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Research article

Cutting efficiency of different cross sectional design protaperrotary instruments - *in-vitro* study

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Abstract

Aim: The purpose of this study is to assess the effect of different cross sectional designs along with variable metallurgical modifications on the cutting efficiency of rotary nickel titanium on root canal dentine. **Methodology:** A total of forty mesiobuccal root canals in mesial roots of mandibular first permanent molars with a curvature ranging between 25° to 35°Cwere selected for this study. Canals were randomly distributed into two groups, 20 canals were prepared with ProTaper GOLD rotary system, and the other 20 prepared with the ProTaper NEXT system. Teeth were marked and weighed before and after instrumentation with delta weight (Δ wt = wt pre – wt post) recorded and listed in tables for statistical analysis. **Results:** Samples instrumented with ProTaper GOLD showed increased weight loss (Δ wt) with no significant difference with the ProTaper NEXT. **Conclusion:** A cross section modification for the ProTaper NEXT didn't improve the cutting efficiency as was expected; in addition metallurgical treatments of the Protaper GOLD showed good cutting efficiency.

Key words: Cross section, Cutting efficiency, Protaper.

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1. Introduction

The ability to clean the root canal system effectively depends on both instrumentation and irrigation, while the design of the instruments might be a factor that affects the efficacy of debris removal and smear layer production. Cutting ability is defined as the ability of the instruments to cut through a given material, while the cutting efficiency is the rate of the instrument to cut through a given material [1].

The cutting and cleaning efficiency is a multi-factorial property depending on different parameters such as; metallurgical properties, cross sectional configuration of the shaft, sharpness of flute, flute design (number of flutes, helical angle, and rake angle) tip design, lubrication during cutting, wear resistance, chip removal capability and mode of use [2].

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Root canal cutting tools are under constant evolution, every day new geometrical designs evolve with new metallurgical modifications incorporated, all those aiming to improve the quality of the chemo-mechanical preparation phase of root canal therapy, for both dentist and patient. Modification of instruments to increase cutting ability is very important in modern endodontic practice, as it increases its efficiency [3], and decreases the time needed for therapy, which in turn decreases the patients suffering of the procedure.

The cross section of the instrument in particular has been of prime interest to researchers [4-7] over the time. Oliet and Sorin in 1973 evaluated the cutting efficiency of Squared cross sectional reamers versus triangular cross section, passing through the invention of the U-shaped cross section and being used in many systems such as the ProFile 29 series [8] and the Quantec system [9] with the relieved U-shape design. These where the first generation files which were characterized by having passive radial lands. Second generation files were innovated to possess active cutting edges with fewer instruments to prepare the canal [10], this included the ProTaper with a convex triangular cross section, and its modification the ProTaper Universal with a relieved triangular cross section. Tulsa dental recently introduced the ProTaper NEXT and the ProTaper GOLD [11].

ProTaper GOLD has been released with claims of having an active cross section and increased flexibility, durability and with innovative metallurgy. It has been claimed to have 50% increased cyclic fatigue resistance. [11] ProTaper NEXT has a unique rectangular cross section with an asymmetric rotary motion and M-wire NiTi alloy for increased cyclic fatigue.

2. Materials and Methods

Sample preparation:

Sample size and type:

Forty extracted human mandibular permanent first molar teeth.

Inclusion criteria:

1. Human mandibular first molar teeth
2. Fully formed apices
3. No previous root canal treatment done.
4. All mesial roots have a type three root canal system.

Root preparation and grouping:

Soft tissue, calculus and foreign bodies were mechanically removed. For disinfection and dissolving organic debris, teeth were fully immersed in 2.25% sodium hypochlorite solution for 24 hours. The teeth then washed in running tap water, and then samples were stored in saline until use.

Coronal access was achieved by using Endo-Access and Endo-Z burs (Dentsply-Maillefer). Teeth were then hemi sectioned bucco-lingual at the bifurcation level with a diamond disc mounted in high-speed contra-angle with copious water coolant and the distal root with its part of the crown were discarded. The mesial halves were used for the preparation of mesiobuccal canals (n=40 root canals). A fixed root length was obtained of 17- mm. from the apical end by grinding the crown.

