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A Comparative Study of Root Canal Shaping by Automated Rotary Ni-Ti and Conventional Hand Instruments

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Summary:

A total 30 root canals, curvature ranging between 0 and 35 degree, were divided into three groups, A, B and C, consisting of 10 canals in each. Five canals from each group were prepared with FlexMaster using crown-down technique and the others with hand instrument K-Felxofile using conventional and step-back technique. Irrigation was done with sodium hypochlorite (NaOCl) solution and ethylene di-amine tetra-acetic acid (EDTA) after canal preparation by each instrument size. All the prepared roots were then cut longitudinally using diamond burs in turbine handpiece. Canal preparation was examined separately with scanning electron microscope (SEM). The preparation time was also recorded. Data were analyzed statistically using the non-parametric test (Mann-Whitney U test). Completely cleaned root canals were not found with any of the two instruments. FlexMaster instruments maintained the original canal shape and curvature with uniform and regular dentine surface. The time taken to prepare root canal by FlexMaster was significantly better (p< 0.01) than hand instruments.

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Introduction:

Primary goal of root canal treatment is to completely clean and shape the root canal system, maintaining the original path of root canal. Over the years, a variety of instruments and techniques have been proposed to reach the goal. Optimal shaping and cleaning of root canals is one of the difficult aspects of root canal procedure. Manual instrumentation, to reach the goal, is generally believed to be more effective than mechanical instrumentation[1-4]. But several studies have concluded that none of the instrumentation techniques or devices is able to produce completely cleaned root canals, maintaining the original curvature, especially when the canal is curved[1, 5, 6]. It is, therefore, important to develop an instrumentation technique that will prepare the root canal maintaining the original curvature in a minimum time. However, some investigators have recently claimed that automated devices using rotary Nickel-Titanium instruments with various tapers led to good instrumentation results, even in severely curved root canals[7, 8]. But a little is known about the effectiveness of these systems. Rotary FlexMaster instruments (VDW, Antaeos, Munich, Germany) have recently been introduced with varying tapers and designs. According to the manufacturer, the FlexMaster instruments, available in 2, 4, 6 and 11% taper K-type blades with their unique cross section similar to a triangle having convex sides offer increase stability, high cutting efficiency, good debris removal and tortional resistance. Three different tapers made the system best suited for each canal portion and reduced stress on instruments. Instrument with 11% taper is used as an introfile for coronal enlargement; 4% and 6% taper instruments are used for radicular canal preparation using crown-down technique whereas 2% taper is used for safe apical enlargement (Fig-1). The non cutting tip prevents canal transportation and ledge formation while the unique depth marking, being X-ray visible, facilitates clear identification of the file position in the canal thus determines correct working length. With all these benefits, FlexMaster system is claimed to be an efficient, reliable, simple, clear and safe system for easy and faster preparation of all types (more or less straight, moderately curved & curved) of root canals. So far, there are only a very few experimental studies have been carried out on the efficiency of FlexMaster system[9-12]. This experimental study was designed to compare rotary Ni-Ti FlexMaster instruments with K-Flexofile hand instruments in shaping root canals. Time needed for completion of root canal preparation were also evaluated.

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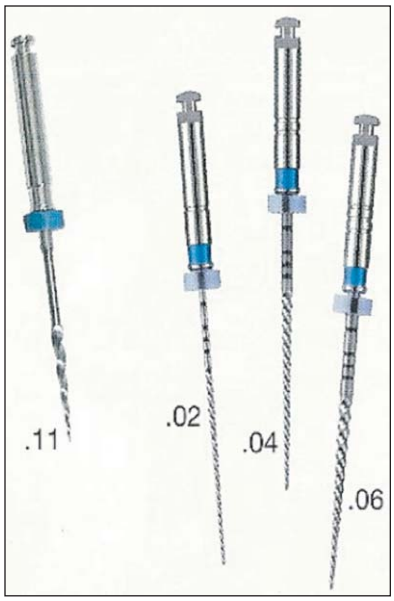


Fig.-1: *Showing Flexmaster instruments with different tapers.*

Legends to Figure 1: FlexMaster instruments, available in 2, 4, 6 and 11% taper K-type blades. Instrument with 11% taper is used as an introfile for coronal enlargement; 4% and 6% taper instruments are used for radicular canal preparation using crown-down technique whereas 2% taper is used for safe apical enlargement.

