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Percentage Taper Variations in Endodontic Files- A Review

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Abstract

Endodontic files were initially standardized with a linear variant percentage of 2% taper. These file system shows a drastic difference in percentage taper which can impair the formation of a smooth confluent root canal preparation. A constant percentage file sizing system was later introduced in 1991; it makes more logical sense in the percentage taper of files. However the actual volume of dentin removed between files is inconsistent. At this increase in size, the difference in dentin removal between each file varies from approximately 16% between the first two sizes and approximately 45% between the last two sizes The next system of file introduced is constant volume removal (CVR) type. In this file system the diameter increases uniformly from D1 to D2.The volume of file is the frustum (formed between D1 and D2), each subsequent file in the set has volume greater than its previous file in a predetermined manner

Key-words: *ISO taper files, Constant percentage taper files, Constant volume removal files*

INTRODUCTION

Root canal files were originally produced by the Kerr Manufacturing Company in (1915), is the oldest instruments for cutting of dentin- ANSI no: 28, ISO no: 3630/1. The instruments were made from stainless steel wire that is ground to a tapered square and twisted to get a file, during the process it is work hardened Prior to 1959, endodontic files were not manufactured according to any set standards. That is, the size, shape and overall configuration varied from manufacturer to manufacturer.

During 1959, a standard known as variable linear dimensional (VLD) standardization came into being. Endodontic files manufactured after 1959 were defined by the diameter of the file at a point approximately 1 mm from the tip (D1).

At the 1989 in the Congress of the American Association of Endodontists, Schilder proposed a new criterion of standardization for the instruments: rather than increase by a constant measurement (0.05 mm), he suggested they be increased by a constant percentage (29.17%) from one number to the next. This new criterion is based on the observation that there is a drastic and sudden increase in size of 50% when passing

from no:10 to no: 15 or of 33% while changing from no: 15 to no: 20, while it is very minimal in higher instrument i.e. , 13% from no: 40 to no: 45 and 10% between no:50 and no: 55.During root canal preparation difficulty is encountered in a smooth canal preparation on changing from no: 15file to no: 20, while some sizes, such as no: 45 or no: 55 when changing from precursor to successive one, instrumentation is so easy or loose fit that they are frequently skipped.

The newly introduced constant volume removal (CVR) system is based on the actual volume of dentin removed from by the file. Each file removes exactly the same increase in volume as its previous one and there is no irregularity in volume removal like those encountered in the previous systems.

DISCUSSION

The taper of instruments of ISO standardized endodontic file is .02mm/mm of length starting from the tip, Thus the working diameter is the product of taper and length of the tip. The most efficient, shank side cutting flute is 16mm coronal to D0.It is identified as D_{16} and is the most active aspect of the instrument.ISO files have a standard taper of .32 mm over 16mm of the cutting blade[1].

Though hybrid files and new generation files have substituted or replaced .02% taper files. These files are inevitable to negotiate the teeny weenie areas of root canal hitherto unapproachable by any other instrument, There is a misconception that apical diameter D0 increase by .05mm in endodontic instrument between sizes no: 10 and no: 60.This over simplification critically affect the meticulous cleaning and shaping of root canal system. Dr Pierre Machtou and Dr Herb were the first ones to caution about the mismatch of apical tapers between successive instruments or it did not have a constant percentage change (Table 1).

The percentage change between consecutive instruments is calculated by taking the difference between Do diameters and dividing it by D0 of the small instrument and multiplying it with100 to get the percentage.

% change between two instruments =

$$\frac{D_o \text{ of bigger instrument} - D_o \text{ of smaller instrument}}{D_o \text{ of smaller instrument}} \times 100$$

There is a gross variation between percentages taper between subsequent instruments. This gross apical taper discrepancy can create enduring problem that will deleteriously affect cleaning and shaping of root canal .Smaller instruments show wide variation in taper while larger instruments show a better transition in apical taper .It is always appropriate to have a low percentage difference between D0's in successive instruments especially in smaller instruments.

