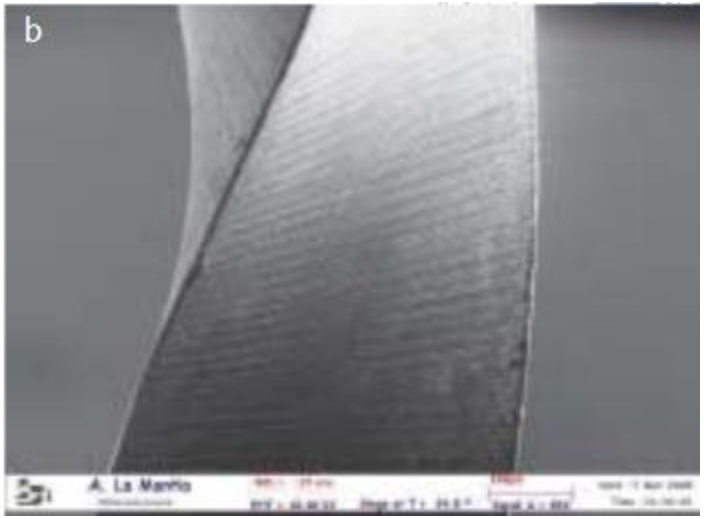


Figure 5. Representative morphology of an endodontic file (ProFile #15) after mechanical testing, showing the reversion in the direction of the helix. (SEM original magnification - 200x).





ROTARY REVOLUTION

Changes in Files

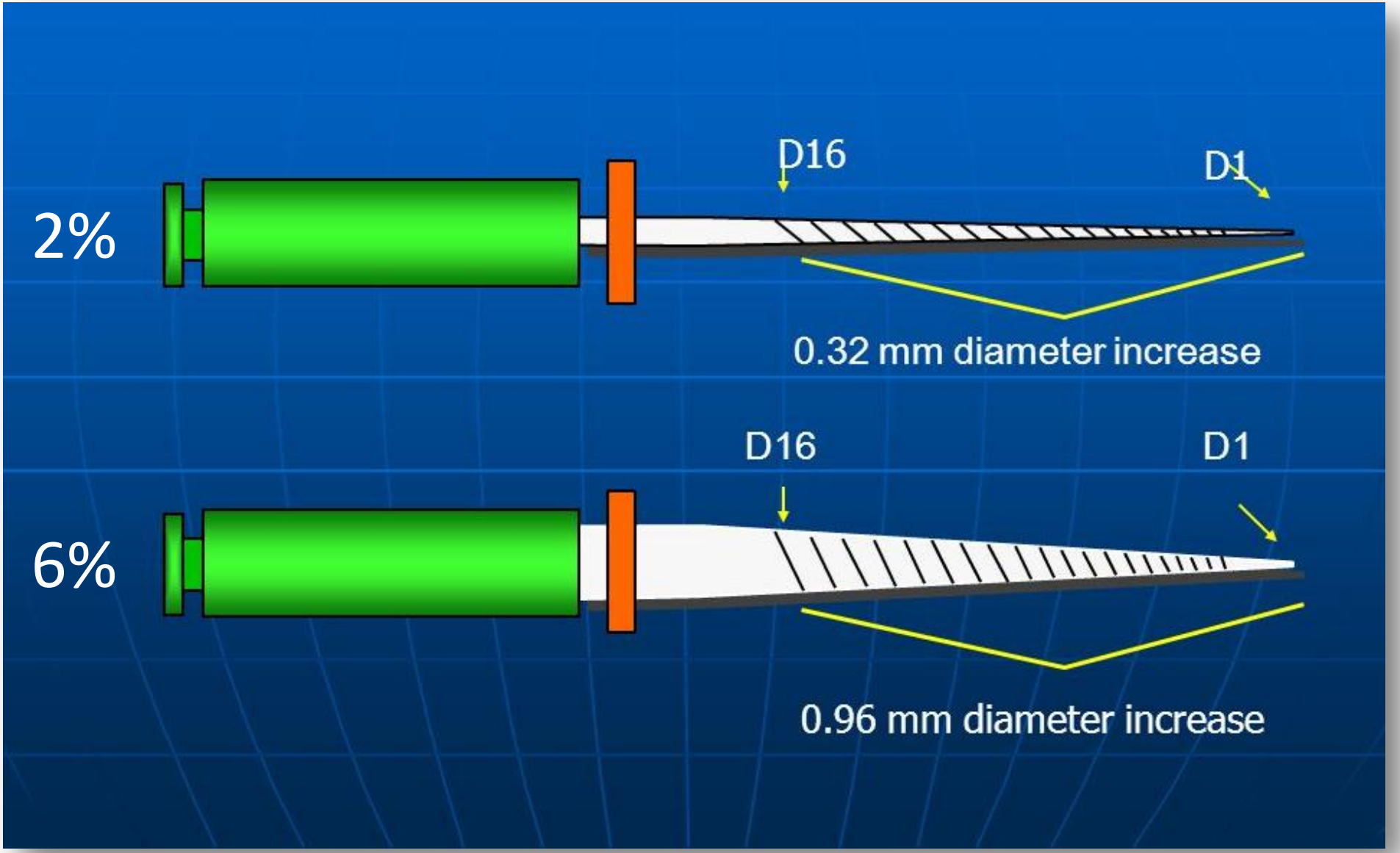
- Material (SS to Ni Ti)
- Design (working end size, tip, taper, blank, rake angle, helical angle & pitch)

Changes in Handpiece

- Speed (gear reduction)
- Torque control

Taper

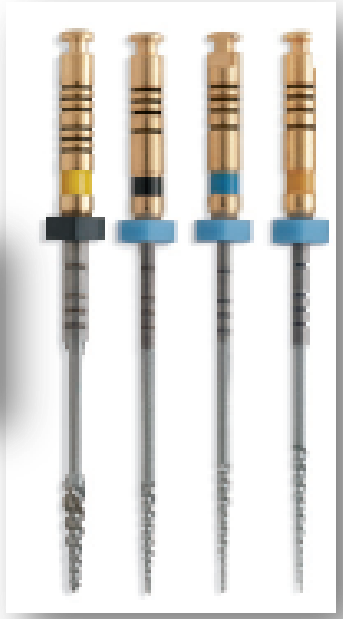
- The amount/percentage of the file diameter that increases each millimeter along its working surface from tip towards the handle


2%
D16
D1
0.32 mm diameter increase
6%
D16
D1
0.96 mm diameter increase

Tapers can be--

- Constant taper- Profile
- Varying or Graduating taper- Greater taper files (GT) & Quantec
- Progressive taper- ProTaper