Materials and methods:

A total number of 47 extracted human maxillary and mandibular molars were collected. Coronal access cavities were prepared using diamond burs on a high speed handpiece according to the standard extension for optimal inspection of all root canal openings. Radiographs were taken with ISO number. 10 or 15 files, using paralleling technique, to determine the canal curvatures according to the method described by Weine in 1968[13]. Finally 30 root canals out of 119 that met the criteria for acceptance (Table-I) were selected. The selected specimens were divided into three groups and prepared with either FlexMaster rotary Ni-Ti instruments or with stainless steel hand K-Flexofiles as described in Table-II. Irrespective of the system applied, after each instrument, the canal was flushed with 5.25% NaOCl and 15% EDTA alternatively[14]. Selected 15 canals for control (five canals randomly selected from each group) were prepared with stainless steal hand K-Flexofile instruments. Specimens in group A were prepared by conventional method whereas specimens in group B and C were prepared by Step-back technique. Residual 15 canals (five canals from each group) with different curvatures were prepared with rotary Ni-Ti FlexMaster instruments using Crown-down pressureless technique in a low torque motor (E Master, VDW, Munich, Germany) at 150-300 rpm contra angle 4: 1 handpiece (W & H, Burmos, Austria) according to the manufacturer's instructions (Table-II and Fig.-2)

Table-I

Criteria for acceptance of the root canals

Inclusion criteria	Exclusion criteria
1. Canal curvature ranging 0° to 35° according to method described by Weine in 1968	1. Wisdom teeth
2. Previously untreated root canals	2. Teeth with open apices
3. Canals that could be negotiated to the apical foramen with a file size ISO 10 without any resistance	3. Teeth with filling
4. Initial binding file that did not exceed size ISO 20	

