

**Cutting Efficiency as Correlated with Design
Feature Measurements of Three Different Rotary
Root Canal Instruments. In-Vitro Study.**

Thesis

**Submitted to the Faculty Oral and Dental
Medicine
Cairo University**

**In partial fulfilment for the requirements of
Master's Degree in Restorative Dentistry
(Endodontics)**

By

**Mohamed Medhat Kataia, B.D.S
MUST, Egypt**

2009

Supervisors

Professor Dr Salsabyl Mohamed Ibrahim

Professor of Endodontics, Endodontic Department

Faculty of Oral and Dental Medicine,

Cairo University

Professor Dr Eman El Mahalawy

Professor of Engineering, Mechanics Department

Faculty of Engineering,

Cairo University

Assistant Prof Dr. Ghada EL-Hilaly Eid

Assistant Professor of Endodontics, Endodontic
Department

Faculty of Oral and Dental Medicine

Cairo University

**MAY GOD BLESS MY MOTHER, FATHER AND
SISTER**

Acknowledgment

Deepest thanks and gratitude must be expressed as it is felt to the generous, giving and caring Professor Dr Salsabyl Mohamed Ibrahim Professor of Endodontics, Endodontic Department, Faculty of Oral and Dental Medicine, Cairo University. Her generosity had exceeded the limits, as she gave me the gift of time and knowledge.

Special thanks for Professor Dr Eman El Mahalawy , Professor of Engineering, Mechanics Department , Faculty of Engineering, Cairo University. Her unlimited kindness, help and support throughout the time of this study allowed the accomplishment of this work.

Deep appreciation for Assistant Professor Dr Ghada Elhilaly Eid as she had given me valuable information and help, I would have never imagined more outstanding assistance, thank you.

Special thanks for the hospitality of the British University in Egypt, without question their love for research and science had been demonstrated through their welcome to this work.

Endodontic Professors at Cairo University, endless thanks are extended, for God had made them a cause to any what help I can offer in the benefit of Dental Medicine (ENDODONTICS).

Dear Dr Mohamed el Sabry and colleagues at Misr University for Science and Technology; thank you for your endless support when I needed it most.

My unquestioned thanks is also given to Engineer Hady Safer for his work and effort he had given in this study.

DEDICATION

To the devoted and forever-caring Father and Mother; they after GOD gave me the world I needed.

To the loving sister Engy, for she means life to me.

LIST OF CONTENTS

List	Page
Introduction	1
Review of literature	2
I. Invention of conventional root canal instruments;	2
II. Geometrical design characterization of rotary nickel titanium root canal instruments:	4
III. Effect of geometrical instrument design on the cutting ability of root canal instruments:	7
IV. Relation between design of instruments and resistance to failure:	27
Aim of study	34
Materials and Methods	35
Materials and Devices	35
Methods	36
I. Part I: Comparative assessment of geometrical design variation in the three systems;	36
II. Part II: Gravimetric determination of cutting efficiency and debris retention of the three tested systems;	39

Results	45
I. Part I: Comparative assessment of geometrical design variation in the three systems;	45
II. Part II: Gravimetric determination of cutting efficiency and debris retention of the three tested systems;	77
Discussion	86
Summary and Conclusion	95
References	99
Arabic Summary	108

List of tables

List	Title	Page
Table 1	Number of flutes in the ProTaper and V-Taper system.	46
Table 2	The measured width of the liberator set of instruments as received at three predetermined points.	48
Table 3	One way analysis of variance by ANOVA test comparing weight loss mean values after preparation of MB canal for all groups.	79
Table 4	Probability (P) values by Newman-Keuls multiple comparison pair wise test between total weight loss mean values after MB canal preparation for all groups.	79
Table 5	One way analysis of variance by ANOVA test comparing weight loss mean values after preparation of ML canal for all groups.	79
Table 6	Probability (P) values by Newman-Keuls multiple comparison pair wise test between total weight loss mean values after ML canal preparation for all groups.	80
Table 7	One way analysis of variance by ANOVA test comparing weight loss mean values after preparation of two canals (MB and ML canals) for all groups.	80
Table 8	Probability (P) values by Newman-Keuls multiple comparison pair wise test between weight loss mean values after preparation of two canals (MB and ML canals) for all groups.	80
Table 9	Weight gain mean values of the file after preparation of MB canal and One way analysis of variance ANOVA test comparing between weight gain mean values for all groups.	82
Table 10	Probability (P) values by Newman-Keuls multiple comparison pairwise test between weight gain mean values after MB canal preparation for all groups.	83
Table 11	Weight gain mean values of the file after preparation of ML canal and One way analysis of variance ANOVA test comparing between weight gain mean	83

