Original article

A comparison of root canal preparations using stainless steel, Ni-Ti hand, and Ni-Ti engine-driven endodontic instruments – an in vitro study

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Abstract

The main advantage of nickel titanium instruments is that they permit canal preparation with less transportation and ledging. Hand used Ni-Ti and rotary Ni-Ti instruments have a wider range of elastic deformation and greater flexibility. The aim of the present study was to evaluate and compare the preparation time, loss of working length, apical transportation, instrument deformation and fracture with stainless steel, Ni-Ti hand and Ni-Ti rotary endodontic instruments. Fifty freshly extracted human mandibular molars with curved roots were collected and stored in 10% formalin. The samples were divided into 3 groups of 15 each. The access opening was made for each tooth and the biomechanical preparation was carried out using crown down pressureless technique in all the groups. Group I was instrumented with stainless steel files, group II with hand Ni-Ti and group III with Ni-Ti rotary files. The preparation time to enlarge each canal was recorded in minutes and seconds, which included only active instrumentation. Following preparation, the final length of each canal was subtracted from the original length to give the loss of working length. SEM photographs of the deformed and fractured instruments were taken. The apical transportation was measured using computer software (Microdraw 4.1). The readings were noted and statistically analyzed.

The results of this in vitro study showed that the mean preparation time was less with Ni-Ti rotary (1.85 min) when compared to hand Ni-Ti (6.33) and stainless steel files (6.73), which was statistically significant. The loss of working length was more for stainless steel group which was statistically significant ($P<0.05$) when compared with the other 2 groups.One instrument in stainless steel and one in Ni-Ti rotary files were fractured. Only one instrument in stainless steel file deformed permanently. Apical transportation was found to be greater in stainless steel group than other groups ($P<0.01$) which was statistically significant. Considering the parameters in this study, Ni-Ti rotary files proved to perform better than the other two groups.

Key words: Canal preparation, crown-down pressure less technique, double exposure radiographic technique.

Introduction

One of the most important steps in root canal treatment is cleaning and shaping of the root canal[1, 2]. Cleaning is necessary to remove all the pulp tissue, necrotic debris, microorganisms and the infected layer of dentine from the canal walls, whilst shaping involves the enlargement of the canal system to facilitate the placement of a root filling[3].

Over the second half of the twentieth century, advances in endodontic instruments and techniques allowed millions of previously condemned teeth to be saved.

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Traditional cleaning and shaping techniques employing hand instruments have a variety of steps, depend on the clinician's skill, and are often complex. Recent advances, including the use of nickel-titanium in instrument manufacture and the introduction of high torque rotary handpieces, have made canal preparation less arduous and more standardized. Rotary instrumentation with nickel-titanium files results in a more uniform preparation with regard to taper and can enhance obturation by providing resistance.

Early systems employing traditional stainless steel instruments were found to produce procedural errors. The introduction of instruments made of nickel-titanium has permitted the development of rotary instrumentation because nickel-titanium is two to three times more flexible than stainless steel and considerably more resistant to clockwise torsional stress.

The main advantage to nickel titanium instruments is that they permit canal preparation with less transportation and ledging. Literature review shows that engine-driven Ni-Ti instruments require less chair time to prepare the canal as compared to stainless steel files[4].

Considering the above mentioned factors, the present study was undertaken to evaluate the preparation time, change in working length, instrument failure and apical transportation in relation to stainless steel, hand Ni-Ti and Ni-Ti engine-driven instruments.

Aims and objectives

To evaluate and compare

- The preparation time.
- Loss of working length.
- Apical transportation.
- Instrument deformation and fracture with Ni-Ti hand, stainless steel and Ni-Ti engine-driven endodontic instruments.

Materials and method

Fifty freshly extracted human mandibular molars with fully formed apices and curved roots were collected from the Department of Oral and Maxillofacial Surgery and were stored in 10% formalin.

Armamentarium

- Straight probe
- Tweezer
- Intraoral periapical radiograph
- Stop watch
- Airotor handpiece
- Gates glidden drills
- Endometer
- K-Y jelly
- Round and straight fissure diamond burs
- 3% sodium hypochlorite
- Normal saline
- Disposable syringe
- Micromotor cord and straight handpiece
- Carborundum disks
- Stainless steel files (15 – 40)
- Ni-Ti hand files (15 – 40)
- Ni-Ti rotary 29 profile series hand piece and files set
- # 15 K-file
- Rubber base impression material
- PVC pipe
- Cold cure acrylic resin

Method

The collected samples were randomly divided into 3 groups of 15 each. The distal roots were amputated at the furcation and were discarded .Radiographs were taken of the mesial roots in bucco-lingual direction. The roots in which the canals exhibited internal calcification and apical root resorption were excluded.

