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DETERIORATION OF TWISTED NITI FILES WITH CLINICAL USE–A DENTAL OPERATING MICROSCOPIC STUDY

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ABSTRACT

The present study aimed to evaluate the ability of DOM to demonstrate the signs of instrument's distortion and to investigate types and frequency of rotary NiTi twisted files (TF) deterioration modes.

Methodology: Eighty-eight discarded TF instruments after clinical use were experimented with. They were grouped into 4 groups of 22 file each according to the TF instrument taper from taper 0.04, 0.06, 0.08, and 0.010. Files were cleaned and sterilized before examination of surface deterioration signs and/or tip fracture. Two evaluators were separately examining the files and Kappa analysis was done.

Results: were statistically analyzed (significance level 0.05). Four types of deterioration were depicted. Unwinding of the instruments at the third-fourth flute was the mostly found deterioration type for all tested tapers (33%). It occurred most frequently in 0.08, 0.06, taper. This was followed by instruments' tip separation (15%) with the maximum number was found in taper 0.08. no one of the examined tapers 0.04 showed tip separation. However, it showed the highest number of tip turn-over among the tested TF instruments. Over-twisting was only found in 5% of all tested TF files.

Conclusions: 40% of TF files discarded after clinical use and examined under SOM showed various signs of deterioration mostly blade unwinding and tip fracture .DOM images were clear and focused, allowed easy and on spot immediate evaluation of signs of deterioration.

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INTRODUCTION

Nickel Titanium rotary instruments were introduced to the endodontic field in 1988 [1] as a great breakthrough in the technology of automated canal preparation. NiTi alloy with its pseudo-elastic (super elasticity and shape memory) behavior allowed the manufacturing of rotary and/or reciprocating files which can be used in preparation of the most challenging canal shapes and curvatures with minimum procedural mishaps in a short appointment time [1-6]. However, since their introduction there is a general perception among endodontic practitioners that, they have a high tendency of separation during canals' preparation. Instruments' separation might occur as a result of various levels of stresses, with or without any apparent signs of plastic deformation. Two mechanisms of fracture have been proposed, torsional (shear) and flexural (fatigue) [7,8].

The design of the instrument has been suggested to affect its mechanical behavior hence the tendency to fracture [7-10]. A multitude of instruments' systems and design modifications were introduced to the market aiming for a safer instruments' use with minimum deterioration and/or separation [11, 12].

Because of the mechanical properties of NiTi shape memory alloy, until recently all instruments' systems are manufactured by machine grinding. Most of these instruments systems were studied either separately or in comparative groups for their clinical performance and/or their mechanical behavior on loading [13]. Topographic examination of machined; used and unused niti rotary files from different systems revealed multitudes of surface defects, irregular surface, milling grooves, multiple cracks, pits, and regions of metal rollover [14-21].

Several strategies have been employed to develop NiTi instruments that should have improved clinical performance and fracture resistance [24]. These included electropolishing the machined surfaces to improve instruments' strength and surface smoothness, ion implantation to create harder surfaces, and use of special surface coatings. However, it resulted in limited or no improvements [23].

It was reported that, slight changes in the composition and/or heat treatment of the NiTi alloy may lead to large changes in mechanical properties (22). Again, the method of manufacturing NiTi instruments by grinding was accused-at least partially-for the resulting incidence of instrument separation as grinding a metal blank leads to cutting and interruption of the wires' grains [24].

In April 2008 Sybron Dental Specialties announced the invention of the twisted file (TF) (Richard Mounce/ Oralhealth May 2008).Twisted file is a unique NiTi rotary instruments manufactured by twisting the wire blank in a procedure similar to that of the traditional stainless steel K-file's design. Inventors of the twisted file claimed that, utilization of the R phase in manufacturing the (TF) overcomes limitations of ground file technology; and opens up new opportunities for file design, increased surface hardness, deterioration, and fracture resistance.

Until today no clean-cut evidence based recommendation as to the number of use of most of the NiTi file systems. Nor even a national or international specification on this issue [24-28]. Again, most of the researches concerning evidences and types of instrument's deterioration are done using stereomicroscope (x10-x40) or scanning electron microscope.[14,26]. In fact this is a good method to observe files' deformation in the lab., but it is impractical and one cannot get benefit from it clinically. Hence, there is a need for examining the instruments in situ during the treatment session and before next use even in another canal for the same patient.

The dental operating microscope (DOM) is an available clinical indispensable tool.

