Intracanal Instruments

Classification of intracanal instruments

They are divided into six groups:

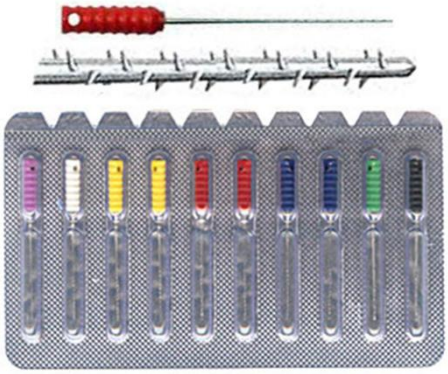
- **Group I**: Manually operated instruments, such as barbed broaches and K-type and H-type instruments.
- **Group II:** Low-speed instruments with a latch-type attachment. Typical instruments in this group are Gates-Glidden (GG) burs and Peeso reamers. They are typically used in the coronal part of the canal and are never used in a canal curvature.
- **Group III:** Engine-driven nickel-titanium rotary instruments. They consist of a rotating blade that can safely be operated in and adapt itself to curved root canals. Most engine-driven instruments available today belong to this group.
- **Group IV:** Engine-driven instruments that adapt themselves three-dimensionally to the shape of the root canal. Like other nickel-titanium instruments, they adapt to the shape of the root canal longitudinally, but additionally, they also adapt to the cross-section of the root canal. There is currently only one instrument in this group: the self-adjusting file (SAF).
- **Group V:** Engine-driven reciprocating instruments.
- **Group VI:** Ultrasonic instruments.

Group I: Manually-operated instruments

Barbed Broaches

They were the earliest endodontic instruments used to extirpate the pulp. They are manufactured by hacking a round, tapered wire with a blade to form sharp, projecting barbs that cut or snag tissue. A barbed broach does not cut or machine dentin; this instrument is mostly used to engage and remove soft tissue from the canal. It is an excellent tool for removing

cotton or paper points that have accidentally become lodged in the root canal.



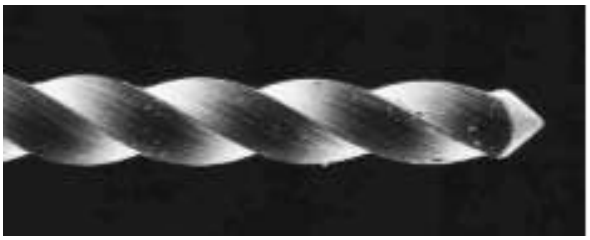


K-type instruments

The K-file and K-reamer are the oldest useful instruments for cutting and machining dentin. They are made from a stainless steel wire that is ground to a tapered square or triangular cross-section and then twisted to create either a file or a reamer. A file has more flutes per length unit than a reamer. K-type instruments are useful for penetrating and enlarging root canals.

The instrument works primarily by compression- and-release destruction of the dentin surrounding the canal. Generally, a reaming motion (constant file rotation) causes less transportation than a filing motion. Transportation is the excessive loss of dentin from the outer wall of a curved canal in the apical segment. As the instrument is increased in width, its flexibility is decreased.





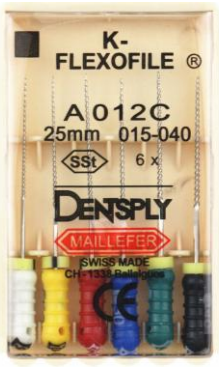
K-flex file

It has a cross-section that is rhomboid in shape. It is a twisted instrument and has a series of cutting flutes. It has 2 acute edges and 2 obtuse edges. The acute angle cuts into the dentin, while the obtuse angle provides more area for debris collection and removal. The cutting efficiency and flexibility are greater than those of the K-type file.

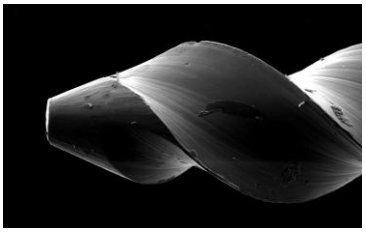


Flex-O-File

This instrument resembles the K-type file, but it is triangular in cross-section. There is better-cutting action and more room for the debris, better flexibility, and more resistance to fracture. The tip of the instrument is non-cutting, so no apical ledge formation is possible.



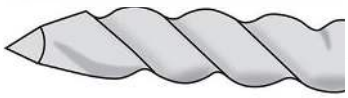




Flex-R-file

The design of the tip of this instrument eliminates the possibility of ledge formation by removing the cutting surface of the tip's leading edge. This guides the instrument in the canal rather than cutting. It has a triangular cross-section, which increases its flexibility. It cuts more efficiently in anti-clockwise motion and can be used for filing action.



