Insturments Used in Endodontics

The technical demands and level of precision required for sccessful performance of Endodontic procedures is achieved by careful manipulation of instruments and by strict adherence to biological and mechanical principles. Although the armamentarium of endodontics has grown in complexity over the past 30 years, yet, the basic instruments used today are not much different from those used at the turn of the century.

Classification of endodontic instruments

Different classifications for endodontic instruments have been proposed, however, the easiest would be to classify the instruments according to their sequence of usage during performing root canal procedure.

I- Diagnostic instruments

II- Extirpating instruments

III- Enlarging instruments

IV- Obturating instruments

V- Miscellaneous

I- Diagnostic instruments

In addition to basic examination instruments (mirror, explorer and twizer) a number of specialized devices are necessary for evaluating the status of the teeth and the surrounding tissues.

(1) ***Visual aids***

Recently, magnifying elements have been incorporated in the endodontic practice to enhance vision in the operative site. These could be as simple as magnifying loops being attached to ordinary eye glasses giving a magnification of 2.5X. Surgical microscopes have recently been adopted in the dental operatories. They offer a wide range of magnification from 2.5-20X together with fiber optic illumination. Operator can work through the eyepiece or a monitor.

(2) Vitality testing

Clinical assessment of pulp vitality is considered an important aspect in reaching proper diagnosis. This can be achieved by stimulating the neural element or by measuring the vascular conductance.

Neural Tests:

This is the most popular method for measuring the pulp vitality through thermal or electrical stimulation of the peripheral nerve endings.

Thermal testing: This includes a group of testing agents either cold or hot.

Cold testing:

Ice	----------	$0^{o}C$
Ethyl chloride	----------	$-7^{o}C$
CO_2 snow	----------	$-78^{o}C$

Hot testing :

Rubber wheel
Hot instrument
Gutta percha stopping

Electrical Testing: This includes a group of devices that deliver a very low electrical current to the enamel surface through the presence of an electrolyte.
These devices are called the ***Electric pulp tester (EPT).***

Vascular Tests

Although the thermal and the electric pulp testers are very popular and widely used, yet, it is the testing of the vascular element, which reflects the true vitality of any tissue rather than its neural supply. Recently, few devices were introduced in the market, which have the capability of measuring the pulpal blood flow. These include

- Laser doppler flowmetry
- Pulse oximetry

(3) Radiographs

Radiograph is an essential tool during all phases of root canal therapy (diagnosis, treatment and prognosis). Because root canal therapy relies on accurate radiographs and focuses on minimizing the amount of radiation the patient is subjected to, different radiographic devices were introduced in the specialty, which includes:

- Plain radiography
- Xeroradiography
- CT-Scan / MRI
- Radiovisiography (RVG)

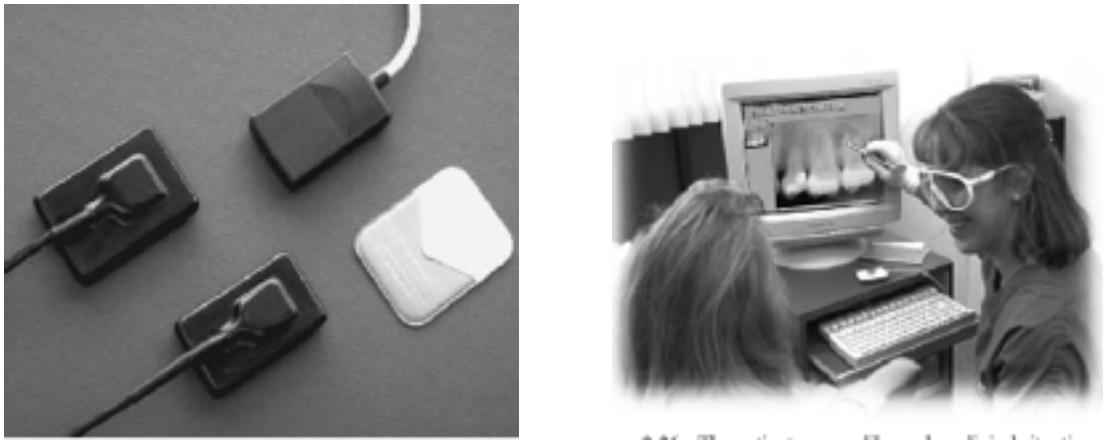

Fig 1: Radiovisiography sensor (left) and the soft ware.

