ORIGINAL RESEARCH

Cutting Efficiency, Surface Change and Hardness: EZ-fill Safe Sider Instruments vs K Files

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ABSTRACT

Endodontic therapy has made deep inroads into every sophisticated dental practice today. Adequate knowledge of the space anatomy, armamentarium and methodology are essential for successful treatment. The aim of this study is to compare the cutting efficiency, surface change and hardness of EZ-fill safe sider with K-file.

Key words: EZ-fill, K-file, safe sider

The hard tissue repository of the pulp space presents many complex configurations, which makes the designing of instruments and instrumentation techniques most difficult. Adequate knowledge of the space anatomy, armamentarium and methodology are essential for the successful outcome of the treatment. Root canal therapy depends on various clinical procedures and skills yet, the factor of substance is essentially satisfactory and shaping for a positive outcome.

To achieve this objective, the quests for newer instruments and instrumentation techniques have been continuously evolving over the years. Reamers are the original intracanal instruments used since the 19th century for root canal instrumentation. With the advent of file system, in which the principle of design were altered to make the instrument more efficient. Initially, these instruments were fabricated from carbon steel, which is replaced by stainless steel owing to its high of corrosion and brittleness.[1]

Nickel-titanium alloys are 2-3 times more flexible and have superior resistance to fracture when compared to stainless steel. This property allowed them to negotiate curved canals with less lateral stresses and transportation.[2,3] The cutting efficiency of nickel-titanium is found to be impaired when compared to stainless steel instruments and they fracture without any warning due to phase transformation. This led to a withdrawn attitude towards nickel-titanium with many users.[4,5]

As a solution to the problems encountered in canal preparation, a new instrument system called the EZ-fill safe-sided has been recently developed bearing in mind the positive features of both stainless steel and nickel-titanium.

The purpose of this study is to compare the cutting efficiency, alterations in surface characteristics and hardness of conventional instruments versus the new flat-sided designed instruments (EZ-Fill safe-sided) for canal preparation.

Material and Methods

Grouping of the Selected Sample

The resin blocks were divided into three groups of six blocks each as Group A, B and C. The dimensions of the resin block are; the length of the block - 30 mm, the width and the height being 10 mm. The canal had an initial apical diameter of 0.08 mm, the length of the canal measured 19 mm from the external surface of the block and the canal curvature was estimated as 30° (Schneider's method). Two separate sets of EZ-fill instruments were obtained for Group A and Group B. Color coding was done on the bottom of each resin block for better identification. Group A - pink, Group B - blue, Group C - green. Instrumentation in all the groups was performed by using step-back method.

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Group A: Samples instrumented with EZ-fill safe-sided instrument system - both stainless steel and Ni-Ti as recommended by the manufacturer.

Group B: Samples instrumented with EZ-fill safe-sided instrument system-only stainless steel instruments were used.

Group C: Sample instrumented with conventional K-files - stainless steel.

Before instrumentation, the resin blocks in all the groups were weighed using an electronic weighing device (Mettler Toledo). The purpose of preweighing was to quantitatively evaluate the weight loss before and after instrumentation in Group A, Group B and Group C.

Specific Observation of Instruments before Instrumentation

The instruments (no. 20 and no. 25) were observed under stereomicroscope at 40x magnification to detect any surface defects caused by the manufacturing process.

Before instrumentation, the instruments in all the three groups (no. 20 and no. 25) were evaluated for their hardness, which was performed using Vickers microhardness tester (Reichert MD 4000E Ultra Microhardness Tester) and the readings were recorded.

Canal Preparation in Group A

Using a watch winding motion, a no. 8 stainless steel instrument was negotiated to the apex, keeping the canal wet with physiological saline. Working length (18.5 mm) was determined visually by inserting a no. 8 stainless steel instrument until it was visible at the apex and then subtracting 0.5 mm from that measurement.

The time taken for canal instrumentation, starting with no. 8 instrument till the completion of the procedure was recorded using a stopwatch. The time recorded was only for the instrument's function in the canal excluding the time taken for irrigation, cleaning of the instrument and instrument change. The number of strokes used per instrument was also recorded.

One stroke is one cutting cycle i.e., insertion of the instrument, perform watch winding motion and withdrawal of the instrument from the canal. This sequence was followed till no. 20 instrument snugly fitted at the working length.

Stereomicroscopic evaluation was performed for no. 20 instrument at 40x magnification after 50, 100, 150, 200, 250 and 300 strokes to detect the changes that occur on the surface of the instrument. After this, coronal enlargement was performed using Gates Glidden burs in a step-back manner. All these procedures were performed under copious irrigation.