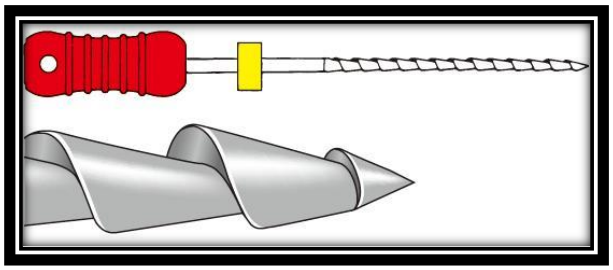


Flex-R file

H-type instruments.

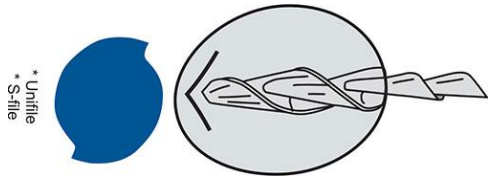
An H-type instrument has spiral edges arranged to allow cutting only during a pulling stroke. An example is a Hedström file. An H-type instrument is better for cutting than a K-type instrument because it has a more positive rake angle and a blade with a cutting rather than a scraping angle. Bending a Hedström file results in points of greater stress concentration than occurs with K-type instruments. These concentration points can lead to the propagation of cracks and fatigue failure. All H-type instruments are ground from a tapered blank. Hedström files are formed by grinding a single continuous flute.





S-file (Uni-file)

This instrument is a ground S-shaped cross-section instrument. This is stiffer than the Hedstrom file. The cutting mode may be with filing or reaming action.



Traditional instruments modifications

1- **Nickel-titanium file**. Files made from nickel-titanium showed greater elastic flexibility and resistance to torsional fracture than stainless steel. This file has a non-cutting tip, and it tends to maintain the curvature of the root canal.

2- **Golden mediums:** These instruments are a series of intermediate-sized instruments. They correspond in size to halfway between standard ISO sizes and correspond to 12,17,22,27,32 and 37 in number.



3- **Canal Master U:** This hand instrument is used to prepare the apical third of the canal. It has a non-cutting pilot tip, a 1 mm length cutting blade, and a narrow parallel-sided shaft. It is used to allow for better cutting with more space for debris accumulation and further removal. It reduces the possibility of ledge or transportation.



Group II: Low-Speed Rotary Instruments

Many types of rotary instruments are used during endodontic procedures. 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. This is particularly important when using an operating microscope when performing such procedures after access to the pulp chamber has been achieved. Straight-line access to the initial point of curvature can be accomplished using rotary instruments such as Gates-Glidden burs and Peeso instruments. Use of these instruments should be limited to the straight portion of the canal preparation. The risk of perforation with these instruments is a possibility. The risk of lateral cutting resulting in perforation is lower with Gates-Glidden burs than with the Peeso drills. The Peeso reamer is used mostly for post-space preparation.



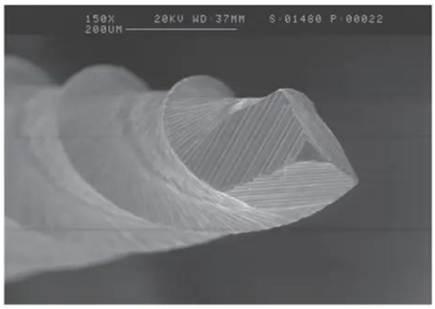


General characteristics of the Files and Reamer

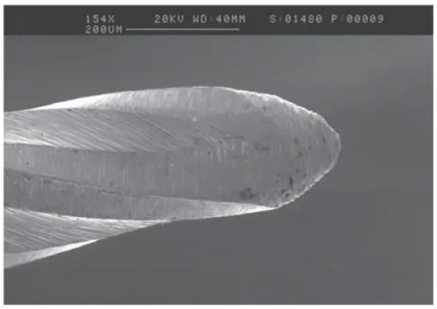
Design elements Root canal preparation instruments such as K-files and nickel-titanium rotary instruments, follow certain design principles. Design elements such as the tip, flutes, and cross sections are considered relevant for files and reamers used in hand and rotary motion.

Tip design.

In root canal preparation, an instrument tip has two main functions: to guide the file through the canal and to aid the file in penetrating deeper into the canal. A clinician unfamiliar with the tip design, in particular of a rotary instrument, may do either of the following: transport the canal (if the tip is capable of enlarging the canal and is used too long in one position in a curved canal) or encounter excessive torsion and break the file (if a non cutting tip is forced into a canal with a smaller diameter than the tip). The angle and radius of its leading edge and the proximity of the flute to its actual tip end determine the cutting ability of a file tip. Cutting ability and file rigidity determine the propensity to transport the canal. The tip design affects file control, efficiency, and outcome in the shaping of root canal systems. The tip of the original K-file resembled a pyramid; instrument tips have been described as cutting, while non-cutting tips, also called Batt tips, are created by grinding and smoothing the apical end of the instrument. A tip modification was introduced with the Flex-R file, which was manufactured fully by grinding so that the transitional angles between the tip and the instrument's working parts blend smoothly. Similar techniques are required to manufacture NiTi K-files. Which typically rounded non-cutting tips are used socalled safe cutting tips. One exception to this rule is rotaries specifically designed as retreatment instruments; cutting tips in that case facilitate the removal of the existing root canal filling material and are sufficiently safe.