II- Extirpating instruments

Barbed (nerve) Broaches

This instrument is manufactured from soft steel by placement of a series of extrusive incisions along the shaft (parallel to the shaft). These incisions are then elevated forming sharp projections. Barbed broaches are used for the removal of intact pulp tissue being slowly introduced into the canal, rotated full turn to entangle the pulp tissue then withdrawn. Because of its weak design (sharp projections), this instrument is limited for

usage in large size canals to avoid fracture. In small sized canals any of the enlarging instruments (H-file) can be used for pulp extirpation.

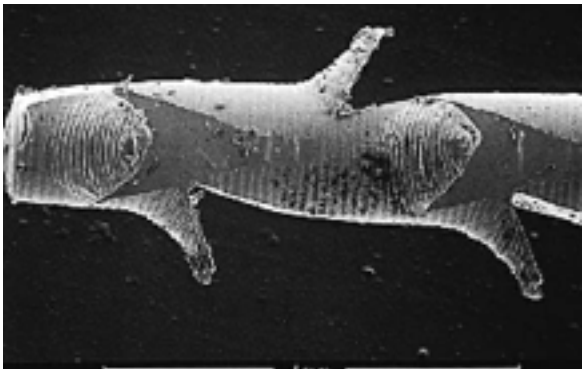

Fig 2: The barbed broach

III- Enlarging instruments

Cleaning and shaping of the pulpal space can be achieved by either Hand-driven instruments or a combination of Hand-driven and Engine-driven instruments.

(1) Hand-driven enlarging instruments

a- Basic enlarging instruments

These instruments were introduced by the beginning of the last century (1904) and are considered by far the most commonly used intracanal instruments. These include four basic instruments, which are:

(i) **K-file**

Fabrication of a K-file starts as a round St.St wire that is cut to form a tapered instrument ending by a pointed tip with square cross-section. This wire is then twisted in a counter clock wise direction to form spirals (flutes), which are 1.5 – 2.5 flute/mm. This instrument can be used in filing action (push - pull motion) or reaming action (insertion - clockwise rotation - withdrawal). When K-file is locked inside the root canal, the continuous clockwise rotation results in unwinding and ends by ductile type fracture. On the other hand, counter clockwise rotation leads to "Sudden" brittle type fracture.

(ii) K-reamer

Similar to K-file, the K-reamer starts as a round St.St wire cut to form a tapered instrument ending by a pointed tip with triangular cross section. This wire is then twisted in counter clock wise direction to form flutes, which are not as tight as the K-file. The number of flutes on the shaft of the reamer are 0.5 – 1 flute/mm. Reamers can be used in reaming action only.

	K- File	**K - Reamer**
Cross - section	Square	Triangle
Flute number	1.5-2.5/mm	0.5-1/mm
Cutting angle	90^{o}	60^{o}
Clearance Space	Less	More
Flexibility	Less	More

N.B: Although the square cross-section of the K-file have a cutting angle of 90^{o} which is considered to be less efficient than the cutting angle of K-reamer (60^{o}), yet, this is compensated by the greater number of flutes the K-file have.

Fig 3: (A) K-file, (B) K-reamer

<u>(iii) H-file (Hedstrom file)</u>

This file is constructed from round St. St. wire by machine grinding forming a series of intersecting cones. This design produces sharp edges at the base of each cone, which cuts tooth structure on pulling only. The cross-section of this instrument shows that it is coma shaped (tear drop) with one cutting edge.

At the junction between each two cones, the shaft of the instrument is weak facilitating its breakage if used in any form of rotation (reaming action). Therefore, H-files are to be used in filing action only.

Fig 4: H-file

(iv) R-file (Rat-tail file)

This instrument is very similar to the barbed broach having metal projections perpendicular to the instrument shaft with an eight pointed polyhydron cross section. R-file is easily fractured inside the root canal and therefore, is not very commonly seen on the market nowadays

Standardization of endodontic basic instruments

Before 1958, endodontic enlarging instruments were manufactured without any established criteria where an instrument of one company rarely coincided with a comparable instrument of another company. The standardization included the following items:

Standardization of size:

The sizing system goes as follows:
6,8,10----15,20,25,30,35,40,45,50,55,60----70,80,90,100,110,120,130,140
.

This sizing system is not arbitrary but is based on the diameter of the instrument in hundredths of a millimeter at the tip of the instrument (Do). As an example, an instrument size 60 means that the diameter of the instrument at Do = 60/100 = 0.6 mm.

Standardization of length

The first standard in length is the full extent of the shaft up to the instrument handle and this comes in three lengths: 25 mm (standard), 31 mm (long) and 21 mm (short).

The second standard in length is the length of the instrument blade (working or cutting area). This length is standard to be 16mm starting at Do and ending at D16.