Table: 1

Percentage Incremental Changes in ISO instruments

Instrument Number	*Percentage increase*
06	
08	33%
8	25%
10	50%
15	33%
20	25%
25	20%
30	17%
35	14%
40	13%
45	11%
50	10%
55	9%
60	17%
70	14%
80	13%
90	11%
110	10%
120	9%
130	8%
140	8%

Small sized instruments are crucial in negotiating micro anatomical parts of the canal with torturous course and bifurcations. A large percentage difference between files can create endodontic complications such as ledge, canal transportation, zipping and stripping [Figure 1]

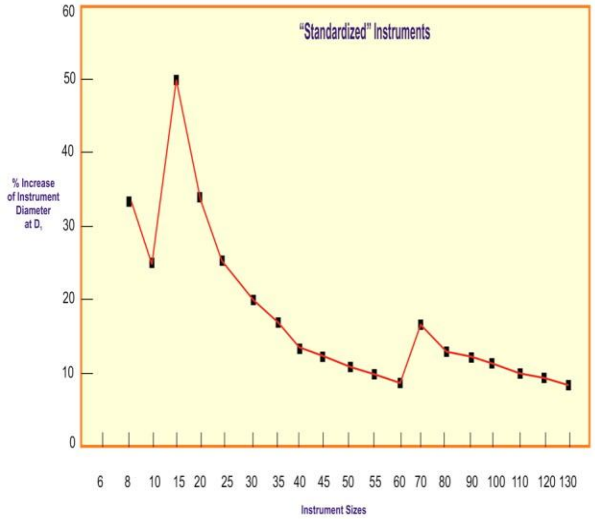

Figure 1 Graphic representation of the chaotic percentage incremental changes at D1 with ISO specified Instruments from no: 6 to no: 130

There is 50% increase in apical diameter from no: 10 to no: 15.The impacts of this extreme difference can be reduced in canal preparation by slightly extending the no: 10 file through the apical foramen, this step will enhance the smooth insertion of no: 15 file till the apex. By this procedure the percentage change between files can be reduced from 50% to 25%.Constant recapitulation is critical for a smooth flowing canal anatomy or else canal preparation will have multiple irregular steps. These irregularities will form micro pockets that lodges bacteria

During 1991 a new endodontic file sizing system was introduced known as constant percent files (CP). The constant percent change sizing system was the first of its kind in endodontic file size standardization in over thirty years .It is based on changing the diameter at D1 by an exact percentage. Endodontic treatment became popular during this time period and clinicians were finding difficulties in negotiating canals especially narrow ones with the variable linear dimensional standardization [2]. Since endodontic instruments were used by hand or with oscillating tools, it was becoming increasingly difficult to treat the more difficult endodontic cases. The difficulty with the VLD system is that the percentage change of file size is erratic. The percentage change of D1 from a no: 8 file to a no: 10 file is 20%, from a no: 10 to no: 15 file the change is 50%, and from no: 15 file to no: 20 file the change is 33%. In order to rectify this defect, CP system was introduced; it is based on a constant percent change from one file size to the next. Each D1 is exactly x% larger than its previous file, and root canal treatment is accomplished with minimum number of instruments [3]. In the currently utilized CP system, x is 29.17%. Files produced under the CP system utilize a D1 to D2 differential of 0.6 mm instead of 0.3 mm as files in VLD system. The CP system provides a smoother transition from one file to the next since each file is same percentage larger than its predecessor.

On comparing the D1 measurements of the ISO 10-60 instruments with the same instruments of the new series, the difference between first two CP instruments is 29% rather than 50%, as it is between ISO no:10 and ISO no:15 . The difference between the second and third of the CP series is again 29% rather than 33.33%, as it is between ISO no: 15 and ISO no: 20 instruments. The parabolic nature [Fig. 2] of the increase in size in the new series is such that the first five instruments used in succession are all thinner in D1 than the first five instruments of the present ISO system. The sixth instrument is D1 in the new series equal to the diameter of the sixth instrument of the ISO system (35 file) [4].Only two instruments are required to enlarge the apex to D1=0.60 in the new system (no: 7 and no: 8), instead of the five instruments in the ISO system which were required to pass from a no: 35 to no: 60. The parabolic nature [Fig 2] of the increase in size in the new series is such that the first five instruments used in succession are all thinner in Di than first five instruments used in ISO system