To our knowledge, studies concerning extended use of the clinically available DOM for NiTi rotary files quick detection of deteriorations signs are deficient.

Thus the aim of the present study was two-folds: to evaluate the sensitivity of the DOM and its ability to demonstrate the signs of instrument's distortion. Secondly to investigate types and frequency of rotary NiTi twisted files (TF) deterioration modes.

MATERIALS AND METHODS

Files' collection

Eighty-eight engine-driven nickel-titanium twisted files* (TF) were used in the study. TF files were collected from an endodontic clinic in Cairo-ARE, in a period of four months during which they were only used by the author. These files were discarded after clinical use because of a recognized deterioration, fracture, or as a routine instruments' renewal- because of a decrease in cutting efficiency. Upon their previous use, after making the access cavities, canals were negotiated and glide path were made to a #15 stainless steel hand K-file and estimated working length was taken. TFs were used in canals shaping following the manufacturer recommendations. Crown down preparation was done with no pecking action as instructed. A suitable TF was inserted passively in 2-3 seconds with 1-2 mm of dentin engagement in a controlled continuous manner at 500 RPM. A torque controlled electric motor (VDW)** was regularly used. Canals were irrigated with 5.25% NaOCl and recapitulated after every TF use. During instrumentation; TF was not left rotating stationary in the canal-as recommended. After each insertion, TF was wiped clean of debris, and canals were irrigated and recapitulated before the next TF file insertion.

Files grouping

Grouping of discarded files were done according to the file taper (0.4, 0.6, 0.8, and 0.10). All files used in the study were of the 23mm length. Twenty-two file from each file taper were picked up randomly. All selected TF files were submerged in 1% NaOCl and subjected to ultrasonic cleaning for 10 minutes. This was followed by autoclaving of the files groups.

Dental Operating Microscope (DOM) examination

Each file was inspected at a magnification of (X21) utilizing a Dental Operating Microscope*** for any visible deformation: fracture, unwinding, over-twisting, tip turn-over. Deformation type(s) was registered relative to each file. For the un-winded files, site of the deformation was determined by counting the number of flutes starting from the instrument tip to the far end of the unwound region [28]. For the fractured files, the remaining length of the instruments was measured. Photographs of deteriorated files were then captured and saved for further image analysis

Statistical Analysis:

Data were analyzed by using Chi-square test $P < 0.05$

RESULTS

No visible defect

The highest number of files showing no visible defect was found in files taper 0.10. This was followed by taper 0.04, 0.08. in a descending order respectively with no significant differences between them figure 1. Taper 0.06, however, showed a significantly lowest number of no visible defect features (table 1).

Unwinding

This feature was found to occur in a percentage that ranged from 40.9% in instruments of 0.08 taper to 22. 3% in both instruments tapers 0.04 and 0.010 (figures 2 and 3). 36.4% of TF files taper 0.06 showed unwinding (table 1). No significant differences were found between the groups

* SybronEndo, Orange, CA, USA)

** VDW Motor Silver-DENTACART

***Dental Operating Microscope (DOM; Carl Zeiss)

TABLE (1). Types of defect relative to the number of used TF taper as seen under the DOM

TF taper	No. of files	No visible defect		Unwinding		Over twisting		Tip turn over		Fracture	
No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0.04	22	10	45.454^{a}	6	27.272^{a}	1	4.545^{a}	5	22.727^{a}	0	0^{a}
0.06	22	5	22.727^{b}	8	36.363^{a}	3	13.636^{a}	2	9.090^{a}	4	18.181^{b}
0.08	22	8	36.363^{a}	9	40.909^{a}	0	0^{b}	0	0^{b}	5	22.727^{b}
0.10	22	12	54.545^{a}	6	27.272^{a}	0	0^{b}	0	0^{b}		18. 181^{b}

NB: Similar superscript letters indicate statistical significance per defect within the same type of defect at P < 0.05

Over-twisting:

This feature was seen in taper 0.06 were 3 instruments out of 22 (13.6 %) showed over-twisting (figure 4). Again, one instrument out of the 22 TF studied of taper 0.04 showed blade over-twisting. A statistically significant difference was found between them and tapers 0.08 and 0.010 (table 1).

Tip turn-over:

Occurred mostly in the smaller taper TF instruments of taper 0.04 (22.7 %), (figure 5) and in a lower percent of taper 0.06 (9%) respectively (table 2). This feature however, was not found in larger taper TF files.