Standardization of taper

The file diameter increases at a standard rate of 0.02mm/mm starting at Do ending at D16. This means that the difference in diameter between Do and D16 regardless the instrument size is always 0.32mm (0.02x16=0.32).

Standardization of tip angle

The angle formed between the instrument tip and the long axis of the instrument shaft is standardized to be $75^{o} + 15^{o}$.

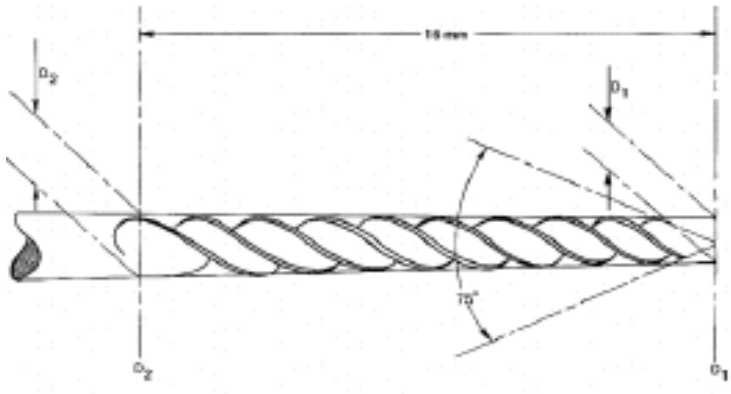

Fig 5: Standardization of basic enlarging instruments.

b- Hybrid enlarging instruments

To debride the root canal space, the enlarging instrument must contact and plane all the walls. Despite the simplicity of that concept there is no instrument that can efficiently clean and shape the entire root canal space while retaining the preoperative shape of the canal. This difficulty is due to the complex pulpal anatomy. Continuous development and improvement in
instrument design and physical properties is aiming to fulfill this goal.
Modifications include:

A.Modification in instrument design.
B.Modification in method of manufacturing.
C.Modification in instrument material.

A- Modification in instrument design:

(i) Modification in instrument cross-section:

Flex-R-file:

The square cross-section of K-file was modified to triangle cross-section **(Flex-R-file)**. This modification led to the following advantages:

- Increase in cutting ability.
- Increase of carrier effect (hold more debris).
- Increase in flexibility (less metal mass).

K-flex file:

Again, the square cross-section of the K-file was changed to rhomboid cross-section **(K-flex file).** The cutting edge of the K-flex file is formed of two acute angles (high flutes), which present increased sharpness while the two obtuse angles (low flutes) provide more space for debris removal. In addition, this change in design increased instrument flexibility.

S-file / Uni-file:

The modification in the single blade of the H-file (tear drop) by adding second blade (S-file & Uni-file) or by adding third blade (Helifile) did significantly increase the cutting ability of the tool.

U-file:

The U-file first appeared in 1988 and its design have been being adopted in most of the recent rotary enlarging instruments (Profile system, Light speed system, and the profile GT system). The U design has two 90^{o} cutting edges at each of the three points of the blade. The flat cutting surfaces act as a planning instrument and are referred to as "Radial Lands". The radial lands allows the instrument to be used in 360^{o} motion (rotary).

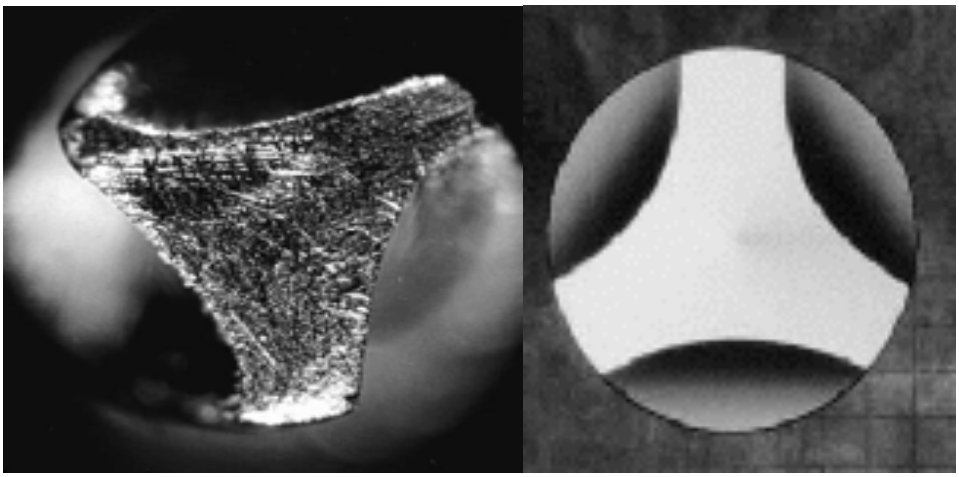

Fig 6: Cross-sectional view of the U-file.