Protaper



Greater taper

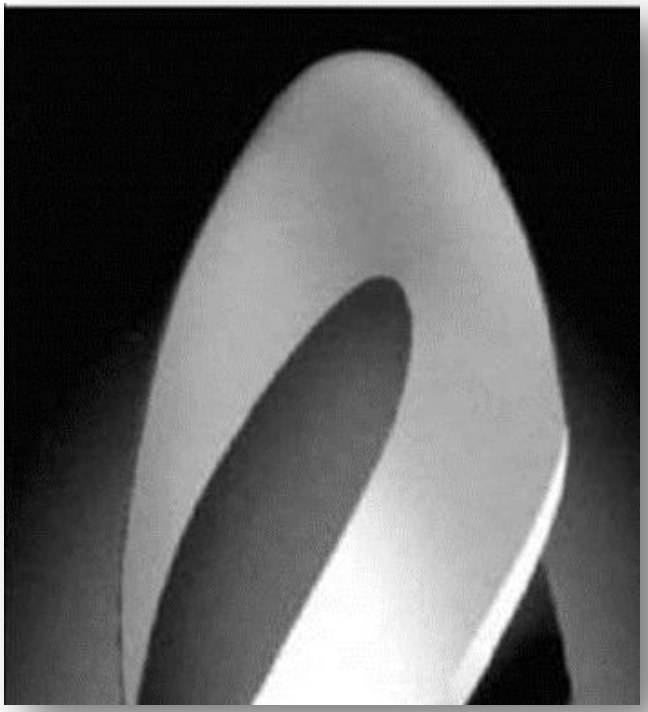
Quantec

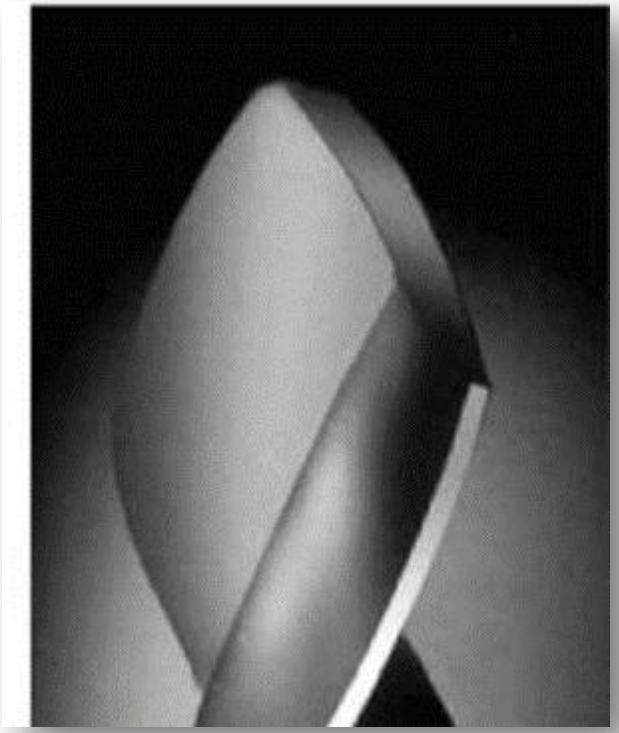
Taper

- **Constant taper** (Same taper & Different tip diameters)
- **Graduating taper** (Different tapers & same tip diameter)- idea behind variable or graduating tapers is that each successive file is only engaging a minimal aspect of the canal wall. Therefore, frictional resistance is reduced and requires less torque to properly run the file.
- **Progressive taper** along its shank- benefits of such a design is reduced torsional loading. Fewer number of files are required

Tip design

- Non-Cutting tip- Profile, GT, Light Speed, K3
- Cutting Tip- K-file, RaCe, Quantec





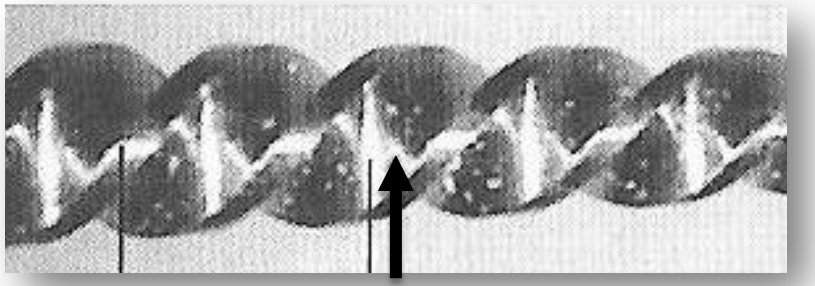
- Non cutting tips- remain centered thus creating no ledges, perforations
- Cutting tip- distinct possibility of transportation

A cutting tip will not transport if it goes to length and is immediately retracted/withdrawn

"Take any instrument to length only one time and for no more than one second, otherwise you risk transportation"

Flute

- Groove in working surface used to collect soft tissue and dentin chips removed from the wall of canal

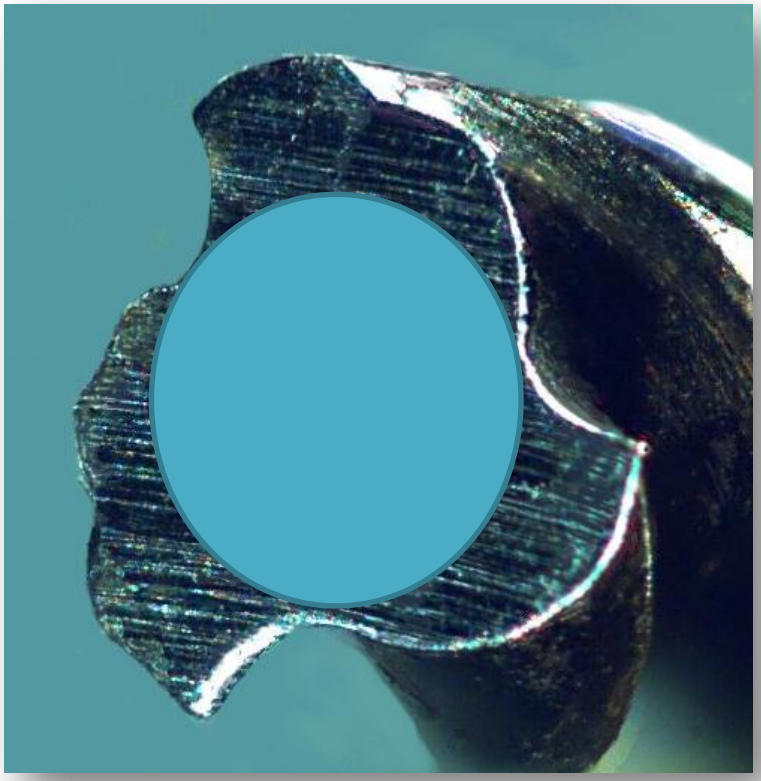


- Different for different instruments
- Effectiveness of flute depends on –

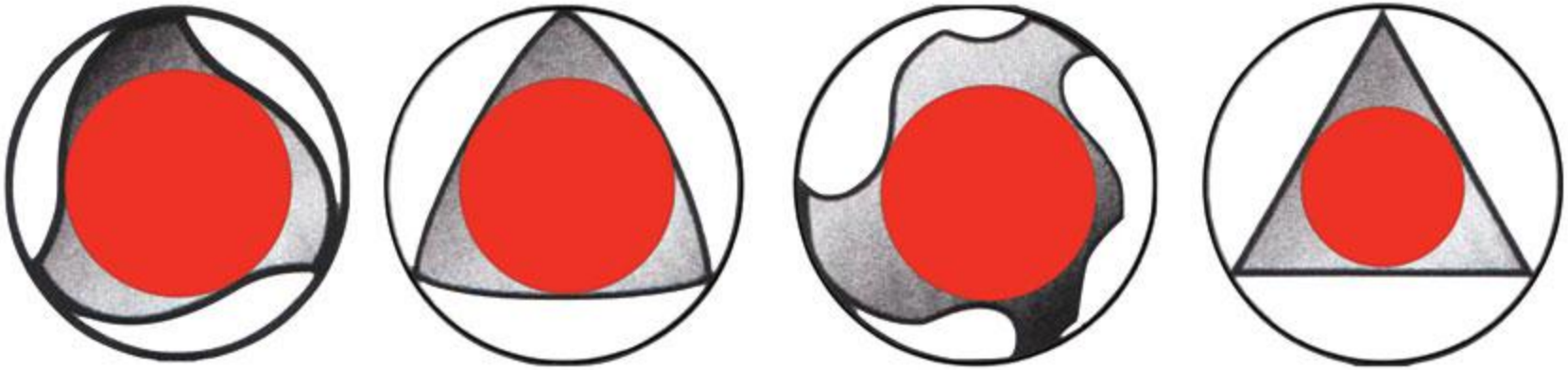
Depth	Width	Configuration	Surface finish