All mesial root canals were controlled for apical patency with a K-File no. 10 (Dentsply-Maillefer). The working length (WL) was measured until the no. 10 K-File's tip was visible at the apical foramen

minus 1-mm (i.e.) the WL was adjusted to a length of 16-mm. All teeth were radiographic in bucco-lingual direction to determine the degree of curvature of each tooth according to Schneider's technique [12]. K files no. 10 was inserted into the buccal and lingual canal to assess the degree of root canal curvatures, which was found to be 15°C-30°C with an average of 22.5°C.

Mesiobuccal canals were prepared with ISO standard 0.02 K-file, taper till size #25.

Mesial roots were divided equally (n=20 teeth with 20 canals for each group) and randomly distributed into two groups according to the used system for root canal instrumentation:

Group I was prepared by using the ProTaper GOLD System.

Group II was prepared by using the ProTaper NEXT System.

Instrumentation Procedure:

Instrumentation of all samples was done bythe same operator, using an X-Smart Micro Motor (Densply) according to manufacturer's instructions, by crown down technique in sequential order, starting with Sx in both systems, and finishing with the $F_2$and X_2 for the ProTaper GOLD and ProTaper NEXT respectively. Copious irrigation was performed by a 27-G irrigation needle using 2-ml of distilled water after each file and a 10-ml after the preparation of the canal was finished.

Weighing procedure:

Before preparation, all roots were dried in vacuum oven 6 hours at 82 °C to ensure they were moisture free. Teeth were then weighed (wt. before)by a four-digit gram high precision balance sensitive scale(Sartorius Precision Balance 2254 S0001, Germany.), identified (serial numbered) and stored in saline in a separate vial. After preparation, teeth were re-dried using the same method and weighed. Measurements were recorded by a different operator in a schematic chart to be used later on for subtractive analysis for comparison between the cutting efficiency of the two systems.

Statistical analysis:

Data presented as mean and standard deviation (SD). Data explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. Change in wt (gm) showed nonparametric distribution, so Mann Whitney U test used to compare between the tested groups.

The significance level was set at $P \leq 0.05$.

Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows**.**

3. Results and Discussion

Difference between Different tested groups on mean Change in wt (gm):

The ProTaper GOLD showed higher mean values of weight loss (**Δ wt =** wt pre – wt post)0.0044 grams, than the ProTaper NEXT (0.00417). The highest amount of weight loss for the ProTaperGOLD was 0.00569 grams, while the lowest was 0.00311. ProTaper NEXT group showed highest weight loss of 0.00529 and the lowest was 0.00305 grams.

Mean and standard deviation (SD) for the Change in wt (gm) for different tested Groups were presented in table 1 and figure 1.

An insignificant difference between ProTaper GOLD (0.0044 ± 0.00079 gm) compared to ProTaper NEXT (0.00417 ± 0.00077 gm) at p=0.314.

Table 1. Mean and standard deviation (SD) of Change in wt (gm) for different tested Groups.

		Group		p-value
		ProTaper GOLD	ProTaper NEXT	
Change in wt (gm)	Mean	.00440	.00417	0.314 NS
	SD	.00079	.00077	
	Min.	.00311	.00305	
	Max.	.00569	.00529	

Means with the same letter within each row are not significantly different at p=0.05.
*= Significant, NS=Non-significant

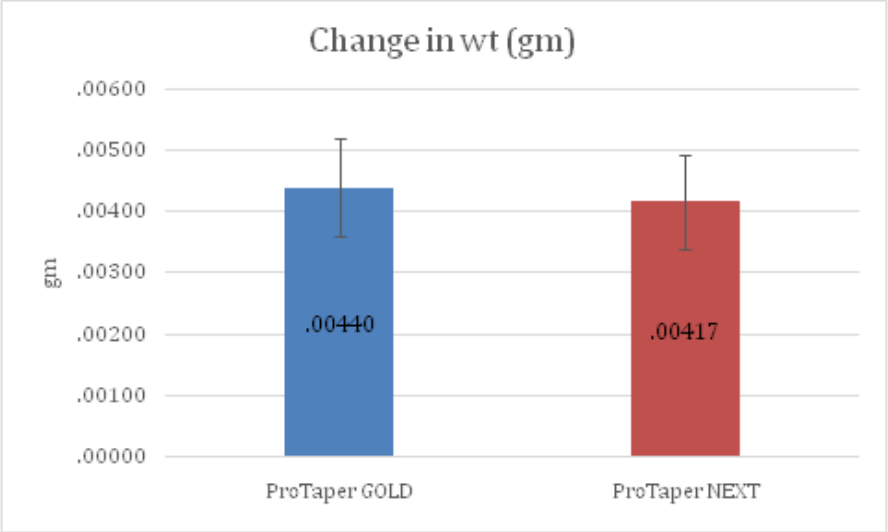


Figure 1. Histogram showing the mean Change in wt (gm) for different tested Groups.