(ii) Modification of depth and angle of blades:

To overcome the inherent weakness of H-file present at the junction of different intersecting cone, a decrease in the depth of the blades introduced by the Uni-file and the S-file significantly decreased the tendency of these tools to break inside the root canal.

(iii) Modification in length of cutting blade:

Canal Master file:

The canal master was introduced in 1989 by Senia and Wiley where the cutting segment of the instrument was reduced from 16mm to 1-3mm. They claimed that this modification should reduce the chance of canal transportation and ledging during enlargement of the curved canals.

Profile Great taper system (GT):

This is a rotary enlarging tool having a cutting blade of 6-8 mm instead of 16mm.

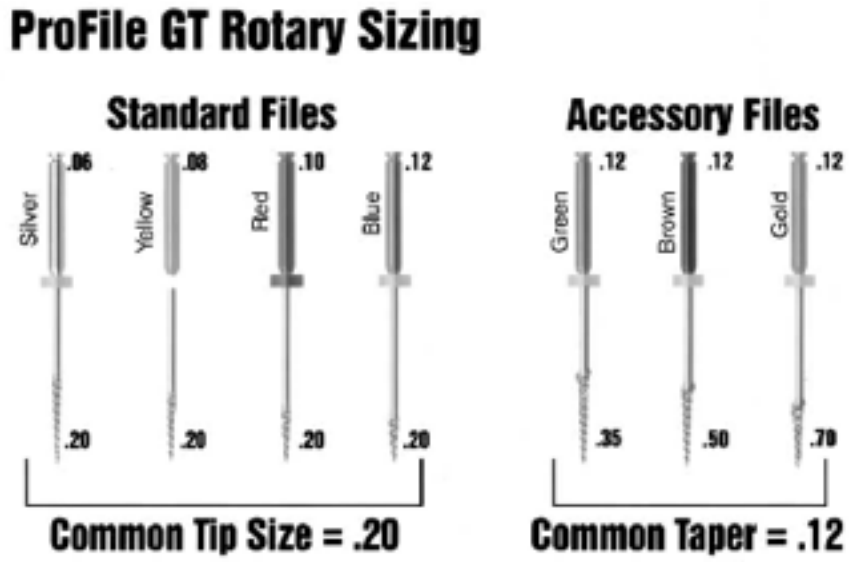

Fig 7: The profile GT system showing limited cutting blade.

Light speed system:

Again, the light speed system is a rotary enlarging tool that exhibits a reduction in the length of the cutting blade starting from 0.25 mm for smaller sizes up to 1.75 mm for larger sizes.

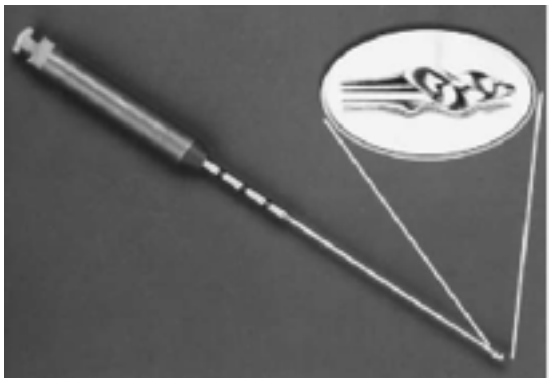

Fig 8: The light speed cutting tool.

(iv) Modification in taper

Instruments with increased taper recently appeared on the market where the standard taper of 0.02mm was replaced by either 0.04, 0.06 or 0.08 mm taper. It is important here to mention that instruments with increased taper are all fabricated from NiTi.

(v) Modification in tip design:

Again the Flex-R-file was the first file introduced in the market in which the angle of the instrument tip being flattened i.e. non-cutting tip. Nowadays all newly produced instruments have a non-cutting tip which was shown to decrease the chances for canal transportation and ledging during enlarging curved canals.