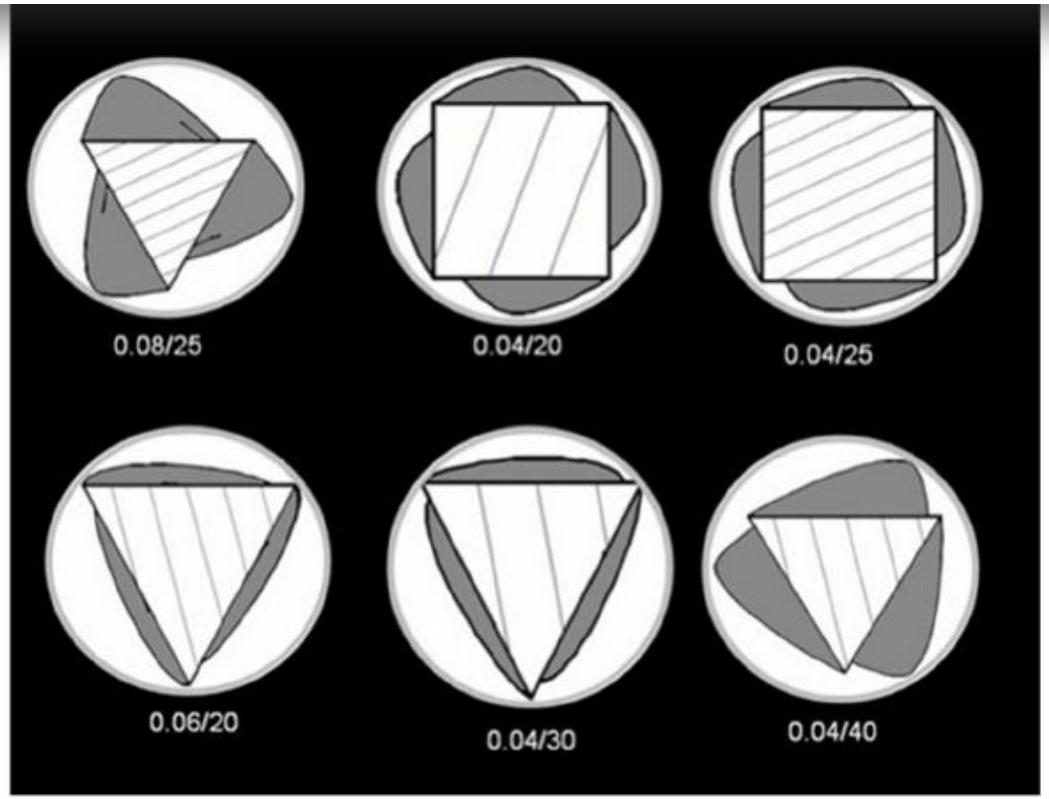
File core

- Cylindrical center part of the file having its circumference outlined and bordered by the depth of flutes
- Flexibility and resistance to torsion is partially determined by core diameter



Most files make a round shape

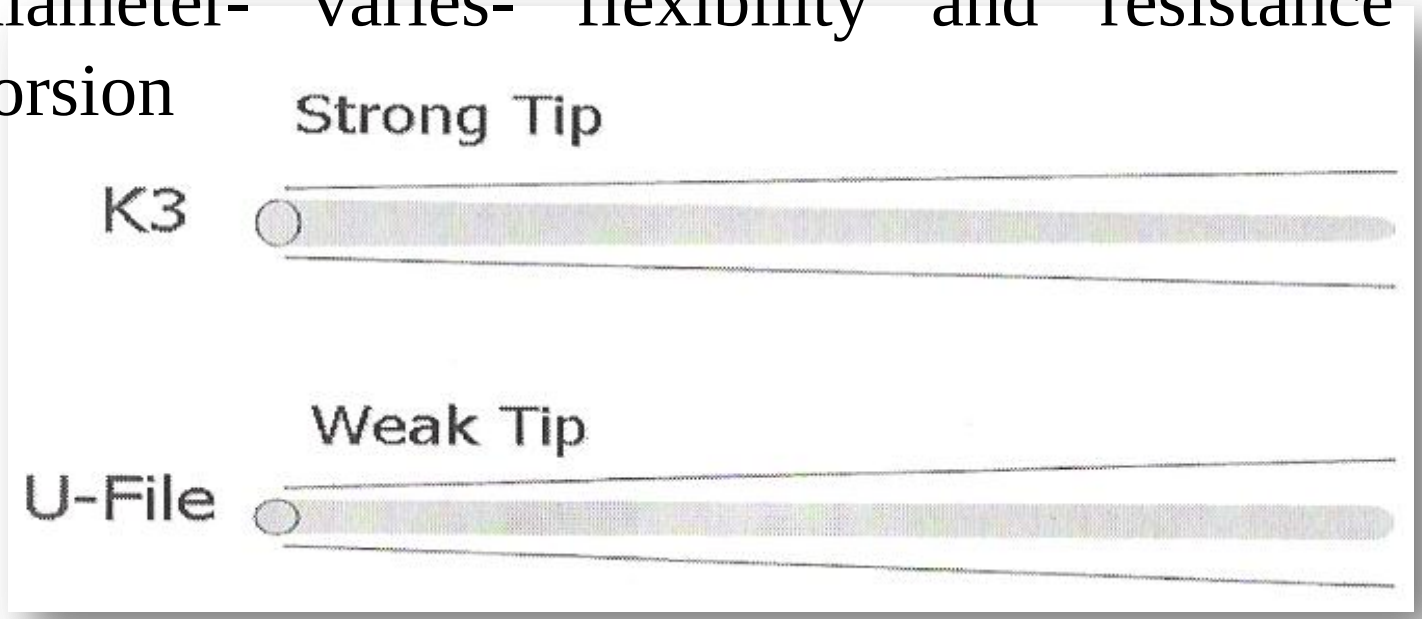




Core taper

- Core taper and total external taper (File Taper)- different

- Relative diameter of core compared to file's total diameter- varies- flexibility and resistance to torsion



Radial Land

Surface projection axially from central axis as far as the cutting edge between flutes

Functions of Radial lands

Reduces tendency of file to screw into the canal

Reduces transportation of canal

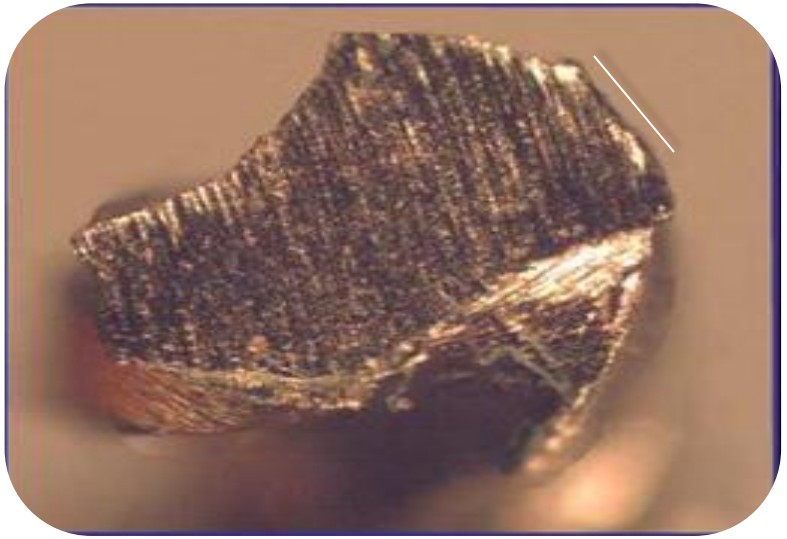
Reduces propagation of micro cracks on its circumference