Discussion

One of the main purposes of the root canal instrumentation is the cutting of the root canal dentine. It is desired to shape and form distinct configuration of the canal space capable of receiving a three-dimensional filling material. The instrument geometrical designs definitely improve the quality of root canal preparation. The present study was carried out in an attempt to define the effect of geometrical design features, of two rotary nickel titanium systems on their ability to remove root canal dentine.

Instrument systems selected for this study are the ProTaper GOLD and the ProTaper NEXT systems. The two systems were introduced to the market by the same company, (Tulsa Dental, DENSPLY) in a very short period of time, having totally different geometrical designs and metallurgical properties [1-4], for this reason it was crucial in this study to determine which of the two cross sectional designs had a positive effect on the cutting efficiency.

Variable materials were used as substrate to measure the cutting efficiency, including extracted teeth [13-15], acrylic wafers [16] Acrylic blocks [15], molded epoxy resin [13], Poly methyl methacrylate [17,18], and Bovine bone [19,20]. In our present study, the selection of natural teeth were done in accordance international consensus, which concludes that, natural teeth were the most frequent substrate used for in-vitro studies, as it mimics the clinical situation more than others [21,22]. This was carried

out according to the work of Cunningham and Senia who recommended the use of mesio-buccal and mesio-lingual canals of human mandibular first permanent molars [23]. Furthermore, the original rounder cross section of the mesio-buccal and mesio-lingual root canals as evaluated by Wu et al [24] which did give a near to standard starting configuration.

Cutting dentine is an essential step during root canal instrumentation and contributes to the removal of infected dentin. Quantitative measurements of dentine removal by an instrument have generally been described under the term "cutting efficiency." For endodontic instruments, this depends on the interaction of a number of factors such as cross- sectional configuration hardness and sharpness of the blade (cutting edge), flute and blade design, tip design, lubrication during cutting, wear resistance, chip removal capability, and method of use [5]. The substrate (dentine) to be machined is also an important factor.

There have been no standard guidelines for measuring the cutting efficiency of endodontic instruments, nor an agreed optimum cutting efficiency for rotary files. This has led to a plethora of methodologies for quantifying cutting efficiency [25,26]. Invariably, this was determined in an indirect way—that is, the ability to remove material after a finite period of time or effort. Various definitions of cutting efficiency have been proposed [2,26-31]. yet; others have expressed cutting efficiency as the weight loss of the (dentine) specimen after cutting[32,33].

The cutting efficiency in the present study was evaluated by gravimetric analysis of the tooth before and after preparation of MB root canals. This is the simplest, most accurate way of measuring the amount of extracted volume of root canal dentine specially when eliminating the effect of variables. So the mean cutting efficiency of the groups was concluded through the cumulative mean weight loss of each group following sequential preparation (serial preparation)[34].

Although the instrument systems showed insignificant differences in the amount of dentine removed, yet the ProTaper GOLD group showed a slight increase in the mean delta weight, this may be attributed to the convex triangular which showed thicker core due to the mode of cutting which is the symmetrical rotation, compared to the thinner core of the rectangular cross section of the asymmetrical ProTaper NEXT cutting motion. In addition to the cross section, the instrument systems showed different tapers, where the GOLD has an F3 file with a taper of 0.9 while as that of the X3 is 0.7 [11].

These results come in accordance with the previous studies that showed that the triangular cross sectional design of reamers can cut more active than the 90 degree angle of squared cross sections of files, yet in the same manner with insignificant differences between the two cross sections [2].

Conclusion:

A cross section modification for the ProTaper NEXT didn't improve the cutting efficiency as was expected; in addition metallurgical treatments of the Protaper GOLD showed good cutting efficiency.

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