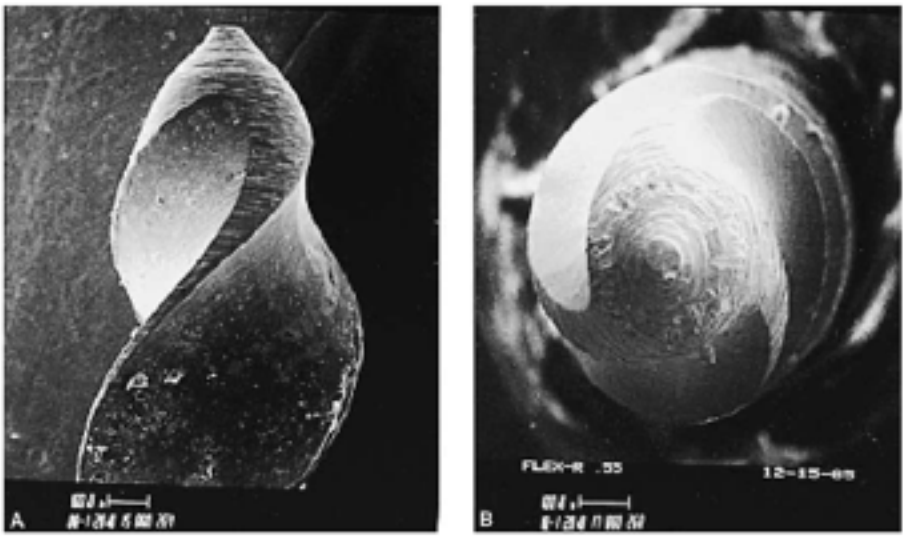

Fig 9: Front (A) and top view (B) of an instrument with non-cutting tip.

(vi) Modification in numbering system

Golden mediums:

These are instrument sets with intermediate sizes (12.5, 17.5, 22.5, 27.5, 32.5, …..). These sizes were suggested to decrease the big transition in diameter between small size instruments.

Profile Series 29:

In 1992, Schilder introduced a new numbering system known as the Profile series 29. This new system presents instrument sizes that progress by a constant percentage increase (29%) from one instrument size to the next. Profiles comes in sizes 00,0,1----------11. This system offers two advantages; First, it provides constant increase in instrument diameter (29%) and second, it provides fewer number of instruments compared to the ISO system.

B- Modification in method of manufacturing

The Flex-R-file (modified K-file) was the first St. St.file to appear on the market with a new concept in the method of fabrication. Instead of instrument twisting, the flutes were created by grinding or milling to decrease the internal stresses induced inside the instrument during the twisting process. Grinding is totally necessary for instruments made of Nickel-Titanium because their super elasticity prevents their twisting.\

C- Modification in instrument Material:

When basic instruments first appeared they were fabricated from carbon steel, however, due to decreased flexibility and low corrosion resistance of carbon steel, instruments were fabricated from stainless steel. The only intra canal instrument that is still manufactured from carbon steel is the path finder which is used to negotiate calcified narrow canals.

Inspite of the reasonable flexibility of St. St., it was not very satisfactory in preparation of curved canals. This led to the appearance of super elastic instruments fabricated from Nickel-Titanium (NiTi). NiTi instruments do offer better flexibility however, its cutting ability could be questionable.

Nickel Titanium (NiTi):
NiTi alloy was first introduced in 1960 for orthodontic wires. In 1988, Walia and associates introduced NiTi to be used in fabrication of endodontic files.

	NiTi	**St.St.**
Super elasticity	Very high	Lower than NiTi
Resistance to fracture (Torque strength)	Lower than St.St.	High
Wear resistance	Higher than St. St.	Low
Cutting ability	60% that of St.St.	Higher

(2) Engine-driven enlarging instruments

The popularity of using engine driven instruments for preparing and enlarging root canals is increasing aiming to increase speed and efficiency. Engine driven enlarging instruments can be classified according to the type of motion employed into :

A- Devices utilizing vibratory motion (sonics and ultrasonics)
B- Devices utilizing rotary motion (low speed contra-angle)

A- Vibratory instruments

These instruments depends on the vibratory action of enlarging tool inside the canal. Generally, two categories of devices have been developed based on the frequency of vibration.

	Sonics	Ultrasonics
Frequency	Less than 20KHz	20- 50 KHz
Power	Compressed air	Electric current
Irrigant	Water	NaOcl
Cutting tool	Rispi and Shaper files	K-files and D-files
Brands	Endosonic 3000	Cavi Endo

The main debriding action of Sonics/ultrasonics was initially thought to be by "Cavitation", a process by which bubbles formed from the action of the file become unstable and collapse causing vacum-like action. Nowadays, it is believed that a different physical phenomenon occurs called "Acoustic Streaming" which is responsible for the debridment.