Supports the cutting edge

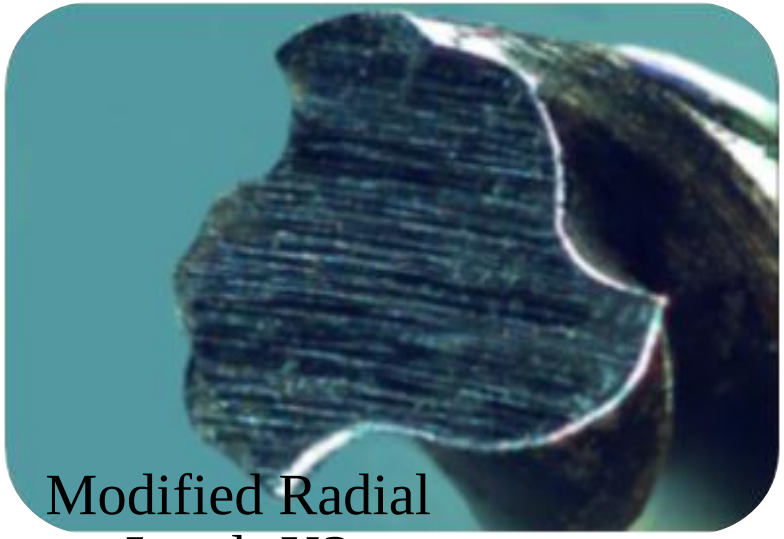
Limits the depth of cut

Types of Radial land

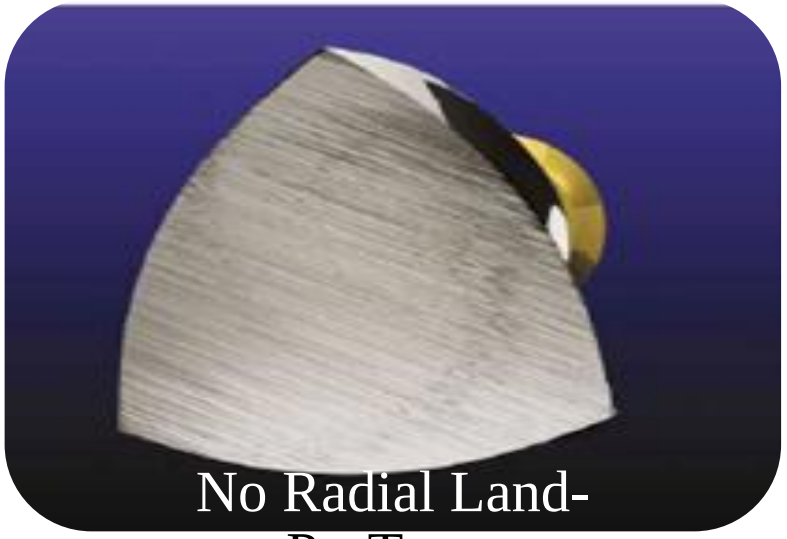
Full Radial Land-Profile



Recessed Land- Quantec



Modified Radial Land- K3



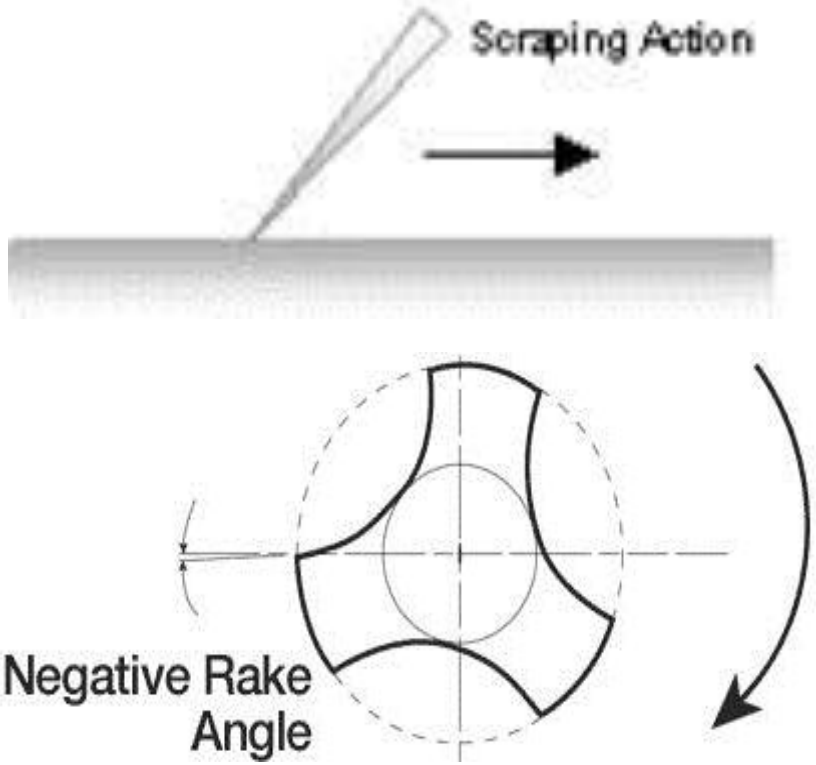
No Radial Land- ProTaper


Wide radial land- increases friction
Thin marginal land with more core- good cutting, increased strength