Access preparation for each tooth was carried out. Cleaning and shaping of the mesio-buccal canals of all the teeth was carried out with 3 different sets of experimental instruments Fig.(1). The root canals in group I were prepared with stainless steel files (15-40), group II with hand nickel titanium files (15-40) and group III with Ni-Ti profile rotary 0.29 series. Crown-down pressureless technique was performed in all the 3 groups. K-Y jelly was used as lubricant.

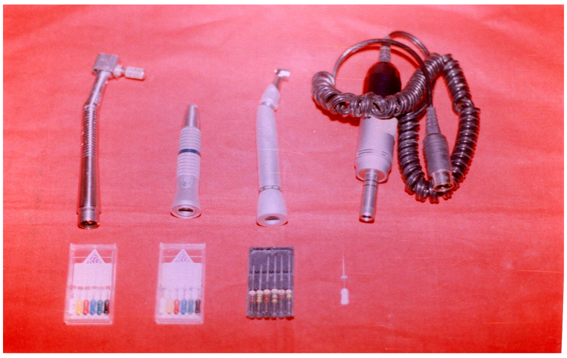

Fig 1

The preparation time and loss of working length were noted for each tooth. A double exposure radiographic technique was used to evaluate the apical canal transportation that occurred during preparation procedure. All deformed and fractured instruments were sent for scanning electron microscopic study.

Crown-down pressureless technique

In this technique the working length of the tooth is not established in the beginning. The access cavity was filled with 3% sodium hypochlorite and the first instrument was introduced into the canal.

A No. 40 file was passed into the canal to the point of resistance and was prepared till it was loose in the canal. A No. 2 followed by No. 3 Gates Glidden drill was used to flare out the radicular access. Working length 3 mm short of the radiographic apex was obtained. A No. 35 file was placed in the canal until resistance was felt and rotated till it was loose. The procedure was repeated using 30, No. 25, No. 20 and No. 15 files. This procedure was carried out till the files reached the obtained working length.

Then the working length was determined placing a No. 15 file till the apex. Final smoothening and flaring of the canals was carried out with No. 40 file. Copious irrigation was done using 3% NaOCl and normal saline after using each instrument. The above described procedure was carried out for group I and II.

The procedure for rotary profile series was carried out as described below.

Profile orifice shapers No. 3 (0.06/40) was the first instrument used. The rotating instrument was inserted, slight in and out motions for about 5 – 10 seconds was carried out. When progression became difficult it was stopped and next instrument was picked [profile orifice shaper No. 2 (0.06/30)]. The same movements were performed till there was resistance and repeated sequentially with 0.06/25, 0.06/20 and 0.04/25. The working length was determined using No. 15 K-file.

The apical preparation upto the exact working length was done using 0.04/20 followed by 0.04/25. Final flaring was done using 0.06/20 with a slight in and out motions.

Double exposure radiographic technique

The teeth were imaged utilizing a device constructed of poly vinyl chloride. This device was attached to the cone of a dental x-ray head, there by allowing for constant tube film distance and central beam angle for each radiographic exposure Fig(2). An index for the x-ray film was fashioned by adding acrylic resin to the end PVC piece and with the acrylic soft, seating (petroleum jelly) lubricant to # 2 x-ray film packet in the surface of the acrylic Fig(3). This produced an impression of the film packet upon its removal. The x-ray film packet was covered with rubber base impression material. The lingual surface of the tooth was placed into the unset material to create an imprint. The buccal surface of the tooth was faced towards the x-ray beam. The working length IOPA was taken keeping the tooth in position. The last instrument used was placed in the canal and a second exposure was made. The radiograph thus obtained demonstrated a double exposure with both instruments clearly visible on each image.

Fig 2

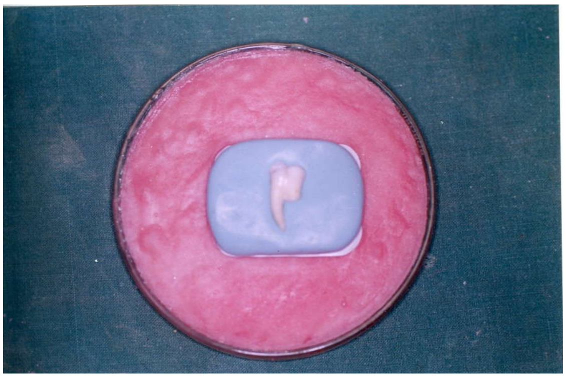

Fig 3

Preparation time: The time taken to enlarge each canal was recorded in minutes and seconds. It included only active instrumentation and not irrigation time or the changing of files.