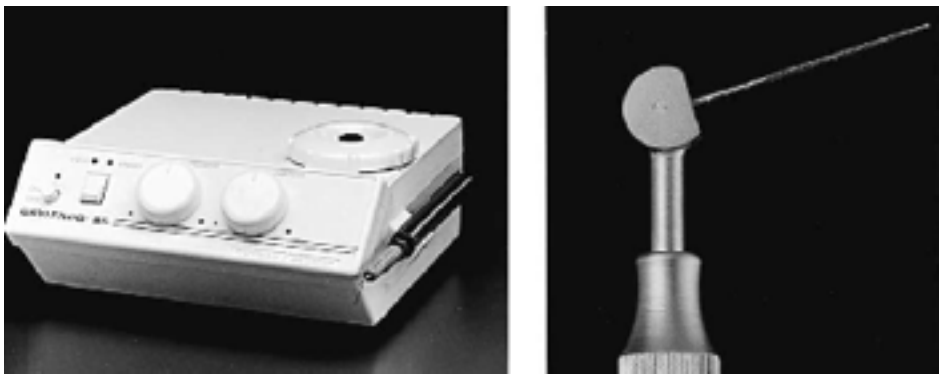

Fig 10: An ultra sonic unit (left) and the ultrasonic tip (right)

B- Rotary instruments:

These are formed of two parts, a part which supplies the motion and in this group it is a rotary motion supplied by three types of low speed contra-angles. These three hand pieces are: a full rotary hand piece, a reciprocating quarter turn hand piece and a reciprocating hand piece with vertical stroke. The second part is the enlarging tool which differs according

to the type of contra-angle used. Different systems are present on the market among which:

Type of contra-angle	Enlarging tool	Usage
Ordinary low speed contra-angle (360°)	Gates Glidden drill and Pesso drill	Coronal 2/3 of the canal
Giromatic (Quarter turn 90°)	St. St. files with latch	Full length prep
Canal Finder (Quarter turn +vertical stroke)	St. St. files with latch	Full length prep

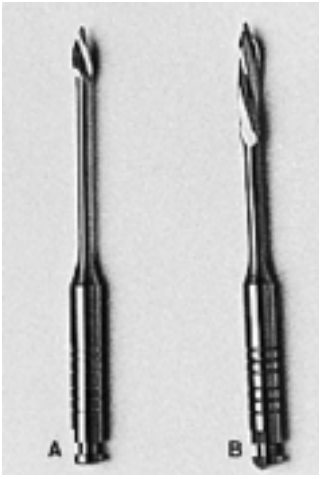

Fig 11: Gates Glidden drill (A) and the pesso drill (B)

Attempts to use conventional St. St. files with rotary hand pieces for root canal enlargement was not so successful over the years due to the decreased flexibility of st. st. which caused instrument breakage and changes in root canal configuration (ledging and perforation). However, the introduction of NiTi metal as a substitute for St.St. in manufacturing of endodontic enlarging instruments led to the development of new rotary enlarging instruments. These new systems include:

1. Profile and Profile GT systems.
2. Light speed system.
3. Quantec system.
4. Pow-R system.

5. Protaper system
6. Hero 642 system.

All these systems have the same basic features with some differences. They all share the following:

Hand pieces:

- Reduced Gear (300-1200 rpm)
- High Torque

Enlarging tool:

- Nickel Titanium
- Increased taper

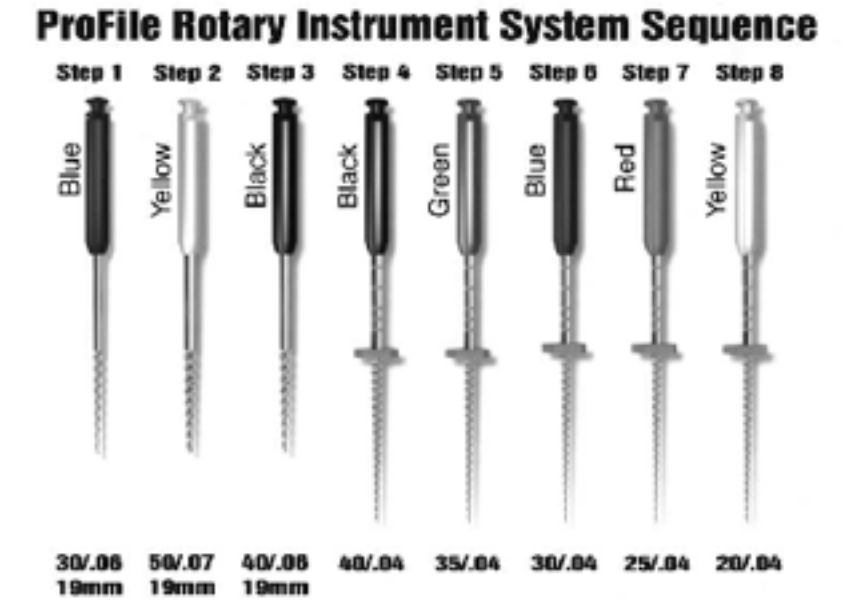

Fig 12: The profile system.