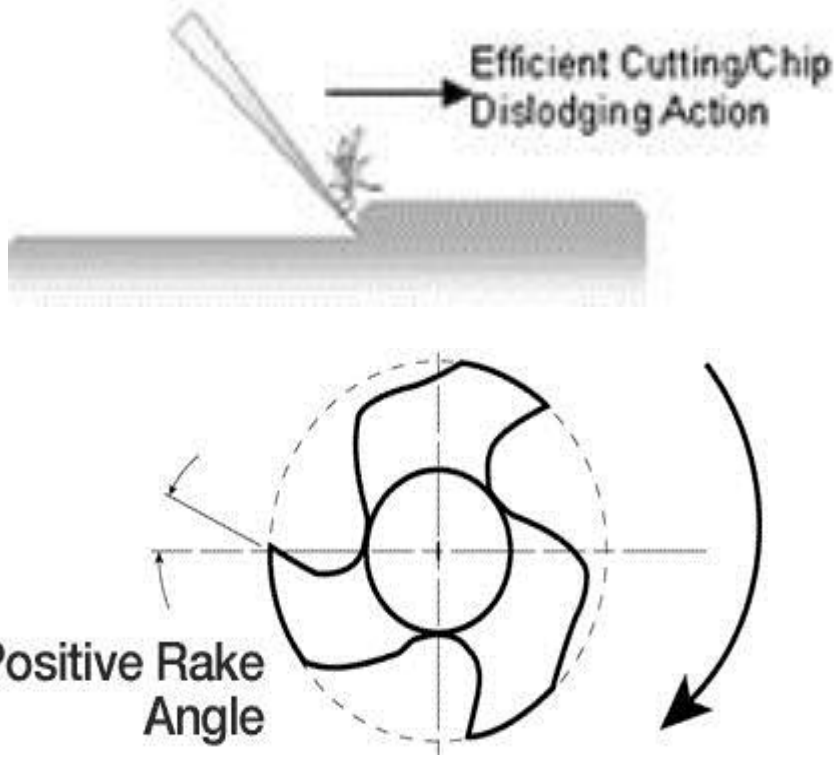
Rake Angle

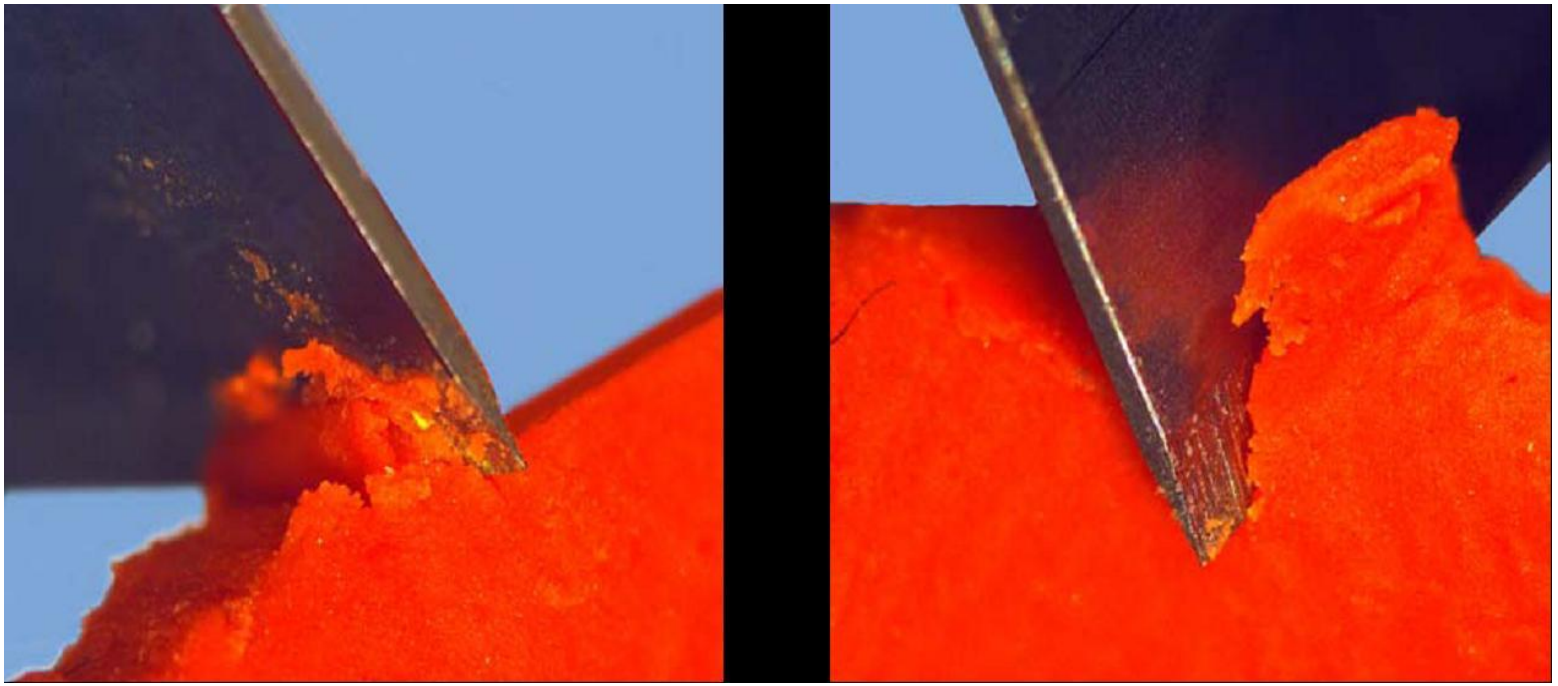
Angle formed by the leading edge and radius of the file

