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Fundamental design features of NiTi instruments; - A Review

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ABSTRACT

From the last decade there has been improved technology with Nickel Titanium (NiTi) endodontic files which shows phenomenal growth in endodontic technology. These technologies have made root canal treatment faster, less straining to the dentist and patient. Most importantly, better success rate and results of these new technology instruments lead to accordant, expected, and reproducible shaping of the root canal. This review article is to present the design features of NiTi instruments which are used for root canal space preparation. each design of NiTi instruments have specified roles during shaping and affect the performance of NiTi rotary instruments. In this article summarized every design of NiTi instrument like Taper, Tip design, cutting edge, flute, land, pitch, core, helical and radial angle.

Keywords:
Rotary Instruments, NiTi Files, Taper, Radial Land, Rake Angle

1. Introduction

Endodontic instruments became the major reason for the success of pulp space therapy. These instruments help in cleaning the pulp space properly and which helps in proper obturation of the root canal space three dimensionally. Earlier endodontic procedures were done using traditional stainless steel hand files but now the use of improved technical precision of NiTi instruments gave the successful performance of endodontic procedures. Over the last decade, endodontic instruments have undergone a total revolution after evolution of the Nickel Titanium (NiTi) instruments [1]. Hand NiTi instruments followed by Rotary NiTi instruments were developed in dentistry. Before we use the NiTi instruments clinically, understanding the design features of a NiTi instruments is mandatory. The principle design features like Taper, Tip design, cutting edge, flute, land, pitch, core, helical and radial angles are explained in this review article [2].

1. Taper

Taper measures the increase in file diameter per mm from the tip of the instrument towards the handle of the file. This taper help in preparing the root canals of required diameter without over enlarging the root canal.

There are many ways to shape a root canal. First, instrumentation done from apical to the coronal level with the use of hand files which are having same taper through the length of the instrument but with varying apical tip diameters. In this hand or a rotary instrument that having a constant taper (2 to 10%) with different tip diameters Example Greater taper files (Figure 1). Secondly,

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instrumentation done from coronal to apical direction of root canal by using varying tapers. These hand or rotary files have different tapers throughout the length of the instrument (from .04 to 12%) with different tip diameters example ProTaper Universal rotary system [3]. Third, is the hybrid technique combination of apico coronal and corono apical instrumentation technique using constant and variable taper.

Instruments with variable or graduating tapers help in minimal contact with the root canal wall which causes reduced frictional resistance when contact with root canal wall. Variable tapers require less torque for its use in root canal. Hence, less chance of instrument separation.

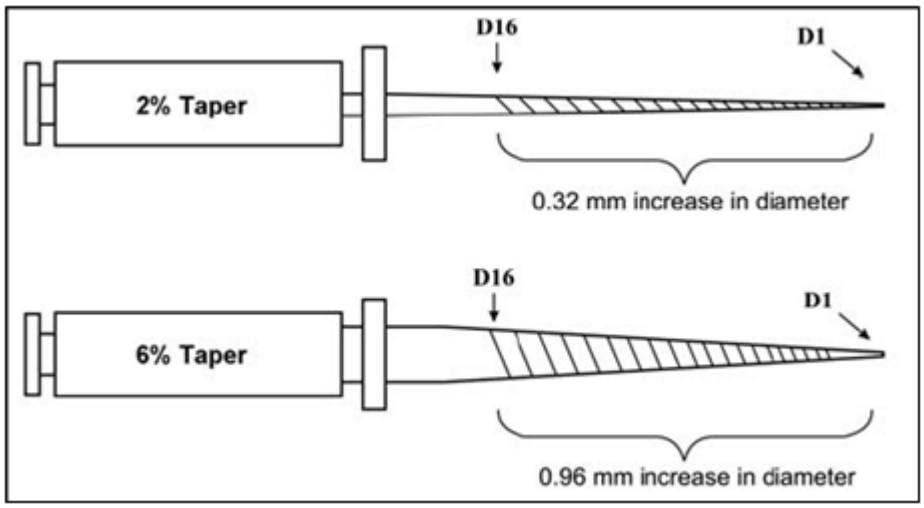

Figure 1. 2% and 6% Constant taper of a Rotary file

2. Core

It is a round centre part of the any instrument outlined by inner borders of flute depth (Figure 2). Core diameter of an instrument determines the flexibility and resistance to torsion. Higher the core diameter will be more resistant to fracture but less flexible and vice-versa[4].