The no. 25 safe-sided instrument was instrumented 1 mm short of the working length and this instrument was also observed under the stereomicroscope after 50, 100, 150, 200, 250 and 300 strokes to observe any changes in the surface characteristics of the instrument. The canal was prepared till no. 40 size instrument using a step-back technique. Stainless steel no. 20 size instrument was used as a patency file for recapitulation.

Following this, Ni-Ti 30/0.04 tapered EZ-fill safe sided instrument was placed in the canal and before it was negotiated to the working length, the point from where the instrument binded initially in the canal to the working length was recorded. This instrument was further worked to the working length. A similar procedure was repeated for Ni-Ti 25/0.08 taper EZ-fill safe-sided instrument. These two instruments were also observed under stereo-microscope at 40x magnification to detect any changes in the instrument morphologically.

Canal Preparation in Group B

The same procedure was performed as in Group A with the EZ-fill safe-sided instruments and the time taken for canal instrumentation was recorded.

Canal Preparation in Group C

The same procedure was performed using the conventional K files and the time taken for canal preparation was recorded and tabulated.

Evaluation of Hardness after Instrumentation

The instruments (Stainless steel no. 20 and 25 in all groups) were evaluated for hardness with a Vickers microhardness tester under a load of 200 gs for 10 seconds. The instrument was mounted on the porcelain slab with a modeling wax. The purpose of

Table 1. Mean, Standard Deviation and Test of Significance of Mean Values for Weight of Resin Blocks before and after Instrumentation between Different Study Groups

Variable	Groups	Mean ± SD (grams)	P value	Significant groups at 5% level
Weight of blocks before instrumentation	A	3.43 ± 0.01	0.18 (NS)	--
	B	3.42 ± 0.01		
	C	3.43 ± 0.01		
Weight of blocks after instrumentation	A	3.42 ± 0.01	0.45 (NS)	--
	B	3.41 ± 0.02		
	C	3.42 ± 0.01		
Difference in weight of blocks before and after instrumentation	A	0.01 ± 20.001	<0.0001 (Sig)	A vs B, C
	B	0.005 ± 0.001		
	C	0.006 + 0.001		

using modeling wax was to hold the instrument firmly on the slab to avoid movement when the indenter of the microhardness tester was placed on the instrument. The instrument was observed under the optical microscope at 160x magnification to obtain a clear flat image, which was then subjected to indentation. After the application of load, a diamond-shaped indentation was observed on the instrument surface.

Results

Mean and standard deviation are estimated for each study groups. Mean values were compared by student's independent 't' test and one way ANOVA.

Multiple range tests by Turkey-HSD procedure is employed to identify the significant groups, if p value in one way ANOVA is significant. In the present study, $p < 0.05$ is considered as the level of significance.

Mean value of weight difference in Group A (0.01 ± 0.0001 g) is significantly higher than the mean weight difference in Group B (0.005 ± 0.001 g) and Group C (0.006 ± 0.001 g) ($p < 0.05$). However, there is no significant difference in weights between Group B and Group C ($p > 0.05$) (Table 1).

The mean difference of hardness of no. 20 instrument in Group C (150.9 ± 46.0) is higher than Group A (71.1 ± 36.7) and Group B (84.4 ± 18.4) (Table 2). There is no statistical significant difference ($p = 0.08$), which could be due to the less number of readings taken for the sample. But there is a significant change seen in the mean value of Group C, which is twice that of Group A and B.

The mean difference of no. 25 instrument in Group C is higher (127.0 ± 32.7) when compared to Group A (33.1 ± 14.6) and Group B (65.2 ± 12.2), which shows a statistical significant difference (p - 0.01)

Table 2. Comparison of Mean Differences of Hardness of Instruments before and after Instrumentation between Different Study Groups

Instrument	Group	Mean ± SD HV	P value
No. 20	A	71.1 ± 36.7	0.08 (NS)
	C	150.9 ± 146.0	
No. 20	B	84.4 ± 18.4	0.08 (NS)
	C	150.9 ± 46.0	
No. 25	A	33.1 ±14.6	0.01 (Sig)
	C	127.0 ± 32.7	
No. 25	B	65.2 ± 12.2	0.01 (Sig)
	C	127.0 ± 32.7	

