Analysis the Fatigue Using ProTaper Rotary Instruments During Instrumentation of Extrated Mandibular Premolars. SEM Obsevation.

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INTRODUCTION

One of the objectives of the surgical preparation of the root canals is their cleaning and shaping which narrows from the coronal access to the apical foramen.

In the last years, a new generation of endodontic files has been introduced. These files are manufactured with a nickel-titanium (NiTi) alloy (55% nickel and 45% titanium) in order to render the instruments flexible and elastic, and make the surgical preparation of curved canals easier, thus minimizing any unwanted complications (Glosson et al. 1995).

Nickel-titanium falls into a category of alloys called "shape memory alloys". Their most remarkable feature is their ability to recover plastic tension when instruments are not loaded, a property known as pseudo-elasticity (Otsuka et al. 1998). The alloy is usually in an austenite crystalline phase. Under loading conditions and at a constant temperature, the austenite phase is transformed into the martensite phase. When the load is removed, the structure recovers its austenite phase and original structure (Saburi T 1998). This phenomenon is related to thermoelastic stress. Martensite is the soft and easily deformed phase that requires only a light load for the instrument to bend.
When the elastic limit of the instrument is exceeded, the deformed instrument generally shows stretching of the helix or severe curving, fracture being the greatest inconvenience. Many fractures occur because the operator is unable to tactilely feel the stress the file is undergoing.

This study was conducted using the ProTaper system. The manufacturer states that these files are specially designed to instrument difficult, highly calcified and severely curved root canals. Their triangular convex cross-sectional design reduces the contact area between the file and the dentine and the slightly negative rake angle. The file active part has multiple and progressive taper.

The purpose of this study was to analyze the degree of fatigue deterioration and the torsion cycles of the ProTaper Systems after they had been used for root canal cleaning and shaping.

Materials and Methods

Twenty ProTaper system instrument packs (Dentsply-Maillefer-Ballaigues-Switzerland) were used. Seventeen packs and 85 instruments overall were actually used whereas 3 and 15 brand new packs and instruments respectively were used as control group. Each instrument pack was numbered from 1 to 20 for identification purposes.

One hundred and seventy single-root first and second inferior premolars with a degree of root curvature less than 25° according to Schneider scale (1971) were selected. The inferior premolars were randomly divided into 17 groups of 10 dental pieces each.

Each pack of ProTaper instruments was used to perform 10 instrumentations according to the manufacturer's directions. It was agreed that F2 be the finishing instrument and that continuous irrigation be delivered to ensure debris removal and instrument lubrication.

After root canal cleaning and shaping, instruments were cleaned ultrasonically and observed under a stereoscopic magnifier (Olympus-Tokyo x 40) to assess the degree of deterioration they had underwent.

The alterations observed were classified as: stripes, cracks, distortions, and fractures.

The data collection sheet was designed in order to identify the packs and the various instruments inside each. The statistical analysis of the data collected using the SPSS 10.10 statistical program for Windows was carried out to compare the packs and the instruments with one another.

The instruments which showed the most damage were evaluated using Scanning Electronic Microscopy (SEM) and compared to pictures of brand new instruments.

Results

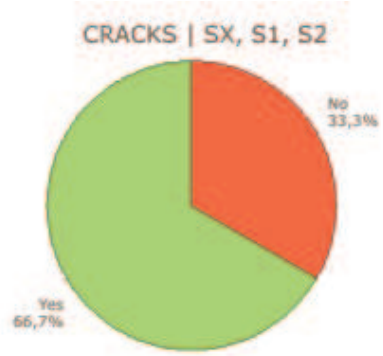
Quantitative Analysis

Table 1 shows the alterations in all instruments used in the study, including the three brand new packs.

	SX				S1				S2				F1				F2			
	Stripes	Cracks	Distorts	Fractures	Stripes	Cracks	Distorts	Fractures	Stripes	Cracks	Distorts	Fractures	Stripes	Cracks	Distorts	Fractures	Stripes	Cracks	Distorts	Fractures
C. 1	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	No	No
C. 2	No	No	No	No	No	Yes	Yes	No	No	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
C. 3	Yes	No	No	No	Yes	No	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No
C. 4	No	No	No	No	Yes	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No
C. 5	No	No	No	No	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No	No	No	No	No	No
C. 6	No	No	No	No	Yes	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No
C. 8	Yes	No	No	No	Yes	Yes	No	No	No	Yes	No	No	No	Yes	Yes	No	Yes	Yes	No	No
C. 9	No	No	No	No	No	Yes	Yes	No	No	No	No	No	Yes	Yes	No	No	No	Yes	No	No
C. 10	No	No	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	No
C. 11	No	No	No	No	No	No	Yes	No	No	No	No	No	No	Yes	No	No	Yes	No	No	No
C. 12	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes	No	No	No	Yes	No	No
C. 13	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No
C. 14	No	No	No	No	No	Yes	No	No	No	Yes	No	No	Yes	No	No	No	No	No	No	No
C. 15	No	No	No	No	No	Yes	No	No	No	No	No	No	No	Yes	No	No	No	Yes	No	No
C. 16	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No
C. 17	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No	No	No	Yes	No	No
C. 18	Yes	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No
C. 7 w/u	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No
C. 19 w/u	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
C. 20 w/u	No	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No