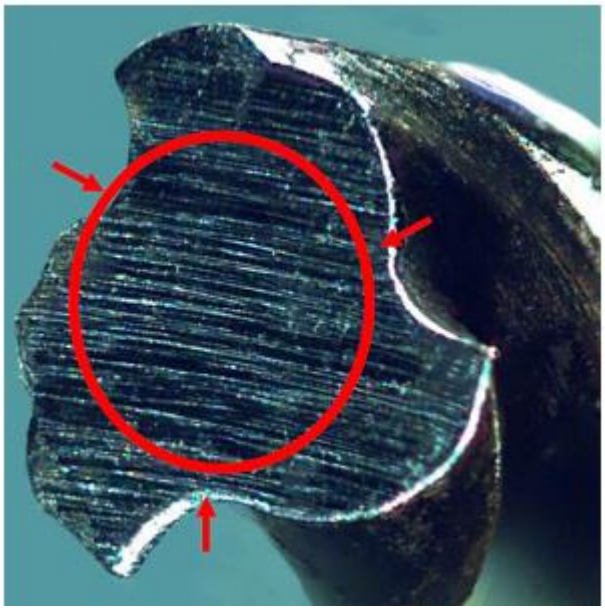

Figure 2: core diameter of a rotary instrument

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3. Flute

Flute formed by the groove on working surface of the file which helps to collect the debris after the file cuts dentin[5]. Effectiveness NiTi endodontic instrument depends on its design features. Increased distance between adjacent flute space and blade is required as to avoid any accumulation of debris and also provide effective way to remove the debris out of the root canal (Fig 3).

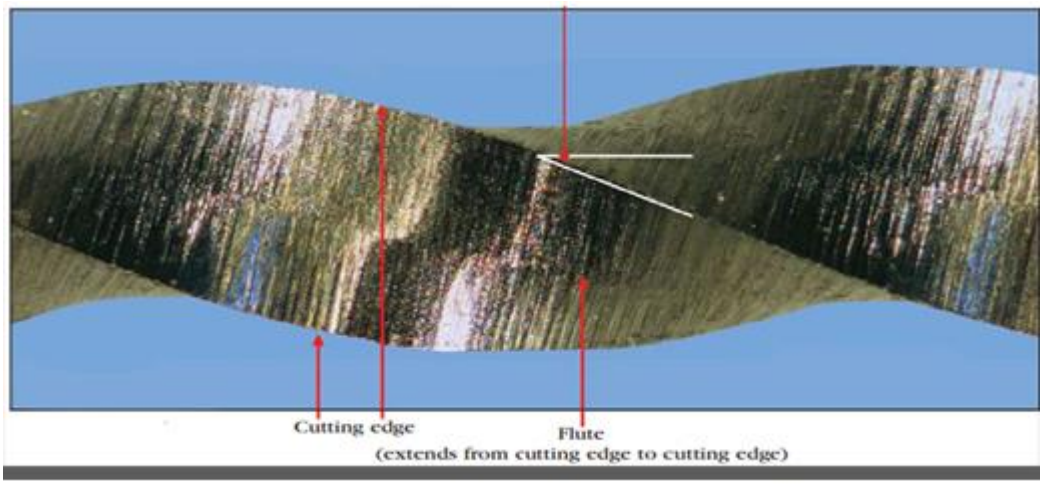

Figure 3: Diagram showing Flute and Cutting Edge

4. Cutting edge

Cutting edge is the main working area of the file which helps in cutting the root dentin. The cutting edge helps remove the dentinal chips and deflects these dentinal chips from the root canal wall [6]. Its effectiveness of the cutting edge is increased by its sharpness and angle of incidence (Figure 4).

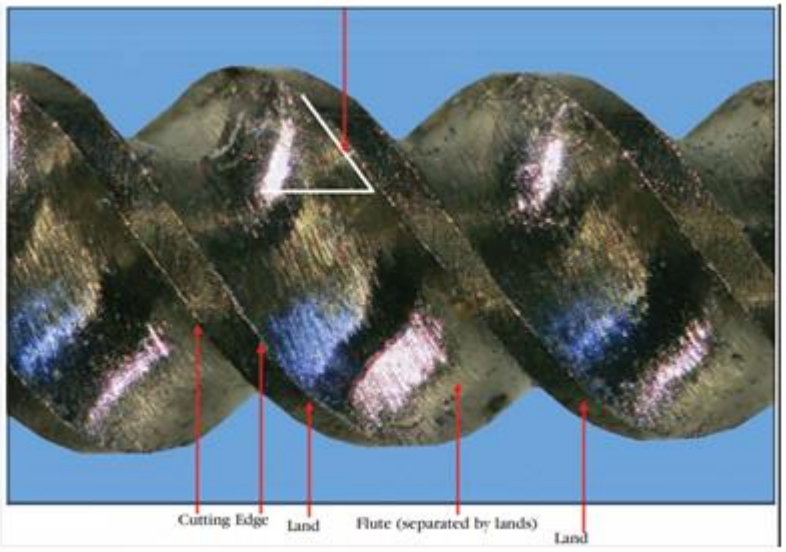

Figure 4: Diagram showing Land, Cutting edge and Flute(Separated by Lands)