Tip fracture:

This feature was found mostly in taper 0.08 in 22.7% followed by both file tapers 0.06 and 0.010 in equal percentages of 18.2 each (table 2 and figure 5 . No one of the studied taper 0.04 TF files showed tip fracture.

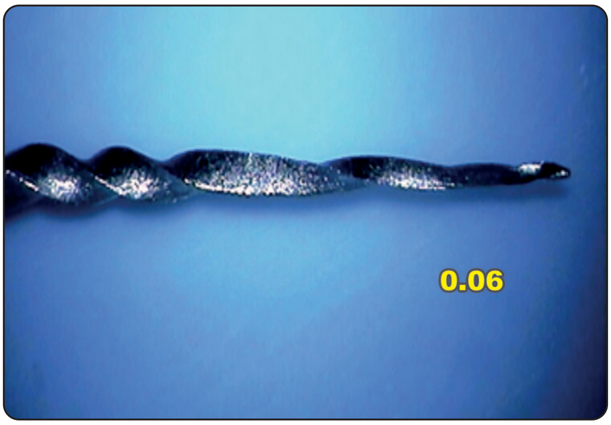

Fig. (2) (left): Photo-DOM micrograph showing unwinding in a TF of taper 0.06. Note that it occurred at the third flute

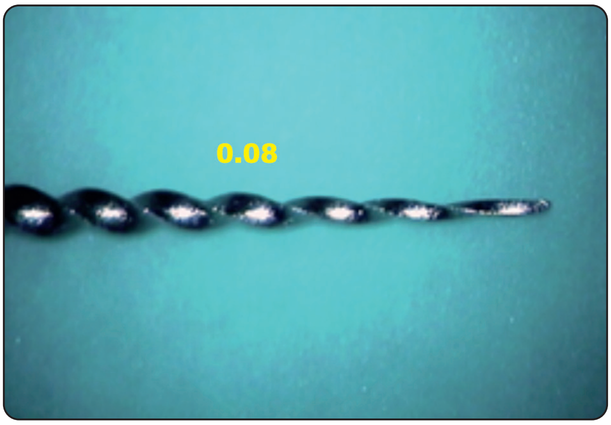

Fig. (1) shows a representative Photo-DOM Photograph of file taper 0.08 with no visible sign of instruments blade deterioration.

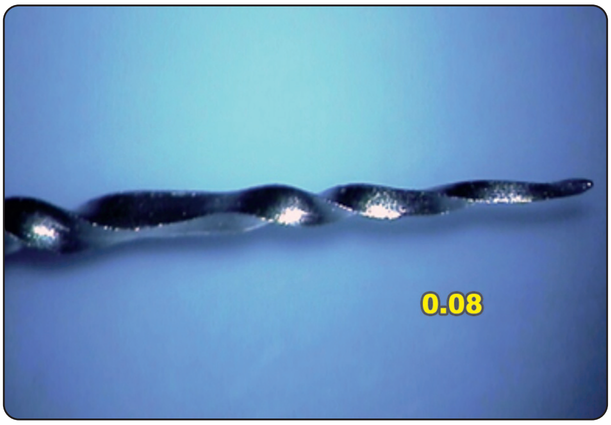

Fig. (3) (right): Photo-DOM micrograph showing unwinding in TF of taper 0.08. Note that it occurred between the third fourth flute

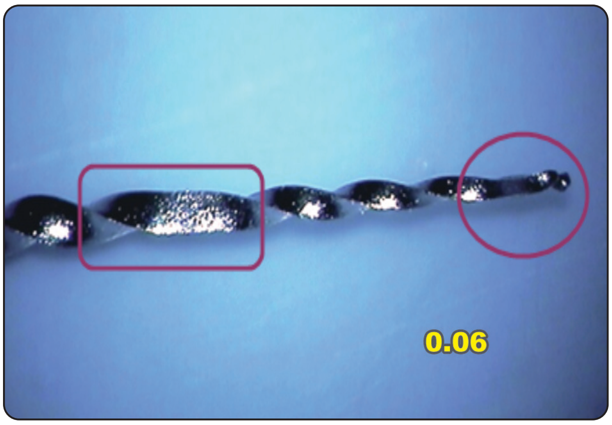

Fig. (4): Photo-DOM micrograph showing: Over-twisting at the tip of TF taper 0.06 at the and unwinding at the 4th flute in the same instrument