Loss of working length: Following preparation, the final length of each canal was determined and recorded to the nearest 0.5 mm. The final length of the canal was then subtracted from the original length to give the loss of working distance.

Instrument failure: The instruments were examined after every use and a record was kept of those permanently deformed or fractured. Such deformed or fractured instruments were sent for SEM study and photographs were taken.

Apical transportation: The obtained radiographic images were imported to a computer monitor via a CCD camera. With a computer program (Microdraw 4.1), a stylus was used to mark on a hipad digitizer image tablet. The pre-operative images of the No. 15 file tip as well as the tip of the largest instrument used for the post operative image. The distance between the points of the small and big instruments was calculated and recorded by the program. The measurement for each sample was compiled for data analysis.

All measurements and readings were noted and statistically analyzed.

Descriptive data that included mean, standard deviation and range were obtained for each group and one-way ANOVA was performed followed by Newman-Keul's range test to find any significant difference among the groups. A P-value of less than 0.05 was considered for statistical significance.

Results

45 extracted human mandibular molars with curved roots were included in this study. Each group consisted of 15 teeth.

Preparation time

The time taken to complete the preparation of canals with the various instruments is shown in Table 1. The mean preparation time for group I, II and III was 6.73, 6.33

and 1.85 respectively. There was no statistical significance between group I and II. However, comparison between group I and III and group II and III showed statistical significant difference.

Overall, the average time taken to prepare the canals was shortest for the profile rotary followed by Nickel Titanium hand instruments and stainless steel files.

Table 1

Groups	No.	Preparation time (min)			Difference between groups*		
		Range	Mean	SD	Groups compared	Mean Diff.	P-value
I stainless steel files	15	4.25-9.19	6.73	1.37	I-II	0.40	>0.05, NS
II Hand NiTi	15	3.40-10.51	6.33	1.73	I-III	4.88	<0.01, S
III Profile Rotary NiTi	15	1.34-2.48	1.85	0.43	II-III	4.48	<0.01, S

One-way ANOVA (F = 65.5, P<0.01, Significant)
Newman-Kaul's Range Test
Minimum significant range: 1.47 min (P<0.01)

Table 2

Groups	No.	Loss of working length (mm)			Difference between groups*		
		Range	Mean	SD	Groups compared	Mean Diff.	P-value
I stainless steel files	15	0.0-1.50	0.53	0.48	I-II	0.40	<0.05, S
II Hand NiTi	15	0.0-0.50	0.13	0.27	I-III	0.26	>0.05, NS
III Profile Rotary NiTi	15	0.0-1.00	0.27	0.37	II-III	0.14	>0.05, NS

One-way ANOVA (F = 4.43, P<0.05, Significant)
Newman-Kaul's Range Test
Minimum significant range: 0.33 min

Loss of working length

The loss of working length that occurred as a result of preparation of the canals by the experimental instruments is shown in Table 2. One way analysis of variance indicated that there was significant variation when compared between group I and II (P<0.05).

Preparation with stainless steel files resulted in a significantly greater loss of distance than with the other files. At the same time, preparation with hand nickel titanium files produced less distance loss than profile rotary files.

Instrument deformation and fracture

One instrument was deformed [stainless steel] and 2 instruments were fractured [one Ni-Ti rotary & one stainless steel files] Fig. (4,5). Table 3 shows that number of instruments which were deformed and fractured.

Overall, failure of stainless steel files was more frequent, than profile rotary files. None of the hand nickel titanium files deformed or fractured.

Table 3

Group I	Group II	Group III
2 (13.3%)	-	1 (6.7%)