5. Land

Land is formed between the flutes from centre of the core which projects axially to the tip of the cutting edge. Land will help in reducing the canal transportation and prevents the digging by

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cutting edge. To reduce frictional resistance with root dentin some of the surface area of the land will be reduced to form the RELIEF. This relief in Land decrease the screwing of the file, Limits the depth of cut, Reduces canal transportation and propagation of micro-cracks on its circumference [7].

6. Pitch

Pitch is defined as the number of spirals or threads per unit length. It Measure the Distance from one cutting edge to next. Smaller pitches will lead to more number of flutes per unit length which leads to increase in helical angle and vice versa. Files with variable pitch, changes flute number along length whereas constant pitch having uniform number of flutes per length. constant pitch with constant helical angle of the instrument causes "sucking down" of file within the canal. e.g. Profile has constant pitch and GT has variable helical angles and pitch [8]. (Figure 5)

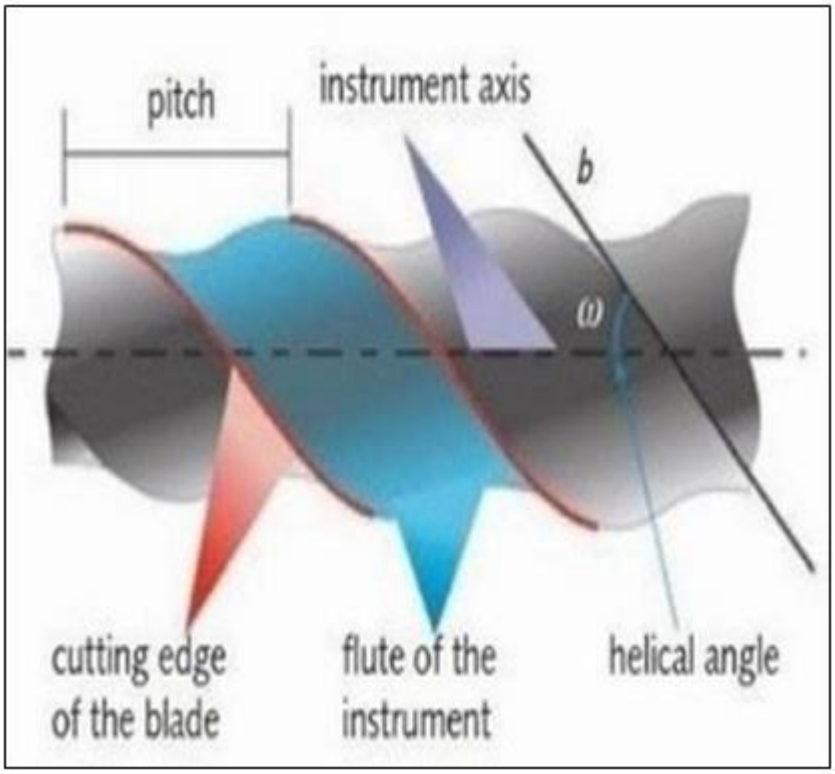

Figure 5: Diagram showing Pitch, cutting edge and Helical angle

7. Tip Design

Tip design is the feature of an instrument tip which help in controlling the instrumentation and outcome in shaping of root canal systems. Tip design guide the file through the canal. Tip design can be divided into three types Cutting, Noncutting and Partially Cutting. Cutting tips are very aggressive in cutting. cutting tip has the ability to cut the dentin at the tip. So it can be used to make an easy way to root apex in narrow and calcified canal. But if it's not used cautiously than it may lead to perforation of the root canal and is difficult to manage. ProTaper universal System Has Shaping files with partially active tip. A non-cutting tip will only guide the instrument through root canal. So these type file less tend to torsional fracture. Example Profile and the Greater taper(GT) and all Finishing files are non-cutting tip. [9,10]. (Figure 6)

