بسم الله الرحمن الرحيم

قالوا سبحانك لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم

صدق الله العظيم

COMPARATIVE MORPHOMETRIC ANALYSIS WITH THE USE OF TWO IRRIGATES TO ASSIST IN RETRIEVING BROKEN INSTRUMENTS: AN IN-VITRO STUDY

Master Thesis Submitted to Faculty of Oral and Dental Medicine, Cairo University, In Partial Fulfillment of Requirement for Master Degree in Endodontics

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Introduction

Although successful Endodontic therapy depends on many factors, the most important step is root canal preparation. When curvatures are present, Endodontic preparation becomes more difficult and there is a tendency for straightening, ledging, separation and apical transportations. The ideal prepared canal is those with uniformly tapered funnel shape from minor apical constriction to canal orifice.

Rotary Ni Ti showed better cleaning and shaping ability; they suffered from low cyclic fatigue with subsequent sudden separation without any warnings. How to deal with a separated instrument depends on certain factors in relation to separated size, site of fracture along the length of the root, before or after the exciting curvature and its effect on the root strength. A problem could exist if separation occurs in narrow curved canal, where the amount of dentin between the inner canal wall and outer root surface is minimal, root at risk of perforation and/ or vertical root fracture.

With the advancement in the use of different designs of rotary instruments, the risk of instrument separation is high. If the separated part impedes adequate cleaning and shaping of the canal, the prognosis of root treatment may be affected. Various new instruments, chelating agents, illumination and magnifications are introduced to the marked claiming superiority in removing fragmented or separated instruments over the traditional procedure.

Review of Literature

Separations of endodontic files interfere with objectives of Endodontics, which are proper shaping, cleaning and obturation so careful attention should be given to prevent procedural mishap. Many studies showed better shaping ability of rotary Ni Ti files with less tendency for ledging , zipping and apical transportations with more tapered preparation and less working time [28]. The superior shaping ability of Ni Ti files is attributed to its superior flexibility, which is derived from its unique austenitic martensitic transformation. However, Ni Ti is liable to sudden separation without any primary noticeable distortion or deformation with naked eye, which change the case from whatever level of difficulty to a new level of severity.

Nickel Titanium alloys were developed by Beuhler, [72] a metallurgist investigating a nonmagnetic salt resistant alloy. Nitinol stands for Nickel Titanium by Naval Ordinance Laboratory. Ni Ti can exists in more than one crystalline form either austenitic (parent phase with B.C.C.) or martensitic (daughter phase with H.C.P.). The transformation from one phase to another is thermo-mechanically induced. A temperature difference between martensitic and austenitic is temperature transition range (TTR). A small amount of cobalt is added as a substitute for nickel to lower the temperature transition range and render it lower than the mouth temperature. In Endodontics we are more concerned about stress induced martinsitic transformation due to complex stresses to which files are subjected during shaping curved canals. The martinsitic transformation requires a reversible atomic process termed twinning that allows reduced strain

during the transformation. Austenitic is low stress high temperature form while martensitic is high stress low temperature form [72]. Two unique properties of great importance to Endodontics which are ***shape memory*** or ***super-elasticity*** (up to 8% of strain are fully recoverable) are derived from this phase transformation property of Nitinol. [41]

Mechanical property	Austenite	Martensite
Ultimate tensile strength (Mpa)	800–1500	103–1100
Elastic limit (Mpa)	100–800	50–300
Modulus of elasticity (Gpa)	70–110	21–69
Strain at failure (%)	1–20	Up to 60

In general, fracture of metal can be classified as either brittle or ductile fracture. Either ductility is the ability of metal to be plastically deformed under tension or compression before it fractures while brittleness is the property of material that does not show any plastic deformation before it separates. Either brittle fractures are characterized by crack initiation that propagates along grain boundaries (intergranular) or between specific crystallographic planes (cleavage fracture) while ductile fractures are characterized by microvoids which coalesce until separating the metal. Features of both brittle and ductile fracture were observed in separated rotary Ni Ti files. [48]

Separation is a potential risk when using any rotary instrument in preparing curved root canal. However, the advent of rotary instruments the efficiency of Endodontic cleaning and shaping has greatly

improved. There are definite pitfalls of their use; as the fact of testing physical properties , as detailed in ADA specification No. 28 are conducted in a static mode and do not consider canal geometry. [82].

The presented review aim to provide an overview of various variables encountered:

I. Factors influencing separation tendency of Ni Ti files:

1. Influence of rotational speed and torque parameter upon the cyclic fatigue of rotary of Ni Ti instruments.
2. Distortion and separation of Ni Ti rotary root canal instruments as related to its geometrical design.
3. Relation of instrument separation to instrumentation techniques.
4. Surface treatment of Rotary Ni Ti instruments and their effect on the corrosion and tarnish, cyclic fatigue and cutting efficiency of Ni Ti instruments.
5. Role of operator in inducing instrument separation.
6. Separation tendency of rotary root canal as related to canal curvature.
7. Multiple sterilization cycles and corrosion on torsional moment, bending moment and angular deflection.