IV- Obturating instruments

Obturation of the root canal system involves the introduction of a biologically compatible filling material inside the root canal. This material should provide three dimensional sealing of the root canal space thus preventing the egress of microorganisms or toxic products into the vital periapical tissues.

Gutta percha, considered to be the most popular filling material for decades have been the focus of development over years. Recent devel-

opments have been directed toward the introduction of delivery systems and devices for the placement of thermoplasticized gutta percha inside the root canal forming a homogenous mass which seals the space three dimensionally. This is highly desirable so as to accurately conform to the anatomic irregularities and complexities of the root canal system. To summarize, gutta percha can be introduced inside the canal either in a non softened state or in a softened state.

1- Non-softened techniques:

Spreaders and Pluggers:

Endodontic spreaders and pluggers are smooth tapered metal instruments used to compress and compact gutta percha within the root canal space. Pluggers have blunted or flat ended tips whereas, spreaders are more tapered with pointed tips. Both spreaders and pluggers are supplied in either of two forms: Finger spreaders/pluggers (finger held instruments similar in design to files but with smooth non-cutting shaft) or Hand spreaders/pluggers (Palm held instruments).

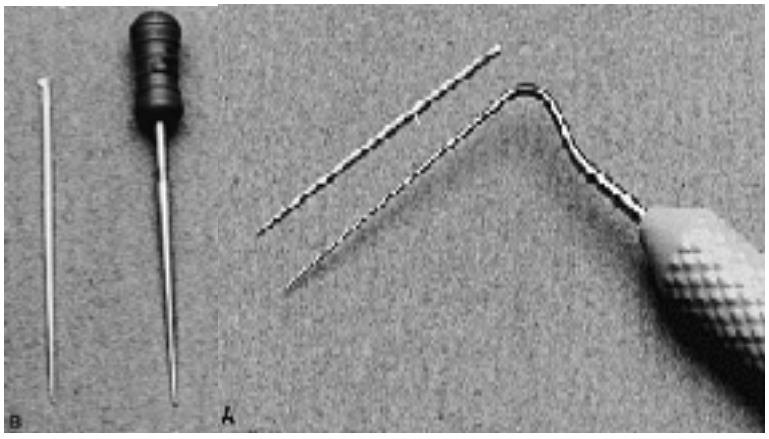

Fig 13: Hand spreader (A) and finger spreader (B)

Lentulo Spiral:

This is a St. St. wire twisted into a spiral used to carry root canal sealer into the root canal.

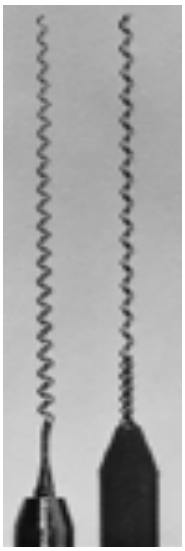

Fig 14: The lentulo spiral

2- Softened techniques:

These are instruments or devices introduced to soften gutta percha either directly inside the canal or soften the gutta percha outside the patient's mouth then carry it inside the canal. These include the following:

Thermal applicators:

Two electric devices are available for softening the gutta percha inside the canal during condensation. These devices are similar to hand spreaders or pluggers, however, their tips becomes warm when the unit becomes activated.

- ***Touch'N'Heat***
- ***System B***

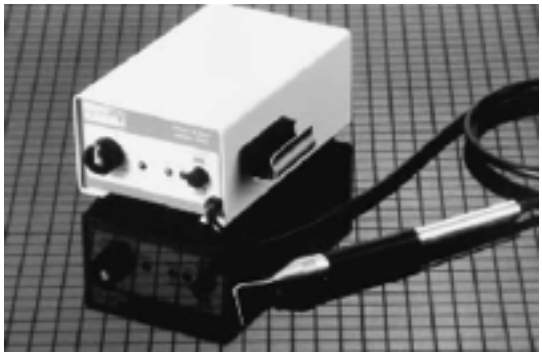

Fig 15: The touch N' heat unit

Thermomechanical compactors:

This system consists of a low speed contra-angle attached to it a compactor which resembles a H-file. The compactor is introduced inside the root canal with the gutta percha master cone in place. The friction produced warms and plasticizes the gutta percha while the instrument flutes force the material apically and laterally.