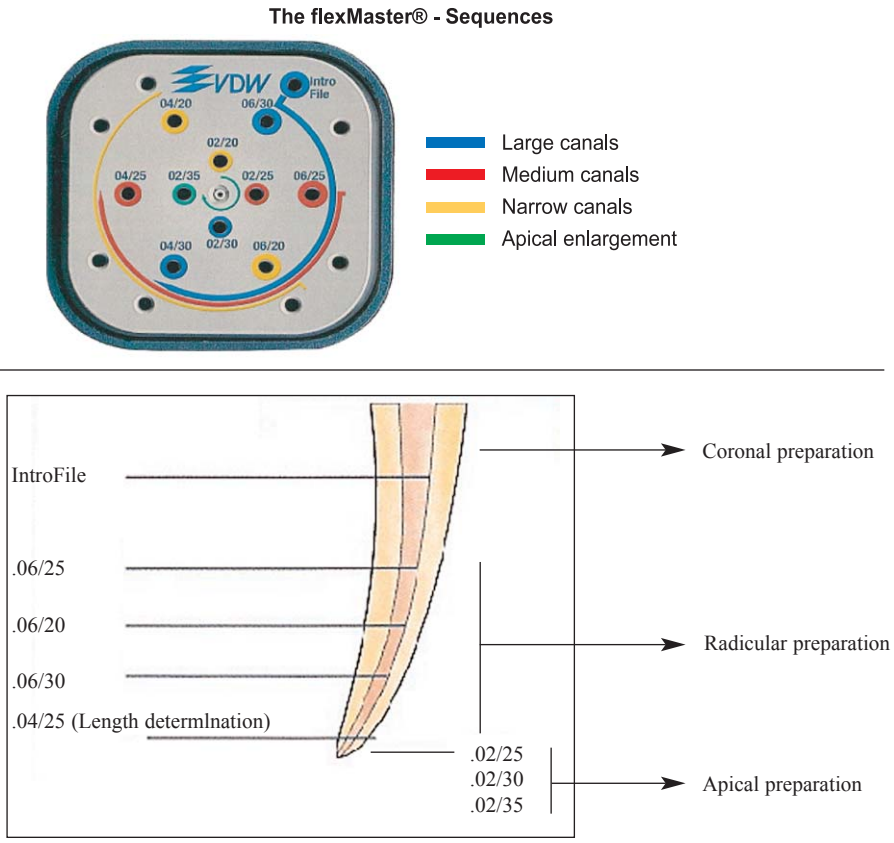
Table-II

Distribution of specimens and corresponding preparation system

Group	Number of specimen (root canals)	Degree of canal curvature	Number of canals prepared	
			FlexMaster (Crown-down technique)	K-Flexofile (conventional and step-back technique)
A	10	0-15 (more or less straight)	05	05
B	10	16-30 (moderately curved)	05	05
C	10	>30 (curved canals)	05	05

Sequence of FlexMaster Instrumentation:

- Estimation of working length by X-ray
- Determination of the size of the canal (large, medium, narrow) and selection of the instrumentation sequence as guided by the manufacturer.
- Creation of straight coronal access and coronal enlargement by Introfile
- Preparation of the radicular canal short of working length (WL-1mm) with sequential series of FlexMaster files of varying tapers (4% and 6%) using crown-down technique as guided by the manufacturer for any specific size (large, medium or narrow) of canals



- Determination of exact working length
- Apical enlargement by using FlexMaster 2% files in increasing sizes as guided by canal anatomy

Fig-2: *Diagrammatic representation of root canal preparation with different taper FlexMaster instruments*

Following examinations were done:

Time required for canal preparation:

Mean working time includes the time for canal shaping, time needed for instrument change and irrigation. Time required for canal preparation was determined for each preparation and the difference in the times required were analyzed statistically using Mann-Whitney's U test; a value of $P<0.01$ was considered significant.

Shaping of the prepared canal:

After preparation, all the roots were separated from crown with a diamond disc, then the root canals were flushed with 5.25% NaOCl and dried with absorbent paper point. All the canals were split longitudinally into two halves with diamond fissure burs in a turbine handpiece, polished and prepared for SEM evaluation. Evaluation was carried out by a second examiner who was blind with all respect of all to the

experimental groups. A SEM (JEOL JSM-T220A scanning microscope, Tokyo, Japan) which produced a 15 kV alteration voltage, at the Department of Operative Dentistry, Showa University, Japan was used to examine and take micrographs of every specimen at 35-1000X magnifications. Canal walls were qualitatively evaluated using the same set of reference photograph as in previous investigations[1,15,16].

Results:

Time required for canal preparation:

Mean working time taken to prepare the canals with FlexMaster system and stainless steel hand K-flexofile is shown in Table-III. Assessments of canal preparation revealed that the FlexMaster instruments have taken almost half of time in comparison to hand instruments irrespective of canal curvature. The mean working time was 4.7±0.76, 5.1±0.74 and 5.6±0.65 minutes for FlexMaster instrumentation and 9.7±0.57, 10.4±1.19 and 12.6±0.65 minutes for the stainless steel hand instruments. The difference was statistically significant ($P < 0.01$) for two different instruments in all groups but the mean time taken by different groups of the same type instrument was not significant.