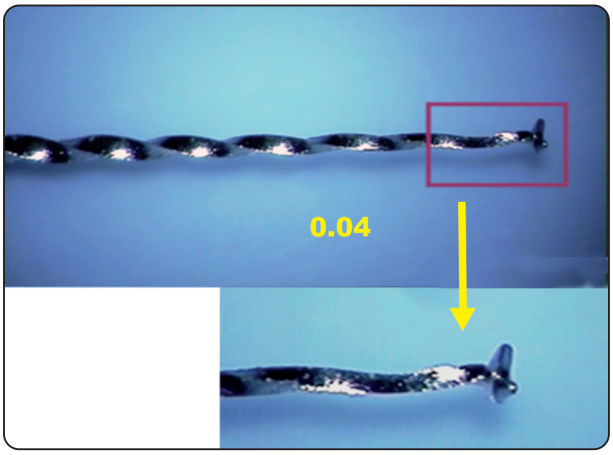

Fig. (5): Photo-DOM micrograph of a taper 0.04 TF- showing blade turn over at the tip and unwinding at the second-third flute (up). A higher magnification of the instrument's deterioration features (magnified)

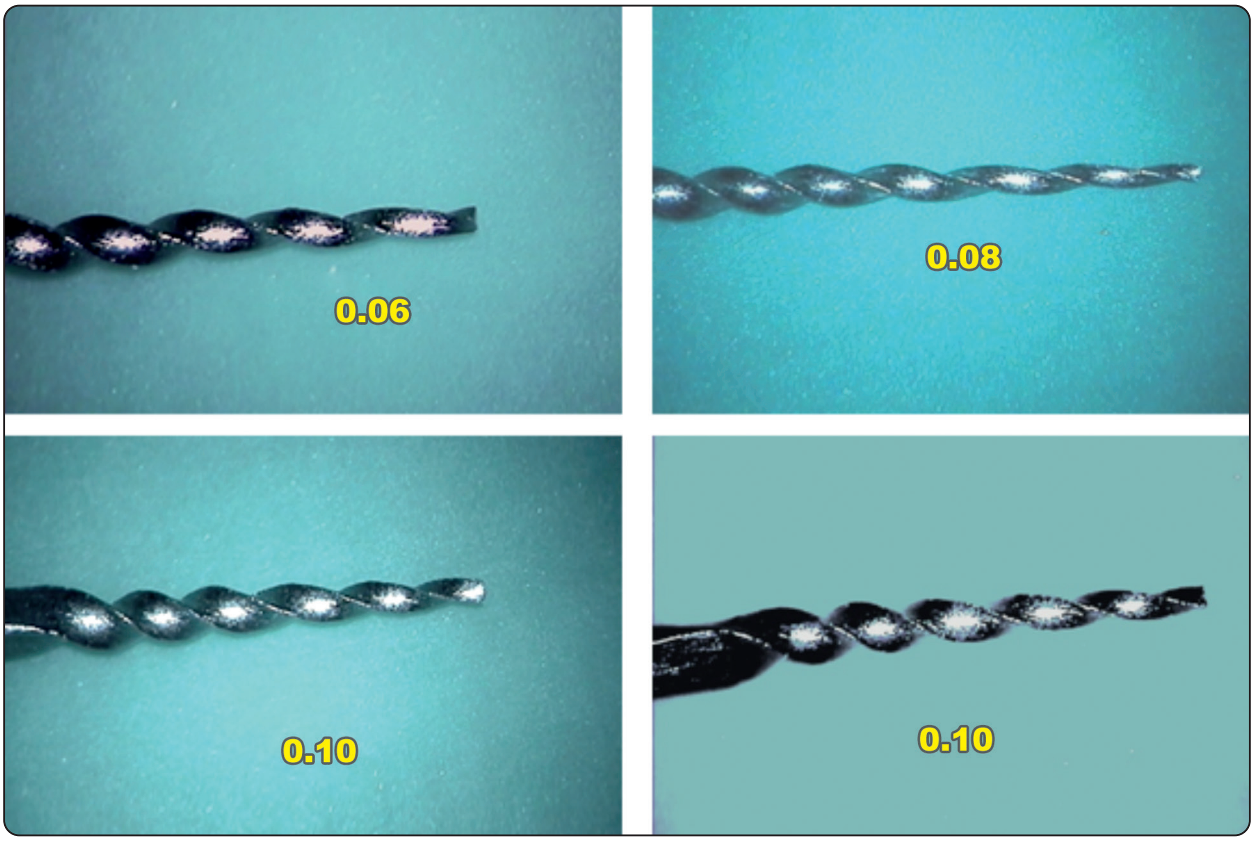

Fig. (6): Composite photo-DOM micrograph showing representative fractured TF at about 3mm. from the instruments tips in all instrument tapers (except the 0.04 taper TF). Note that fracture occurred without further defects \ (flexural type fatigue)