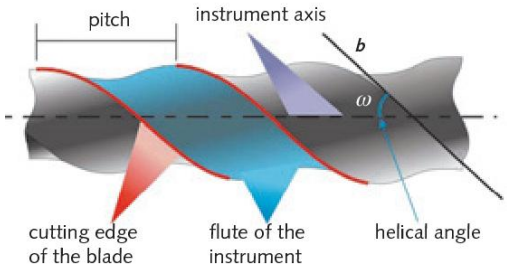
Active Tip
(Protaper Retreatment D1)



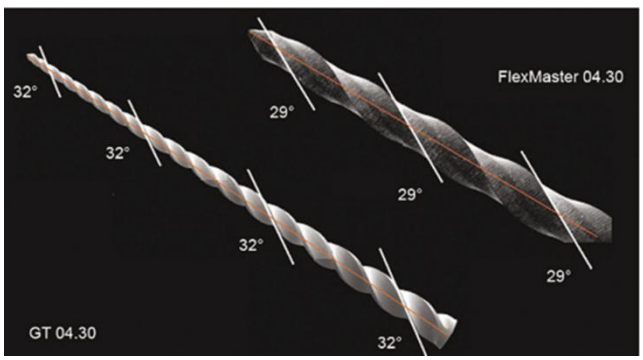
Non Active Tip
(Protaper Universal F3)

Longitudinal and cross-sectional design.

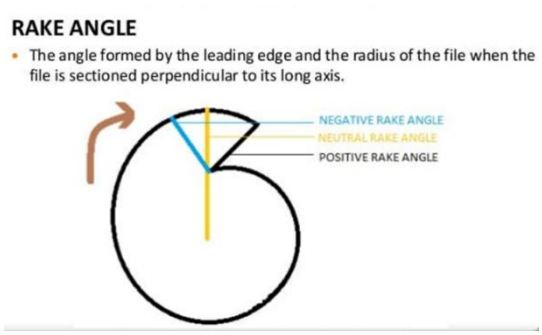
1. **<u>The flute of the file</u>**: It is the groove in the working surface used to collect soft tissue and dentin chips removed from the wall of the canal. The effectiveness of the flute depends on its depth, width, configuration, and surface finish.

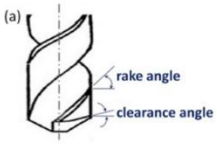


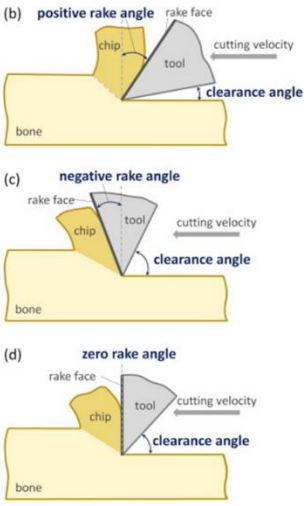
   The surface with the greatest diameter that follows the groove (where the flute and land intersect) as it rotates forms the leading (cutting) edge or the blade of the file.
   The cutting edge creates and deflects dentin chips along the wall of the canal and severs or snags soft tissue. Its effectiveness depends on its angle of incidence and sharpness.
   Some instruments have a feature between the trailing and cutting edge that forms a larger contact area with the radicular wall; this surface is called a **radial land**. This design is believed to reduce the tendency of the file to thread into the canal. It also supports the cutting edge and limits the depth of cut; its position relative to the opposing cutting edge and its width determine its effectiveness. On the other hand, landed files are typically less cutting efficient compared with triangular cross sections. To reduce frictional resistance, some of the surface area of the land that rotates against the canal wall may be reduced to form the relief.
2. **<u>Helix angle:</u>** It is the angle the cutting edge forms with the long axis of the file. It gathers debris collected in the flute from the canal. This angle is important for determining which file technique to use.