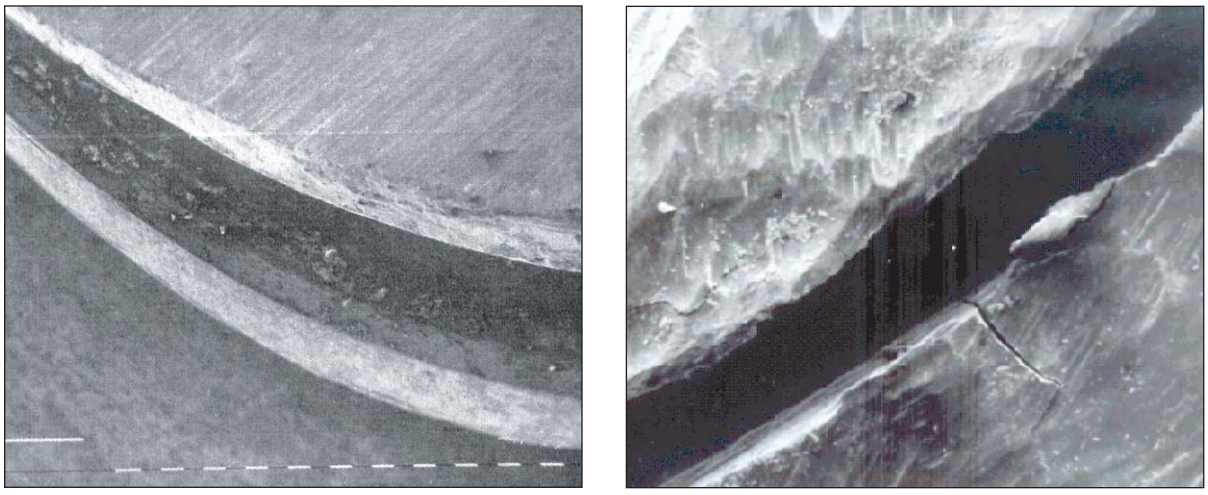
Root canal shaping:

The FlexMaster instruments maintained the original canal shape without any deformity in the canal walls whereas the manual technique, in which hand instrument is used, did not maintain their original shape leaving behind irregular deformed surfaces (Fig.-3).

Table III

Mean working time required by different technique

Group	Degree of canal curvature	Mean working time required in minute	
		FlexMaster (Crown-down technique)	K-Flexofile (conventional and step-back technique)
A	0-15 (more or less straight)	4.7 ± 0.76	9.7 ± 0.57
B	16-30 (moderately curved)	5.1 ± 0.74	10.4 ± 1.19
C	>30 (curved canals)	5.6 ± 0.65	12.6 ± 0.65



(A) (B)

(A) Canal prepared by FlexMaster, curvature of root canal is maintained (No irregular deformed surface) (B) Canal prepared by K-Flexofile, curvature of root canal is not maintained FlexMaster with irregular deformed surface (original magnification x 35).

Fig.- 3: *Canal prepared by FlexMaster and by hand instrument K-Flexofile in apical region.*

Discussion:

In the present study, the root canal preparation efficiency of two instrumentation methods were studied qualitatively by means of a SEM evaluation in the apical and middle portions of the canals. It has been evaluated that only the FlexMaster instruments maintained the original shape without any deformity in the canal wall. In both Ni-Ti and hand instrumentation techniques, partially un-instrumented areas with remaining debris were also found. Similar finding has also been described by other authors, [1, 4, 5, 9] and it is consistent with two other investigations using micro-computer tomography assessment of the canal shapes[17,18]. Peters reported that approximately 35% of the canal surface area was not prepared when different nickel-titanium preparation techniques were used[18]. Although it is recommended to use antibacterial irrigants in combination with chelating agents in order to remove debris as well as the inorganic/organic smear layer[1,19,20] some investigators used sodium hypochlorite alone due to its antibacterial and organic tissue-dissolving properties[10, 21, 22], but Yamada reported that it is not possible to remove the smear layer with sodium hypochlorite[23]. In the present study, 5.25% sodium hypochlorite and 14% EDTA was used as chelating agent but they failed to remove the loose debris and smear layer from both experimental and control groups. Further study may be carried out to evaluate the strength and volume of different root canal irrigants in removing the debris and smear layer during preparation of root canal in the same procedures.

FlexMaster instrumentation was significantly ($p<0.01$) faster than the hand instrumentation. This finding corroborates with the results of several others, that the instrumentation times or other performance outcomes with rotary Ni-Ti instruments are substantially better than those of hand instruments[9, 11, 24,25].

Within the parameters of this study, the FlexMaster maintained original canal curvature in shorter time better than hand instruments. Because of not maintaining the original curvature of the root canal and leaving behind irregular deformed surface, it can be hypothesized that the stainless steel hand instrumentation left the possibility of canal space being inadequately debrided of vital or necrotic pulp tissue, subsequently an inadequate obturation of the root canal space.

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