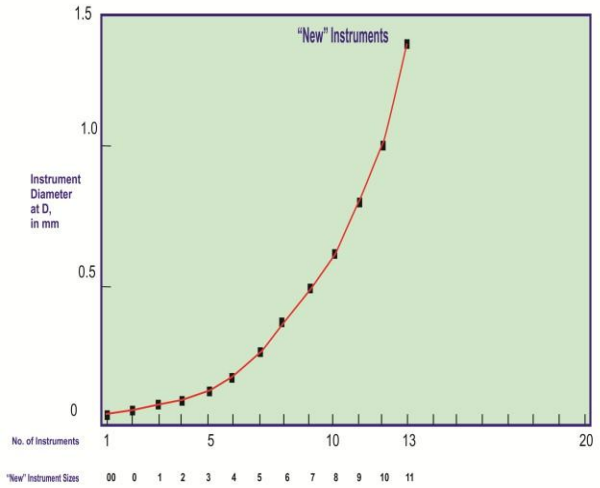

Figure.2. Automatic parabolic nature of increases in size at D_1 in a constant percentage

Endodontic files made of an alloy of nickel and titanium transformed the conventional methods of endodontic instrumentation. Rotary instruments have revolutionized endodontic treatment approach [5]. Each rotary files or reamers can only remove a specific volume of dentin (root material). Since both file sizing systems (VLD and CP) remove irregular volumes per file size, clinical "workarounds" has to be employed in order to prepare root canals when using rotary files or reamers based on this geometry. In complicated cases reamers must be used repeatedly and in alternating manner making the procedure more tedious and time consuming

Currently endodontic files which provide constant dentin volume removal(CVR), from file to file or from reamer to reamer is introduced Although the CP sizing system reflects a constant percent change from one instrument to the next, it does not consider the actual volume of dentin removed by each successive file. The invented constant volume removal (CVR) sizing system is based on the actual volume of dentin removed from file to file [6]. Each file removes exactly the same increase in volume as its predecessor-there are no irregular increases in volume removal like those encountered in both prior file systems. The clinical results are dramatic because the practitioner will be able to use each file in a sequential manner from smallest to largest without the need to alternate sizes or rely on subjective factors. The time required to prepare a patient's root canal drops due to reduced need to interchange sizes during the procedure. In CP system the actual volume of dentin (root structure) removed between files is inconsistent [7][Figure 3]. Files increases at D1 diameter at a rate of 29.17%. At this increase in size, the difference in dentin removal between each file varies from approximately 16% between the first two sizes and around 45% between the last two sizes. But the difference between the volumes removed between CVR files is always the same. This constant change in volume of dentin removed from one size to the next results in a smoother transition from file size to file size [8]. The volume of dentin removed when file passes through the centre line in root canal is determined by the volume of frustum which is formed between diameters D1 and D2, it can be calculated as

$$= \quad \pi\, h/3(r1^2+r1+r2+r2^2)$$

(h is the distance between D1and D2).The volume of dentin removed between files is progressing in a constant volume or a smoother transition occurs between files.

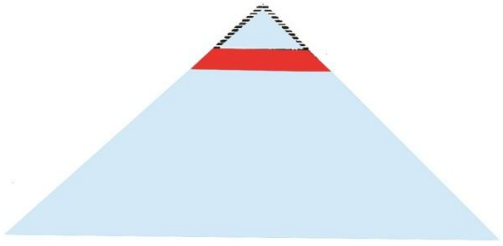

Figure 3 Frustum of instrument

Use of the CVR system:

1. Reduces preparation time.
2. Reduces metal fatigue of the endodontic files.
3. Eliminates need for Crown-down preparation.
4. Provides a less subjective technique

CONCLUSION

A thorough understanding of endodontic file system is necessary for a clinician before working with it. In ISO instruments; negotiation of constricted apical ramifications is very difficult, the basic reason being linear variant taper. However with constant percentage taper instruments dentine is removed in bulk volume with little regard for the volume being removed.

With constant volume removal system (CVR), endodontic file design is to allow the clinician to objectively and quickly prepare a root canal space. This is achieved by proceeding in a step-by-step manner from one endodontic file size to the next [9]. This is not the case with the other systems. In CP system, it is clearly apparent that the subjective judgment of the clinician is extremely important, while CVR system relies on objective clinical techniques

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