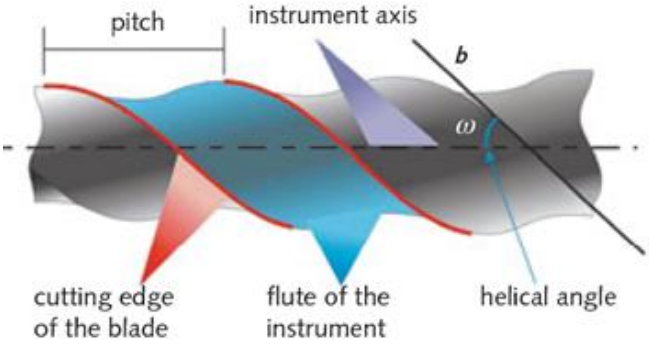
3. **Rake angle:** If a file is sectioned perpendicular to its long axis, the rake angle is the angle formed by the leading edge and the radius of the file. If the angle formed by the leading edge and the surface to be cut (its tangent) is obtuse, the rake angle is said to be positive or cutting. If the angle formed by the leading edge and the surface to be cut is acute, the rake angle is said to be negative or scraping.



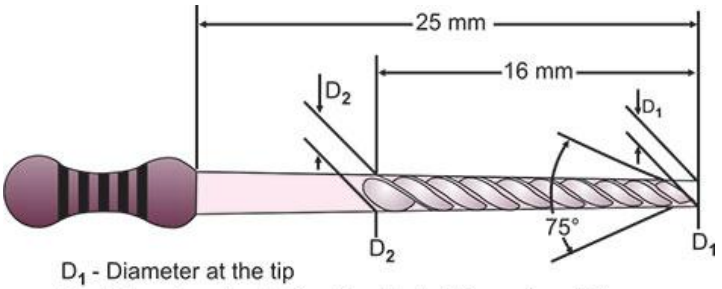




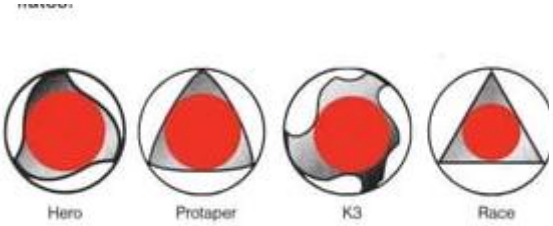
4. **The pitch of the file** is the distance between a point on the leading edge and the corresponding point on the adjacent leading edge. The smaller the pitch or the shorter the distance between corresponding points, the more spirals the file has and the greater the helix angle. While K-files have a constant pitch typically in the range of 1 mm, many NiTi rotaries have a variable pitch. one that changes along the working surface. When variable pitch is used, for example, to modify the helical angle, usually tighter spirals are located close to the tip of the file, and more space between the flutes is located toward the coronal part of the file.



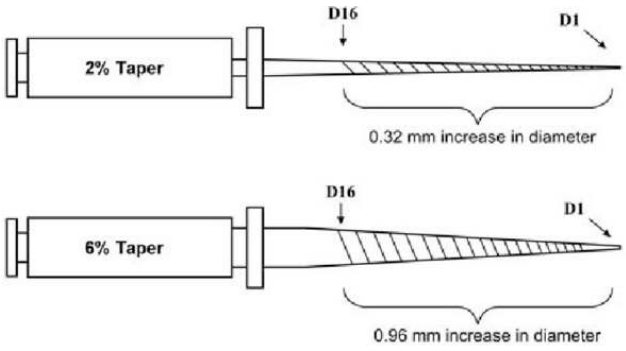
5. **The core:** A longitudinal section through an instrument reveals the core. The outer diameter of a tapered instrument increases from the file tip toward the handle. Depending on core dimensions, flutes may become proportionately deeper, resulting in a core taper that may be different from the external taper. Cutting angles, helix angles, and external and core tapers may vary along the working surface of the file, and the ratios of these quantities can vary among instruments of the same series.



D_1 - Diameter at the tip
D_2 - Diameter at end of cutting blade (16 mm from D_1)
Tip angle is 75° ± 15°



6. **<u>The taper:</u>** It is expressed as the amount the file diameter increases each millimeter along its working surface from the tip toward the file handle. For example, a size #25 file with a #.02 taper would have a 0.27 mm diameter 1 mm from the tip, a 0.29 mm diameter 2 mm from the tip, and a 0.31 mm diameter 3 mm from the tip. Some manufacturers express the taper in terms of percentage (e.g., a #.02 taper is a 2% taper).





0.02 * 16 = 0.32
0.32 + 0.10 = 0.42



0.06 * 16 = 0.96
0.96 + 0.20 = 1.16

7. Alloys

There are currently two principal types of alloys used for endodontic instruments: stainless steel and nickel-titanium. Most manually operated endodontic instruments are fabricated from stainless steel. Stainless steel files are comparably inexpensive, and Several burs and instruments designed for slow-speed handpiece operation, such as Gates Glidden drills, Peeso burs, and pilot drills for intraradicular posts, are also manufactured from stainless steel. Instruments designed for rotary root canal instrumentation, however, are typically made of nickel-titanium. This alloy offers unique properties, specifically flexibility and corrosion resistance.