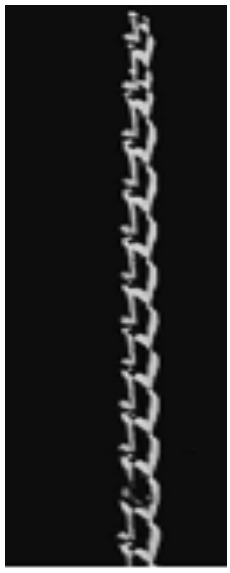

Fig 16: The thermomechanical compactor

Injection systems:

These include two syringe systems for injection of gutta percha

i-Obtura: Device consists of pistol-like delivery unit for introduction of gutta percha through 23 gauge silver injection tip. The delivery unit is connected to an electric unit which warms the gutta percha to the desired temperature (max temp 204 degrees centigrade).

Fig 17: The obtura injection system

ii- Ultrafil: Device consists of preloaded gutta percha filled canules with 22 gauge stainless steel needles. These canules are warmed in a separate heating unit then loaded in a special injection syringe (max temp 70 degrees centigrage).

Gutta percha carriers:

These devices consist of alpha phase gutta percha molded around a metal core resembling an endodontic file (carrier). These carriers were first made of St St, nowadays, they are available in plastic and titanium. Carriers come in sizes ranging from 20-140 with calibrated markings on the shaft to assist in length control. The gutta percha coating these carriers is softened by passing it over flame and then inserted inside the canal. The most popular type of these carriers is called **" Thermafil"**.

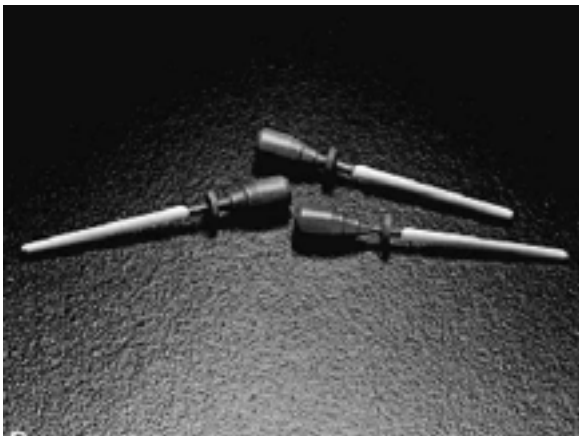

Fig 18: The gutta percha carrier "THERMAFIL"

V- Miscellaneous

1- Apex locators:

Electronic devices used to determine the tooth length before initiating the canal debridment. The first generation of these devices was introduced by Sunada in which the root canal length was determined by comparing the electrical potential difference between the periapical tissues and the oral mucosa.

Fig 19: An apex locator device

2- Endobox:

An organizer for placement of endodontic files where instruments are sorted by sizes.

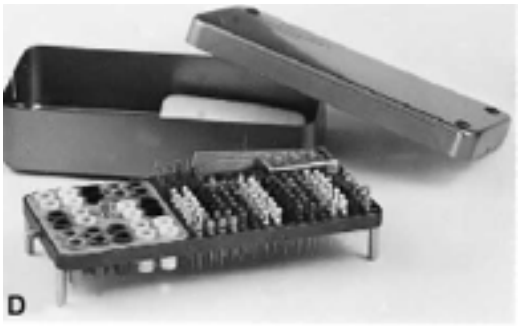

Fig 19: Endobox

3- Endometer:

Metal or plastic autoclavable rulers for measurements during enlargement and obturation.

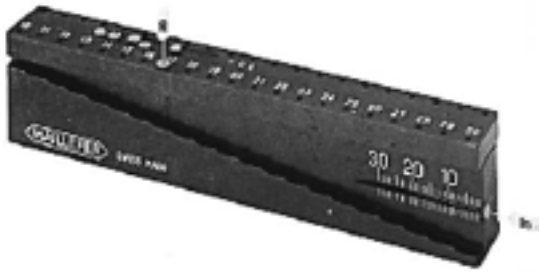

Fig 20: Transfer sponge with an endometer

4- Rubber dam:

Device utilized to isolate the tooth under treatment from the oral environment. Isolation is mandatory to prevent salivary contamination and aspiration of instruments into patients throat. Rubber dam is formed of five components:

- Rubber dam sheet to isolate the tooth
- Rubber dam punch to make a hole in the sheet
- Rubber dam clamp to stabilize the sheet in place
- Clamp Holder to position the clamp in place
- Rubber dam frame to stretch the rubber dam sheet