Negative rake angle



Positive rake angle



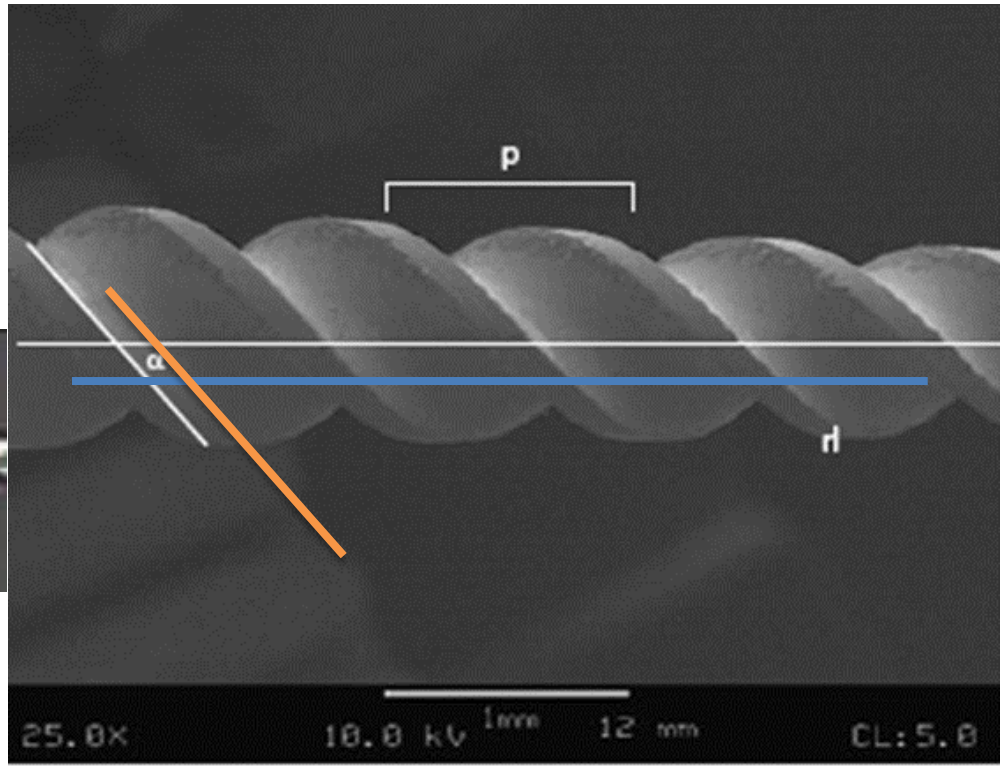


Negative angle

Positive angle

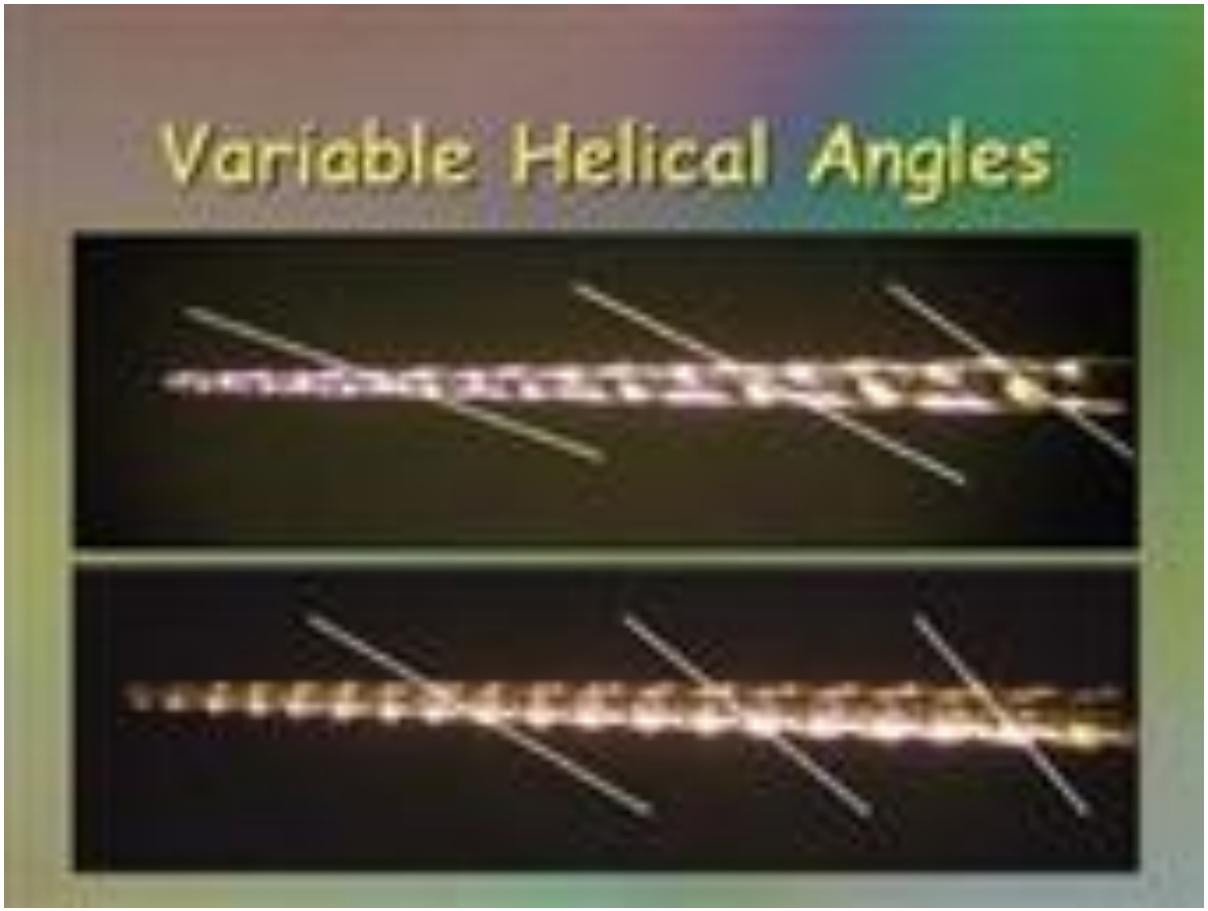
Helical angle

Helical angle is the angle that the cutting edge makes with the long axis of the file



Constant helical flute angle - debris accumulation, "screwing in" forces.

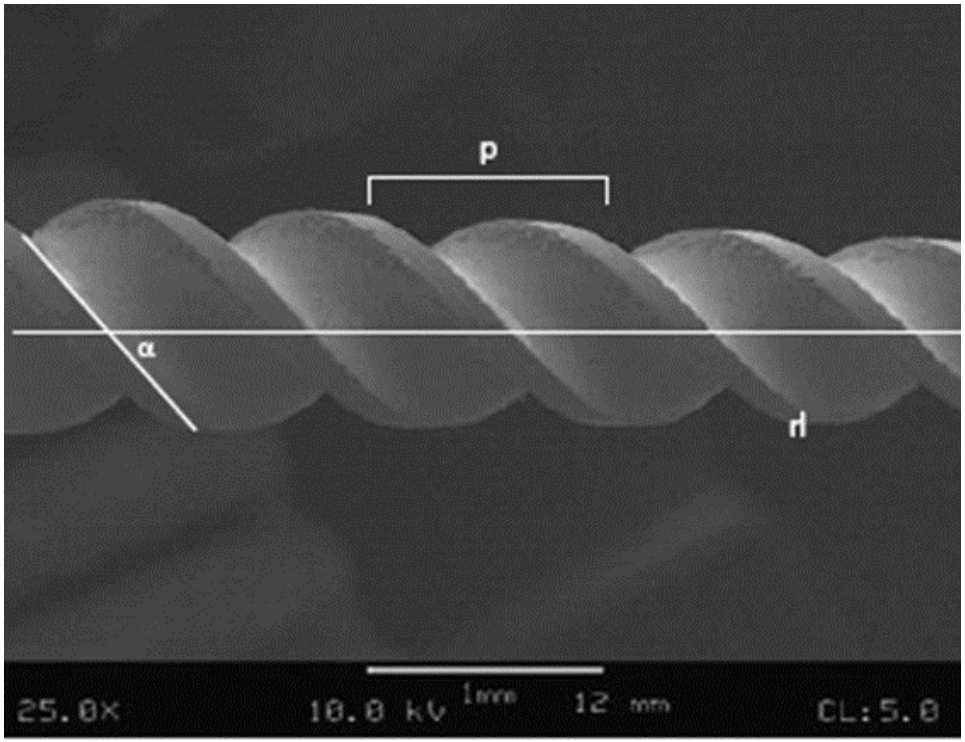
Variable helical flute angles- debris removed in a more efficient manner, file less likely to screw into canal



Alternating helical design- RaCe- reduces rotational torque by using spiralled and non spiralled portions along the working length

Pitch

- Distance between a point on the leading edge and the corresponding point on the adjacent leading edge
- Smaller pitch- more spirals- greater helical angle



Variable pitch & helical angle and constant taper- GT, RaCe, K3.

Variable Pitch & helical angle and progressive taper- Protaper

Constant pitch and same taper- Profile

Ni-Ti Rotary Instrumentation Rules

- The slowest recommended speed appears to be the safest.
- Always lubricate NiTi rotary instruments.(17% EDTA Gel)
- Ensure there is support for the clinician's hand (to compensate for patient movement and for better control of the instrument, and also to reduce the "screwing in" effect).
- Ensure continuous irrigation/flooding of the root canals with Sodium Hypochlorite (or EDTA) during root canal preparation.
- Minimize apically directed pressure on the instrument.

Ni-Ti Rotary Instrumentation Rules

- Permit the instrument to continuously rotate (from introduction into the canal until removal).
- Minimize the cutting time (immediately withdraw the instrument on reaching the desired length).
- Each new introduction of the same instrument should penetrate more deeply into the canal.
- Following the removal of each instrument it should be cleaned and inspected, and replaced as necessary/appropriate.
- Following the use of each instrument, the canal must be thoroughly irrigated, recapitulated, and re-irrigated.
- Apical patency must be regularly confirmed/checked.

ROTARY REVOLUTION

Changes in files

- Material (SS to Ni Ti)
- Design (working end size, tip, taper, blank, rake angle, helical angle & pitch)

Changes in Handpiece

- Speed (gear reduction)
- Torque control

Importance of Speed and Torque

- Speed refers not only to revolutions per minute but also to the surface feet per unit that the tool has, with the work to be cut.
- Greater the speed, more the cutting efficiency
- However there are more disadvantages such as

Loss of tactile sensation	Breakage of instruments preceded by flute distortion	Change in anatomical curvature of canal	Loss of control