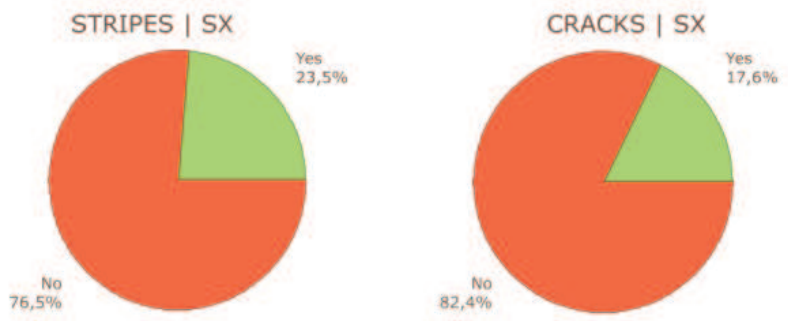
After analyzing all instruments individually, it can be said that:

The Brand New instruments SX, S1 and S2 showed 66.7% cracks without stripes, distortions or fractures.

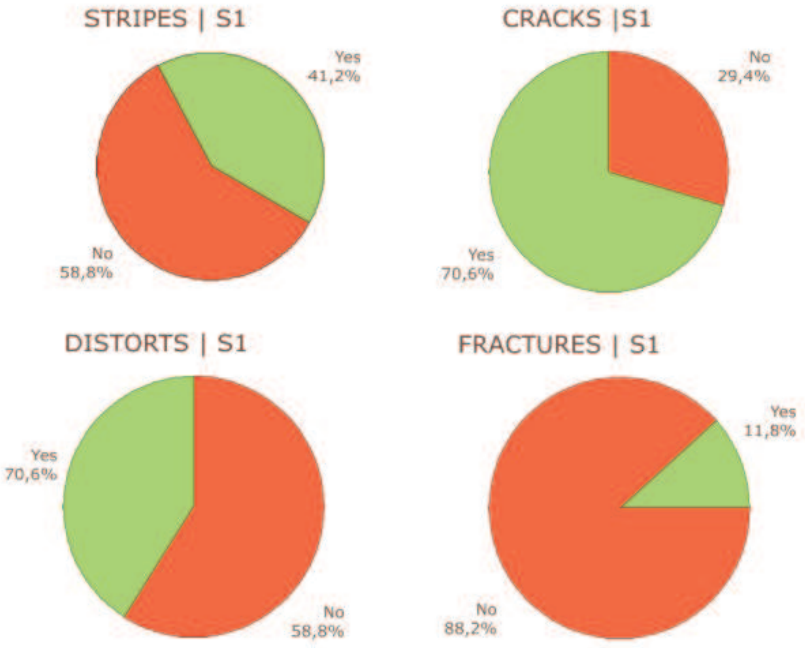


The Brand New instruments F1 and F2 did not show any stripes, cracks, distortions or fractures.

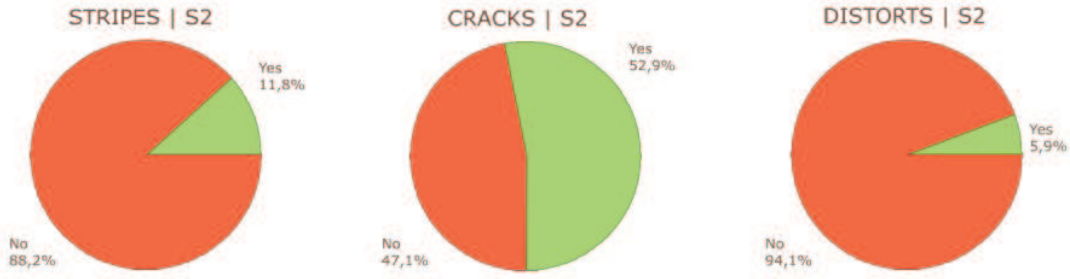
The instruments SX showed 23.5% stripes and 17.6% cracks, and no distortions or fractures.