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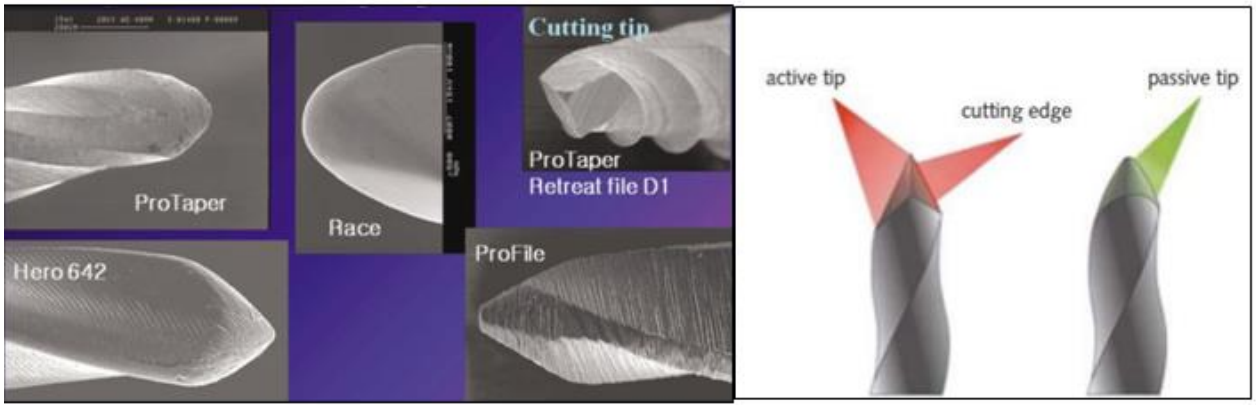

Figure 6: Active and passive tips of a rotary instruments

8. Helical Angle

Helical angle is the angle formed by the cutting edge and long axis of the file. Helical angle determines the cutting efficiency of the instrument. If a Files that have the same helical angle along entire instrument length will have more "Screwing in" forces. This can be decreased by varying the flute angles. remove debris efficiently and prevent digging of the instrument into root dentin. Example, In K3 file system and RaCe system file having variable flute angle which reduces rotational torque by using spiralled and non-spiralled portions[11].(Figure 7)

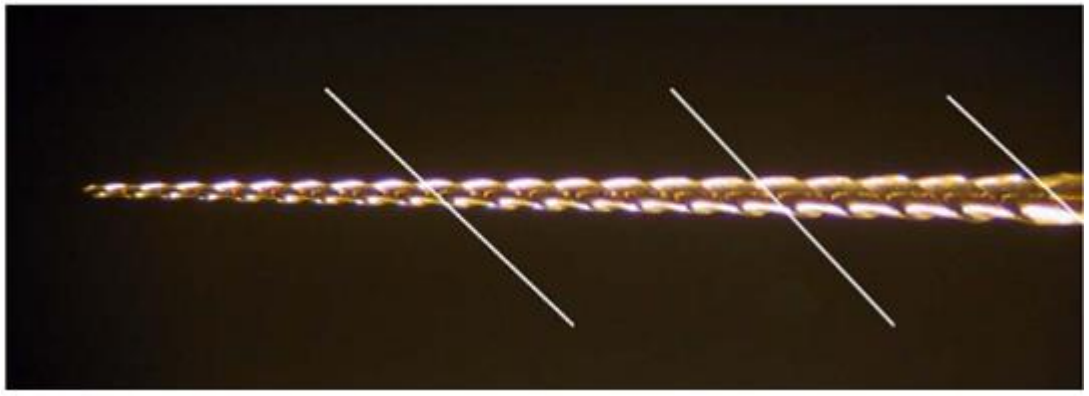

Figure 7: Diagram showing Helical angle

9. Rake Angle

The rake angle is the angle formed by the cutting edge and a cross section taken perpendicular to the long axis of the instrument. Rake angles are of two types Positive and Negative. Positive rake angle has more cutting efficiency. Example ProTaper, Hero 642 and RaCe. Negative rake angle which causes scraping of the root canal. Example Profile. Neutral rake angle are between positive and negative angles. Example Light Speed and GT rotary system [12].

2. Conclusion

Older systems are being updated continually and new endo files are added. These designs of NiTi files help in complete canal cleaning of the pulp space, maintaining the original canal anatomy and root canal curvature. These new rotary design helps to work efficiently, fast and increases the success of root canal therapy. Proper Understanding the fundamentals of file designs, will help in easy operation in different type of canals. Effectiveness of these features can be assed combining

them with preclinical and clinical trials. These designs are selected on the basis of clinical condition. The recent trends in NiTi alloys include heat treatment and controlled memory which are designed to increase the flexibility and reduce the shape-memory properties. To summarize select the instrument of proper design depending on clinical case with increased instrument efficiency, less cyclic fatigue, minimize the risk of instrument separation. Along with these features proper speed, torque and chelation must be used. However, each rotary system has its own advantages disadvantages which have to be considered before using it

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