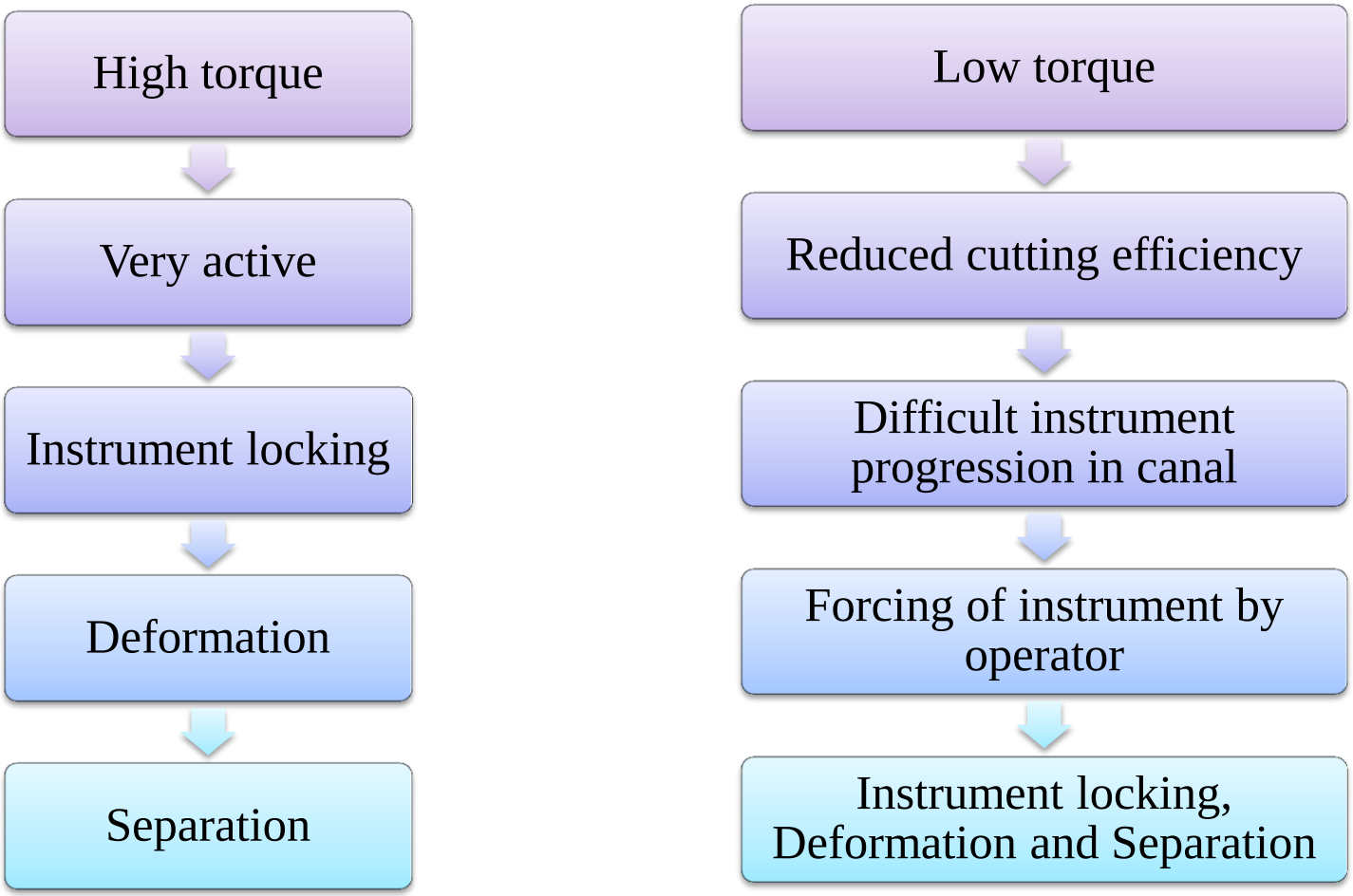
TORQUE IN DENTISTRY

- In many aspects of practice in dentistry, especially for root canal preparation, there is a turning force on an instrument.

- Torque is the ability of the handpiece to withstand lateral pressure on the revolving tool without decreasing its speed or reducing its cutting efficiency.

Marzouk

Importance of Torque- during Cleaning and Shaping



Low torque control motors- torque values set on the motor are supposed to be less than the value of torque at deformation and at separation of the rotary instruments.

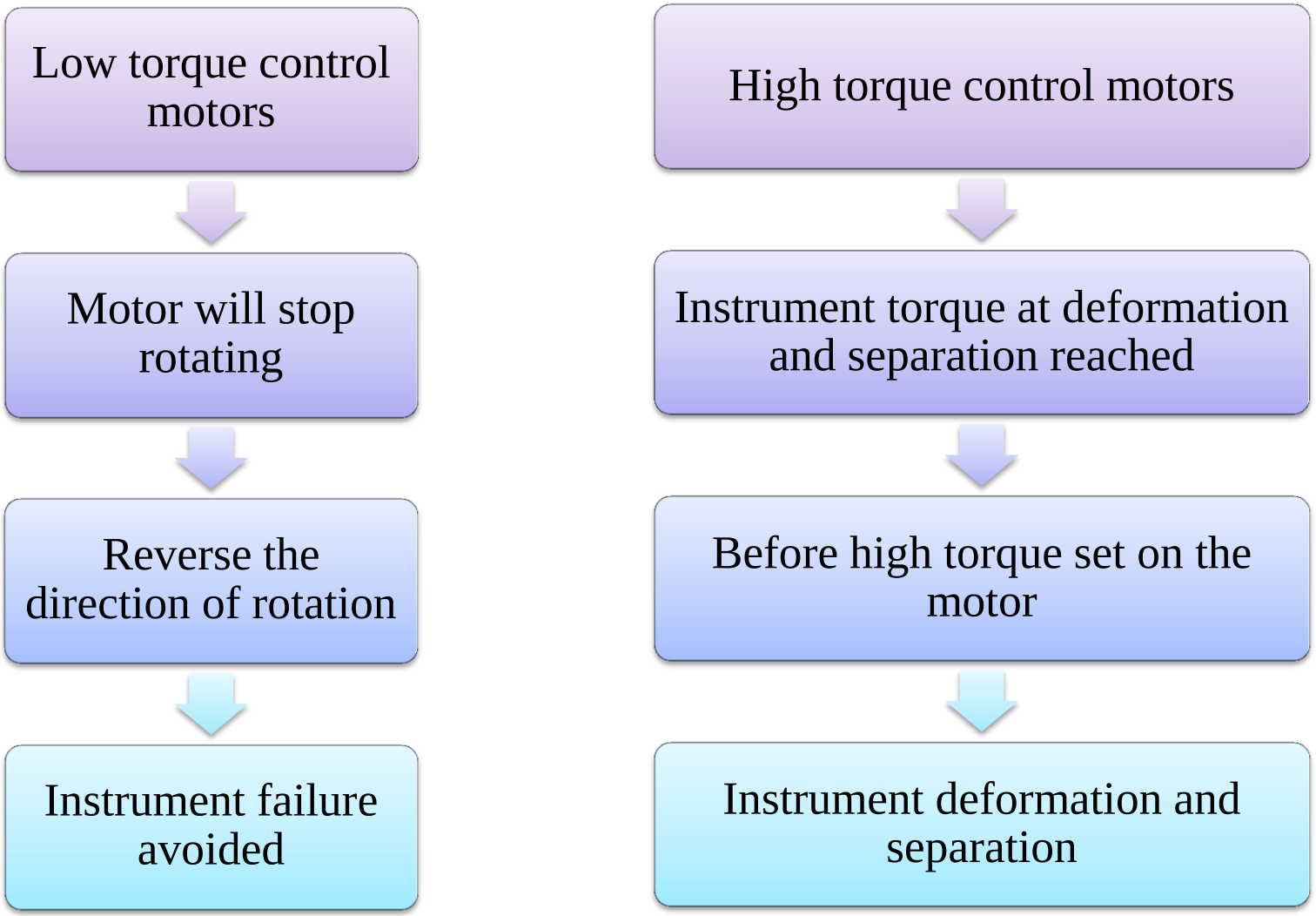
High torque control motors- torque values are relatively high compared to the torque at deformation and at separation of the rotary instruments.