Discussion

Physical and mechanical characteristics of endodontic instruments are the most vital factors, which determine their cutting efficiency and effective serviceability. One such attempt has been made by essential dental systems involving Musikant et al, in developing an instrument system with a different geometry after several years of research called the EZ-fill safe-sided system, which they claim to have superior properties over the conventional instruments.[6]

Resin blocks are used to overcome the impossibility of accurately determining the original canal shape before preparation in natural roots. Moreover, if the original canal shape is not known, the effects of instrumentation are also unknown. The advantages of using resin simulated canals is that the curvatures and the shape of the canal, dimensions and hardness are known, the instrumentation canal so be directly visualized, which helps in better standardization.[7,8]

In Group A, the Ni-Ti 0.08 taper instrument got separated despite the use of watch winding motion as recommended. This separation could be attributed to the failure to recognize that the rate of taper of instrument exceeded the rate of taper of the canal that prevented apical file movement. When an instrument binds on its more shank side cutting blades, the clinician loses apical control. Attempting to work straighter files in curved canals first invites block then predisposes to formation of a ledge that is seen with stainless steel instruments.[9, 10] This could be the reason for the greater taper instruments whether hand or rotary are manufactured with nickel-titanium.

Musikant et al described that the EZ-fill safe-sided incorporates a 'D' shape cross-section by making the circular configuration flat on one side. It also increases instrumentation efficiency because the vertical blades created by the flat sweeps the debris from the flutes to the relieved area. The flat reduces the amount of the instrument cutting surface in contact with the canal, which results in a slightly less efficient instrument but easier to use in the canal as it is not fully engaged in the canal circumferentially. It also provides the dentin debris generated during canal instrumentation to get accumulated in the space between the flat and the canal wall. Therefore, the debris doesn't wedge between the instrument and canal wall. Because less of the instrument is cutting at any one time, less stress is placed on the instruments. By lowering the stresses, the chance of instrument breakage is reduced and consequently the instruments last longer. Further, the flat is not cut deeply into the core of the metal of the instrument, so it increases the flexibility without compromising the strength.

It was observed in this study during instrumentation with the safe siders, there was a sufficient volume of irrigant present in the canal between the flat portion of the instrument and the canal wall making the instrumentation more efficient.[11] The resin shavings were seen suspended in the irrigant lowering the rate of smear layer formation which was not so in the conventional preparation. The wet environment was persistent right through the preparation and the presence of irrigant also reduced the wear and tear of the instrument. The claims made by Musikant et al were well-observed and appreciated during canal preparation in our study.

The conventional preparation using K files (Group C) was found to be more time consuming when compared to Group B and required greater force causing more hand fatigue as compared to the EZ-fill safe-sided instruments. This was due to the greater binding and less flexibility of these instruments. The apical packing of debris was found to be more and required frequent recapitulation.[12]

The instruments in all the groups were examined under a stereomicroscope at 40x magnification before and after instrumentation and for every 50th stroke till 300 strokes. The observations revealed that the stainless steel K files showed more deformations, especially rolling over of the cutting edges, which appeared after 50 strokes, which was not seen in the EZ-fill safe-sided counterparts. The rollover of the blades is more in K file #20 that was due to the greater binding as it was used before coronal flaring. After 100 strokes, more rolling over was seen in K files when compared to EZ-fill safe-sided instruments. The rolling over was exaggerated in K files after 150 strokes whereas initial changes on the cutting blades of the EZ-fill safe-sided instruments was observed. Significant rollover occurred after 300 strokes for EZ-fill safe-sided where as loss of metal, dented and grooved cutting edges was seen on the surface of K files.

From these findings, it is evident that the safe-sided had a pronounced efficiency, durability when compared to the conventional K files. However, clinical trials would be more substantiative.

Hardness tests were performed for instruments before and after instrumentation and the values were recorded. The reason for evaluating the hardness was to show that there was an increase in hardness after instrumentation which is attributed to changes that occur due to cold working. The surface hardness, strength and the proportional limit are increased whereas the ductility and resistance to corrosion are decreased. Further cold working eventually leads the instrument to separate. The variables obtained show that the conventional stainless steel K files were work hardened more indicating greater stress strain levels than the instrument that underwent during instrumentation when compared to EZ-fill safe-sided instruments. Even though, the EZ-fill safe-sided is also a stainless steel instrument, the design, number of flutes and the core made the difference.

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Conclusion

Under the conditions of this study, EZ-fill safe-sided instruments proved:

- More efficient than the conventional K files
- Aids in better removal of debris
- Causes less fatigue to the operator
- Shows less cold working and therefore less chances of instrument separation
- Maintained a smooth reproducible glide path.

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