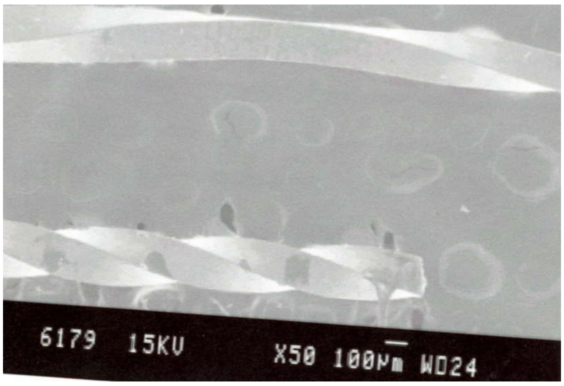

Fig 4

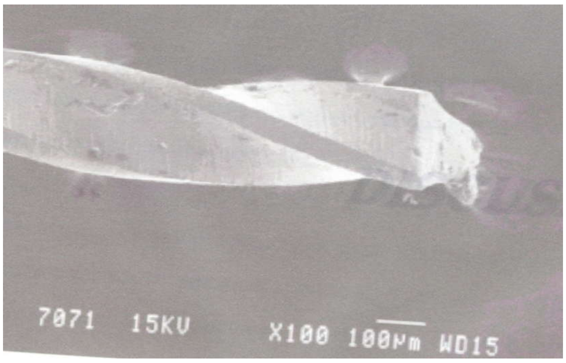

Fig 5

Table 4

Groups	No.	Apical transportation			Difference between groups*		
		Range	Mean	SD	Groups compared	Mean Diff.	P-value
I stainless steel files	15	0.37-0.53	0.43	0.06	I-II	0.12	<0.01, S
II Hand NiTi	15	0.20-0.50	0.31	0.09	I-III	0.22	<0.01, S
III Profile Rotary NiTi	15	0.17-0.23	0.21	0.02	II-III	0.10	>0.01, NS

One-way ANOVA (F = 42.1, P<0.01, Significant)
Newman-Kaul's Range Test
Minimum significant range: 0.11 (P<0.01)

Apical transportation

The mean and standard deviation of apical transportation is depicted in table 4. The amount of apical transportation was found to be least in rotary than other groups.

Discussion

The present study was conducted to evaluate the preparation time, loss of working length, instrument deformation and separation and the apical transportation in relation to stainless steel, hand Ni-Ti and rotary Ni-Ti files.

In the present study the mean time to instrument with Ni-Ti files was 6.33 min. as compared with 6.73 min with stainless steel files. Although this difference was not significant, the instrumentation was completed in a shorter period of time with Ni-Ti file which was in accordance with the study conducted by Himel V.T[5].In this study, canal preparation with stainless steel files was time consuming and tedious[3].

The introduction of high torque rotary handpiece, have made canal preparation less arduous and more standardized. The instrumentation of canals with Ni-Ti rotary was significantly [p<0.01] faster than hand instruments, similar to Glosson C.R[4] study, which also found that Ni-Ti engine driven files were significantly faster than hand instrumentation (P<0.05).Gambill G.M.[6] revealed that Ni-Ti instruments required less preparation time (P<0.05) than stainless steel files.

Control of working distance during preparation is essential if the treatment is to be successful. Extension of working distance can result in perforation of the apical foramen and extrusion of debris, excessive reduction can leave debris within the canal and maintain a focus of infection[7].All the canals were associated with loss of distance, a phenomenon that was explained by Alodeh[3], that the straightening of curved canals inherent in their preparation contributed to the reduction in canal length.

Loss of working length occurred with all file types, but was significantly greater[p<0.05] in the canals prepared with stainless steel files which was in accordance to a study conducted by Al-Omari M.A.O.[7].The working length was maintained significantly more often in the Ni-Ti hand group than in the stainless steel group.

Stainless steel files showed the maximum loss of working length, which may be due to packing of debris into the canal, which is an error that is often correctable. The combination of debris accumulation and tip design may also account for the loss of distance that occurred with these instruments.

Stainless steel files [2 files] tended to separation more rapidly than did Ni-Ti [1]. Least tendency to wear was found in the Ni-Ti hand instruments. These results are in accordance with Zuolo M.L.[8] .Within the Ni-Ti groups, the hand instruments retained better quality than did the rotary instruments. As would be expected, longer usage times resulted in increasing deterioration and separation. The application of vertical force, which induces too much torque, may also be a cause of instrument fracture[9].

Conclusion

This in vitro comparison study of root canal preparation using stainless steel, Ni-Ti hand and Ni-Ti rotary files on their effect on the preparation time, loss of working length, instrument deformation and fracture, and the apical transportation has drawn the following conclusions.

Ni-Ti rotary instruments were found to take less time for root canal preparation than the other groups which is statistically significant.

- No instrument deformation or separation was seen in Ni-Ti hand group.
- The working length was maintained more often with the Ni-Ti hand group.
- The apical transportation was minimal with Ni-Ti rotary files when compared to stainless steel files group.

Under the conditions of this study, Ni-Ti rotary files proved to be better than the other group files with respect to the parameters undertaken.

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