During Root canal preparation

Instruments subjected to Different levels of torque

Torque level equal or greater than the torque at deformation or separation

Instrument will either deform or separate


Low torque control motors
Motor will stop rotating
Reverse the direction of rotation
Instrument failure avoided
High torque control motors
Instrument torque at deformation and separation reached
Before high torque set on the motor
Instrument deformation and separation

HANDPIECES USED IN ENDODONTICS

Quarter turn handpieces (Reciprocating)

- Giromatic
- Endo-Cursor

Vertical Stroke handpieces

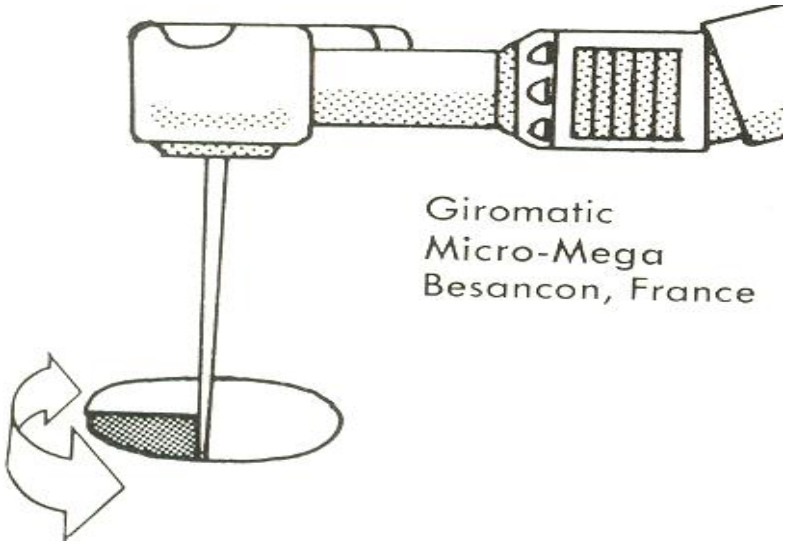
- Racer
- Canal Finder System
- Societe endotechnic handpiece

Full Rotary handpieces

- Latch grip
- Friction grip

Reciprocating / quarter turn handpieces

GIROMATIC (1964)–



- Contraangled flat plane, Reciprocating handpiece.

- Activates reamer/file through 90^0 reciprocating arc at a speed of 1000 cycles/min.

Disadvantages-

Packed dentinal shavings in canal

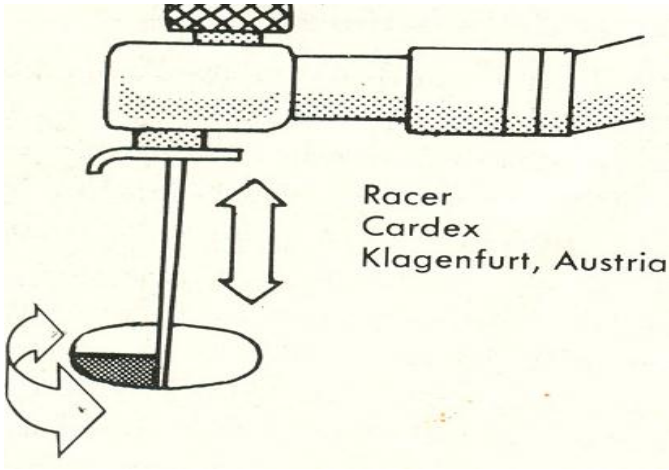
Tendency for creating ledges

Flaring the apex

Canal deviation

Less effective for preparing canals

Vertical stroke handpieces



RACER CONTRA-ANGLE HANDPIECE

- Standard file which oscillates in root canal in an arc of 90˚
- Vertical component of oscillation too
- Disadvantage- Debris may be forced ahead of instrument, with resulting clogging of the canal, also leads to binding

SOCIETE ENDOTECHNIC HANDPIECE

- Length wise vibratory motion to an endodontic file
- No rotation
- Clutch action which allows the file to stop working when too great a resistance is met

- M4 Safety Handpiece (30º)
- Endo-Gripper (45º)
- Endolift --with a combined vertical and 90 degree rotational motion
- The Excalibur handpiece- with laterally oscillating instruments canals
- Endoplaner -an upward filing motion

Full Rotary Handpieces

Torque Limited Rotational Handpieces-

Handpiece	Anthogyr NiTi control	ENDOflash	ENDOadvance	Mtwo direct	SiroNiTi Air+
Manufacturer	Dentsply Maillefer	KaVo	KaVo	Sirona/VDW	Sirona
Suitable for	All NiTi files	Only ENDOflash NiTi and stainless steel files	All NiTi files	Mtwo	All NiTi files
Torque levels	4	3	4	8	5
Reduction	64:1 and 128:1	120:1	120:1	115:1	115:1
Rotational speed (rpm)	312	333	333	350	350–600
Reverse rotation	No	No	No	Yes	Yes

Motor	Suitable for	Torque (Ncm)	Torque levels	Rotational speed (rpm)
ATR Tecnica (Dentsply)	Settings for ProFile, ProTaper, System GT	5–100	Individual for each file	100–800
Dentaport ZX (Morita)	All NiTi files (except LightSpeed)	0.3–4.9	11	0–400
Endo IT (VDW)	All NiTi files	15–500 gcm	Individual for each file	150–1860
EndoStepper (SET)	All NiTi files	0–3.5	Individual for each file	1–5000
NSK Endo-Mate DT	All NiTi files	0.7–4.5	5	125–625
TCM Endo V (Nouvag)	All NiTi files	2–50 Nmm	10	150–2000
TriAuto ZX (Morita)	All NiTi files (except LightSpeed)	0.3–2.6	8	260–300
VDW.Gold (VDW)	All NiTi files	20–500 gcm	Individual for each file	200–2000
VDW.Silver (VDW)	All NiTi files; settings only for FlexMaster and Mtwo	20–410 gcm	15	250–1000
X-Smart (Maillefer)	All NiTi files	0.6–5.2	9	120–800

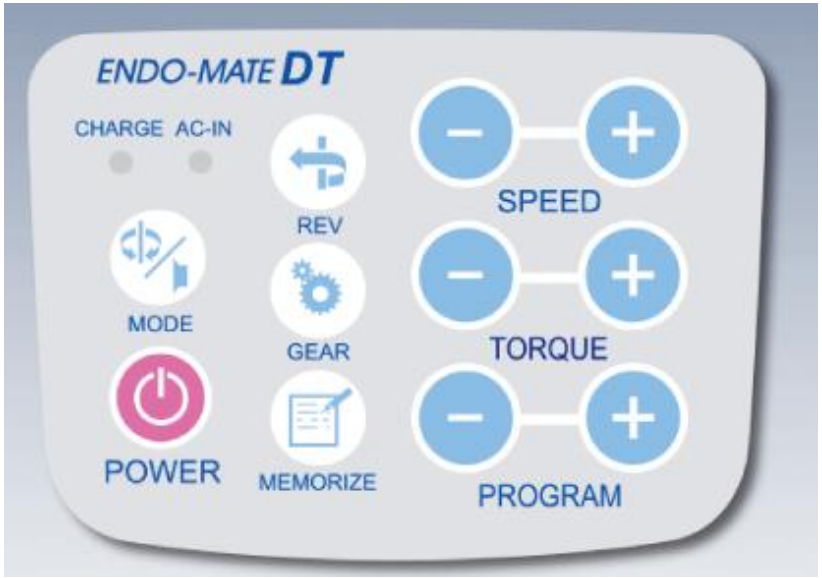
Endodontic motor features-

- Push button chuck
- Auto-Start Stop
- Auto Torque Reverse (ATR)
- Auto Apical Reverse (AAR)
- Built in apex locator

Triauto Zx


NSK
SPEED
300
TORQUE
3.0
GEAR
20:1
PROGRAM
1
ENDO-MATE DT
POWER
SPEED
TORQUE
PROGRAM


NSK
TC2
NSK


ENDO-MATE DT
CHARGE AC-IN
REV
SPEED
MODE
GEAR
TORQUE
POWER
MEMORIZE
PROGRAM

- Endo Mate

Dentaport Zx

X Smart


SPEED
250
min⁻¹
TORQUE
5.0
Ncm
GEAR
16:1
PROGRAM
6
DENSPLY
MAILLEFER
X-SMART
CHRG
AC IN
AUTOREV
REV
GEAR
MEMO
POWER
CAL
SPEED
TORQUE
PROGRAM

Electric torque controlled rotary and reciprocating motors

- ATR Vision
- X-Smart Plus
- VDW Silver Reciproc
- VDW Gold Reciproc

X Smart Plus

VDW Gold