	values for all groups.	
Table 12	Probability (P) values by Newman-Keuls multiple comparison pairwise test between weight gain mean values after ML canal preparation for all groups.	84
Table 13	Weight gain mean values of the file after preparation of two canals (MB and ML canals) and One way analysis of variance ANOVA test comparing between weight gain mean values for all groups.	84
Table 14	Probability (P) values by Newman-Keuls multiple comparison pairwise test between weight gain mean values after MB and ML canal preparation for all groups	84

List of Figures

List	Title	Page
Figure 1	The Flute number, pitch length and helical angles/flute of the F1 and F3 ProTaper file as received, arrow illustrating the two same flutes with different helical angles.	49
Figure 2	Representing the Flute number, pitch length and helical angles/flute of the #40 V-Taper file as received.	50
Figure 3	The constant increase in width at three different points 3, 8 and 12-mm as a measure of taper of the liberator file #30.and # 40	50
Figure 4	The difference in measurements of the pitch length of the Sx , S1 and S2 instruments of the ProTaper system as received and after use (yellow represents the change in the measure of the pitch length).	55
Figure 5	The difference in measurements of the pitch length of the F1, F2 and F3 instrument of the ProTaper system as received and after use (yellow represents the change in the measure of the pitch length).	56
Figure 6	The difference in measurements of the pitch length from the #20 instrument of the V-Taper system as received and after use, #25 instrument of Set 2 and #30 instruments (yellow represents the change in the measure of the pitch length).	57
Figure 7	The difference in measurements of the pitch length from the #35 instrument of the V-Taper system as received and after use from the #40 instrument (yellow represents the change in the measure of the pitch length).	58
Figure 8	The difference in measurements of the helical angles from the Sx, S1 and S2 instrument of the ProTaper system as received and after use (yellow represents the change in the measure of	61

	the helical angle).	
Figure 9	The difference in measurements of the helical angles from the F1,F2 and F3 instrument of the ProTaper system as received and after use (yellow represents the change in the measure of the helical angle).	62
Figure 10	The difference in measurements of the helical angles from the #20, # 25 and # 30 instrument of the V-Taper system as received and after use (yellow represents the change in the measure of the helical angle).	65
Figure 11	The difference in measurements of the helical angles from the #35 and #40 instrument of the V-Taper system as received and after use (yellow represents the change in the measure of the helical angle).	66
Figure 12	The length and position of the deformed area of the #20, #25 and #30 liberator file.	67
Figure 13	The length and position of the deformed area of the #35 and #40 liberator file.	68
Figure 14	Cross section of three different systems at different levels before and after mechanical preparation representing the configuration of each system.	70
Figure 15	Variations in the cross section of ProTaper Universal finisher instrument (F3) as received at the predetermined sites.	71
Figure 16	Photomicrograph of the #20 V-Taper file of set 1 and file #30 V-Taper file of set 5 both deformed at apical third at two different magnifications(50x and 300x).	74
Figure 17	Photomicrograph of the S2 ProTaper file of set 1 deformed at middlel 1/3 at two different magnifications. (50x and 300x).	75
Figure 18	Photomicrograph of the #30 liberator file of set 2 deformed at apical third at two different magnifications(50x and 300x).	75
Figure 19	Photomicrograph of the F1 file of the ProTaper fractured at apical third. Showed consequent	76

	circular striations denoting a pattern of brittle fracture	
Figure 20	Photomicrograph of the #40 of the Liberator fractured at apical third. Showed roundation of the longitudinal machining striations and a mass of debris housed within the twisted part	76
Figure 21	Histogram comparing mean weight loss values of the root after preparation of the MB canal and after preparation of the ML canal and after preparation of both canals for the three systems.	85
Figure 22	Histogram comparing mean weight gain values of the files after preparation of the MB canal and after preparation of the ML canal and after preparation of both canals for the three systems.	85