II. Management of separated instrument and its complications.

1. Methods of retrieval of separated instrument.
2. Complications associated with separated instrument retrieval.

I. Factors influencing separation tendency of Ni Ti files:

1. Influence of rotational speed and torque parameter upon the cyclic fatigue of rotary Ni Ti instruments:

Gabel et al [24] examined the effect of rotational speed on the file distortion and separation. They found that the file distortion or separation is four times as likely to occur at 333.33 rpm rather than 166.67 rpm. This was explained by the fact that every file had a specific life expectancy related to number of cycles so, the slower the speed the more was the cycles until separation. **Dietz et al** [19] bought the same conclusion**.** They examined the influence of rotational speed on the tendency of separation of rotary Ni Ti instruments; they found that the lower speed characterized by deeper tip penetration which indicated a greater resistance to separation.

Daugherty et al [17] examined the effect of rotational speed on deformation rate and preparation time of the canal using rotary Profile 0.04 taper 29 series instruments. Seventy extracted human mandibular and maxillary molars were included in this study. Following access cavity preparation, length determination and assessing degree of root curvature the samples were divided into two groups. Group I were prepared at 150 rpm while group II were prepared at 350 rpm. The number of separated instruments, deformed instruments and time for instrumentation were recorded for each tooth-using stopwatch; no separation occurred in both groups with no significant difference in rate of deformation between the two groups. Preparation time for group II was half that of group I. They recommended using profile instruments at higher speed 350 rpm rather than lower speed 150 rpm in order to

minimize the deformation and preparation time by 50% when fixing other variables.

Gambarini [27] examined the cyclic fatigue of Profile rotary instruments. Thirty Profile instruments were used for this study and divided into two groups, group I of 10 unused files while group II of 20 used files in 10 clinical cases (6-7 molars and 3-4 single rooted teeth). All canals were prepared in a crown down manner at 250 rpm. Cyclic fatigue was tested by allowing the file to freely rotate within a stainless steel artificial canal with 5 mm radius of curvature and number of cycles until separation was calculated by multiplying time and rotational speed. He found that Profile 0.04 taper more resistant to cyclic fatigue than Profile 0.06 taper and he attributed that to less flexibility of greater taper instruments. In addition, a significant reduction in resistance to cyclic fatigue was noted between new and used files.

In a series of research planes **Yared et al** [85 and 86] compared the cyclic fatigue of rotary Ni Ti profile (Profile, Maillefer, Baillageus, Switzerland) at high and low torque values. Extracted human maxillary and mandibular molars with mature apices and moderate degree of curvature (less than 25) were included in this study and divided into three groups. The 100 canals were prepared in a crown down technique by the same operator. In first group, torque was set at 20 Ncm, 30 Ncm for second group and 50 Ncm for the third group. Operators blinded to the study inspect the files after each preparation using 2.5 magnifications for any deformation. Instrument locking, deformation or separation did not occur in any of the three groups. They attributed that to operators' proficiency that adhered to guidelines and exerted minimal pressure during preparation. The rotary Ni Ti files

were subjected to mechanical stresses during root canal preparation; these stresses are dependent upon radius and angle of curvature, dentine hardness, operator's proficiency and motor torque. As the torque, increased the elastic limit of the instrument was exceeded which increased the risk of distortion and intra-canal separation. In a second study **Yared and Sleiman** [89] assessed the deformation and separation tendency of Profile rotary files with 0.06 taper using air, high torque and low torque motors. They showed no significant difference in separation or deformation using the three motors and they attributed that to the skillful clinician.

Yared et al [87] investigated the influence of rotational speed upon instrument separation, deformation or locking. Extracted human mandibular and maxillary molars were used for this study where proper access cavity were performed, coronal flaring , working length estimation and angle of curvature assessment using Schneider's methodology. Only canals that showed snugness with 08 or 10 K-file were included as this indicate narrowness of canals. All samples were prepared using GT Ni Ti rotary files 0.12- 0.06 in a crown down manner. The samples were divided into three groups, group I prepared at 150 rpm, group II at 250 rpm while group III at 350 rpm. They found that neither instrument separation nor deformation occurred in any of the three groups. Instruments locked only in the third group. They attributed negative influence of rotational speed upon separation or deformation tendency to technique of preparation where using GT files in a crown down manner minimized stresses at the file tip.

Martin et al [40] assessed various factors influencing instrument separation among which were rotational speed, radius of curvature and type of rotary instrument used. Extracted human mandibular