DISCUSSION

The present study was conducted to investigate the feasibility of using the in-clinic DOM as an easy, efficient, effective and quick tool for routine observation of the rotary NiTi file's deterioration in situ. It means that, the file is examined in the operatory and before insertion or re-insertion in the canal. This might minimize instrument's related procedural errors and sudden mishaps because of undetected file's deterioration.

The main difference between light microscope and electron microscope is that beam of electrons is used for magnifying the image of an object while visible light is used in the light microscope to magnify images of tiny areas of materials or biological specimens [29]. The dental operating microscope (DOM) was lunched for clinical use to magnify operative fields especially in endodontic treatment and microsurgery [30]. Because of the unsurpassed help in magnifying and illuminating the operative field; it facilitates detection of tiny orifices both through the access cavity- in an orthograde or in apical surgery- retrograde approach [31,32].

The DOM used in this study was Carl Zeiss with a range of magnification that reached x21.25, resolution up to 64, and depth of field 2. Except for a recent study that used naked eye or loops to measure the sensitivity to depict damaged instruments; to our knowledge no study was found in the literature that used DOM in examination of NiTi rotary instrument after clinical use.

In the present study, the DOM showed features of instruments deterioration and fracture profiles similar to those presented in most SEM investigations at a similar magnification. This might be due to the especially high resolution –reaching 64 – in the herein used DOM. Nevertheless, comparisons with similar studies using SEM showed the ability of the DOM to reveal and depict blades deformations in terms of untwisting, over-twisting as well as blade turnover.

It was stated that, gross deterioration and work-caused defects that was recommended to be regularly and easily monitored for St. St. hand/ rotaries are not applied to the NiTi instruments – for many reported reasons. Actually this statement may not be correct as recognized in the normal daily practice. Again, many of the researches proved through SEM examinations that deterioration of the files blade prior to instrument's separation do occur in NiTi instruments [14,26].

The TF file was selected to be investigated in this research based on the unique manufacturing process –by twisting- to reveal under a magnification of X21 using DOM effect of instrumentation on the file topography and fracture incidence of various tapers. According to the inventors, in the TF instruments; the triangular cross sectional file twisting was made possible by utilizing the R-phase state of nickel titanium. This phase was reached by modifying the molecular structure of the material through a proprietary process of heating and cooling [24].

An important result is the recognition that about 40 percent of the studied used TF instruments showed no defect at the magnification used. This might be because of the manufacturing process of twisting the file as well as the adaptive technology of the TF adaptive in particular [33].

Again, new adaptive technology rotary file with unique kinematics was developed - Twisted File Adaptive rotary system (TF adaptive). It utilizes both continuous and reciprocal motion together based on the file behavior inside the canal. At the beginning the file starts to rotate freely inside the canal in a crown down direction until resistance is felt, then the motor itself will switch to reciprocal motion by 75° to counter back the possible taper luck effect, then switches to rotate again [33].

The over-twisting or over- winding of the instruments blades was mostly scarcely noted in all TF tapers examined. Exception was seen in taper

0.06 were 3 instruments out of 22 (13.6 %) showed over-twisting (figure 4). Again, one instrument out of the 22 TF studied of taper 0.04 showed blade over-twisting.

Except for few single use files; most of the manufacturers for NiTi rotary instruments are not specifying number of use before discarding the instrument [34] . Indeed, no one single ANSI/ADA specification was lunched for the number of use of a NiTi instruments until today [34]. This was reported to be because of the vast number and verities as well as NiTi materials variations, design modifications, and heat treatment methods [35]. On the other hand, endodontic practitioner is in need of a suitable available tool for monitoring instruments before use or reuse [35,36]

CONCLUSIONS AND RECOMMENDATIONS

- DOM is an invaluable quick tool for in situ observation of NiTi instrument deterioration before use.
- Regular checking of the instrument's tip and blade should be a routine before re-use even for the same patient.
- Further study is needed for comparison of features of deterioration using SEM for comparison.
- An evidence based recommendations as to the safe number of use for different rotary NiTi instrument brand is needed-especially for those which are not specified as a single use instruments.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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