Introduction

Shaping and cleaning of the root canal system and the elimination of all debris before obturation are the most important requirements to improve the quality of root canal preparation, which lead to better obturation, apical seal, and eventually to better prognosis for the treated tooth. This step has been done using hand instruments which has been time consuming and tedious.

The idea of inventing an engine driven root canal shaping and cleaning instrument has been the dominating concept of all scientist's minds in the late decades. Rotational root canal drills have been in constant modification in the design feature and the metallurgical aspects for years. This constant modification has given the experience that the innovational nickel titanium material has been superior when it comes to the mechanical properties, which are needed in the drilling process during the endodontic treatment. Tremendous advances in the design of these instruments definitely did improve their cutting efficiency.

Newer generations are introduced to the market with specific design features such as variable taper, absence of helical angles and flutes and the changes in cross section design. Understanding of the manufactured geometrical design and correlate the specific design of the instrument in cutting and shaping root canal to improve their clinical performance is important.

Review of Literature

I. Invention of conventional root canal instruments;

Through the years multiple instruments have been used to instrument within the root canals, remove of pulp tissue, and preparation of the root canal to receive the obturating material.

At first, the painful tooth that was not mobile and not decayed was to be cauterized ⁽¹⁾ (i.e.) the teeth were not to be prepared, but afterwards root canal preparation and the insertion of pivot posts and crowning the teeth took place.

After years of relative inactivity, a remarkable upsurge in the endodontic instrument design and refinement was developed. Historically, very little was done to improve the quality or standardization of instruments until the 1950s, when two research groups started reporting on the sizing, strength, and materials that went into hand instruments ⁽²⁾.

By 1962, a working committee on standardization had been formed including manufacturers, the American Association of Endodontists (AAE), and the American Dental Association (ADA). This group evolved into the present-day International Standards Organization (ISO). It was not until 1976, however, that the first approved specification for root canal instruments was published (ADA Specification No. 28), 18 years after Ingle and Levine first proposed standardization in 1958 ⁽²⁾.

Development of rotary instrumentation was developed to decrease instrumentation time and simplify the procedure. The first use of rotary devices was described by which fine rectangular needles were inserted passively into the canal and rotation was started once the

apical foramen was reached, thin needles were used in curved canals⁽³⁾. He developed the first endodontic hand-piece for engine driven root canal preparation. By using specially designed needles on a 360⁰ rotational hand-piece, he prepared the canal. Austrian company (W&H in 1928) developed cursor filing contra angle, a contra with a combined rotational and vertical motion. In 1958 an endodontic racer hand piece was developed using a vertical stroke motion then again in 1964 the Giromatic hand-piece was developed to overcome the inflexibility of conventional endodontic hand instrument, it transformed the continuous rotation of the hand piece into alternating quarter movement.

Modification of the endodontic hand-pieces was modified by the introduction of the canal finder system, which was reported to facilitate the penetration of severely curved and constricted canals without perforation and ledging⁽⁴⁾.

Continuous development in endodontic hand pieces continued until this time were an electric hand piece with gear reduction and torque control producing a constant steady speed was utilized for all rotary nickel-titanium systems.⁽⁵⁾

Walia et al⁽⁶⁾ were the first to use a nickel titanium file in the Endodontic field. Nickel-titanium for use in endodontic instrumentation was introduced as a more flexible alternative to stainless steel. This innovative discovery helped in the improvement of the quality of shaping and cleaning phase of the root canals by accommodating the special morphology and root canal environment.