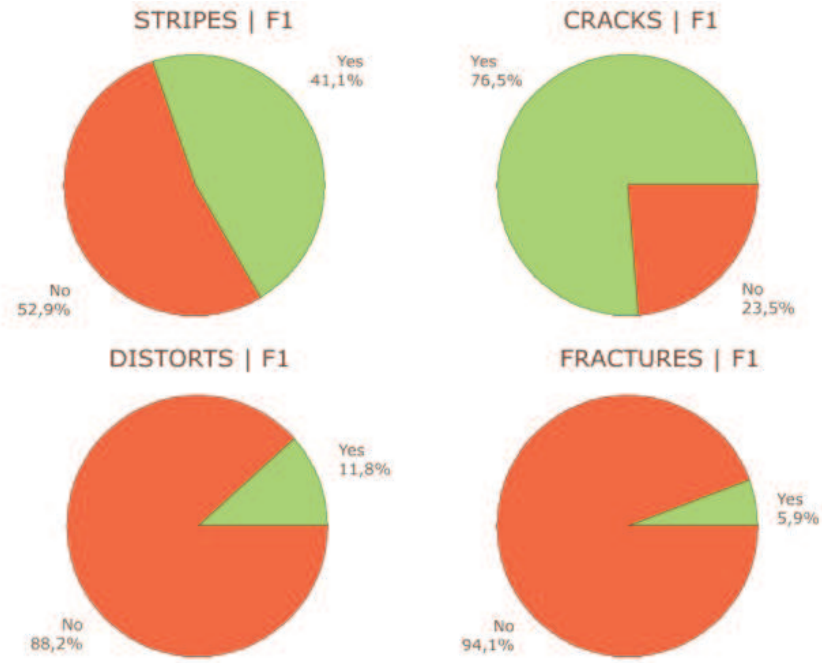
The instruments S1 showed a high percentage of stripes (41.2%) and cracks (70.6%), and 41.2% distortions and 11.8% fractures.



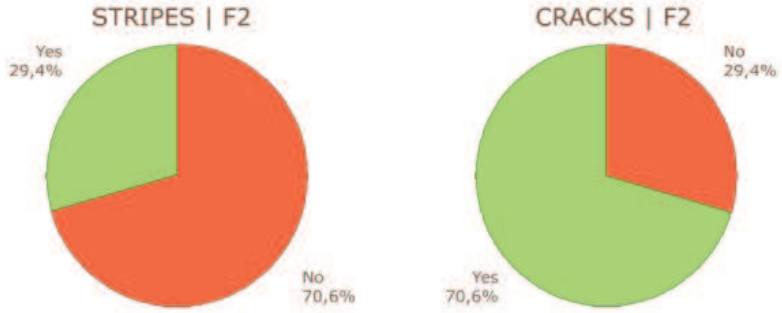
The instruments S2 showed 11.8% and 52.9% stripes and cracks, respectively, and a low percentage (5.9%) of distortions and no fractures.



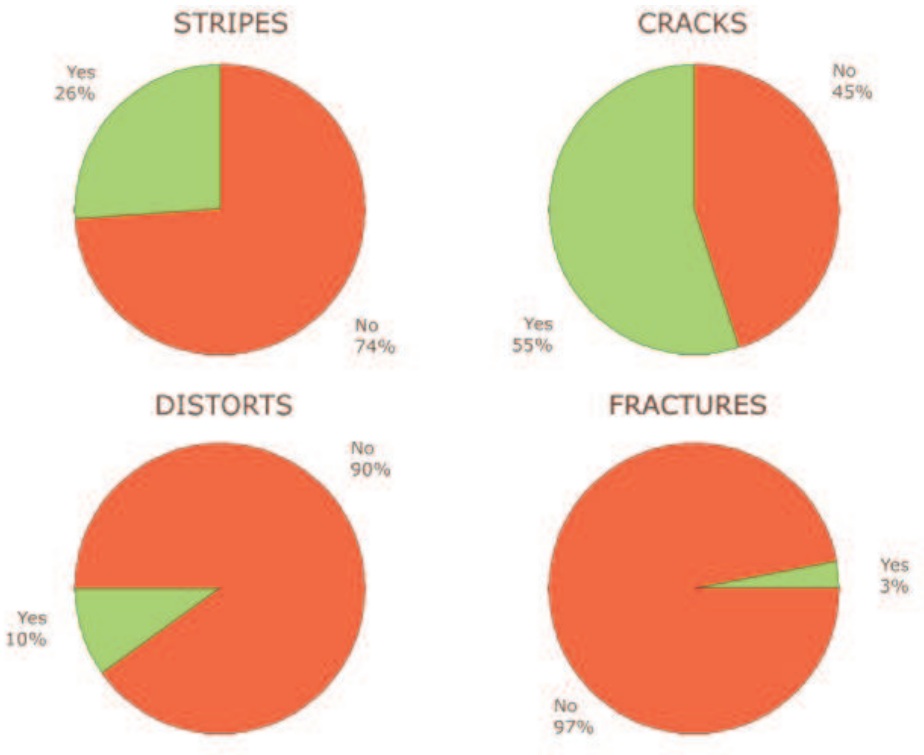
The instruments F1, that shape the apical third, showed a high percentage of stripes (47.1%) and cracks (76.5%), and a low percentage of distortions (11.8%) and fractures (5.9%).



The instruments F2 showed 29.4% stripes and 70.6% cracks, and no distortions or fractures.

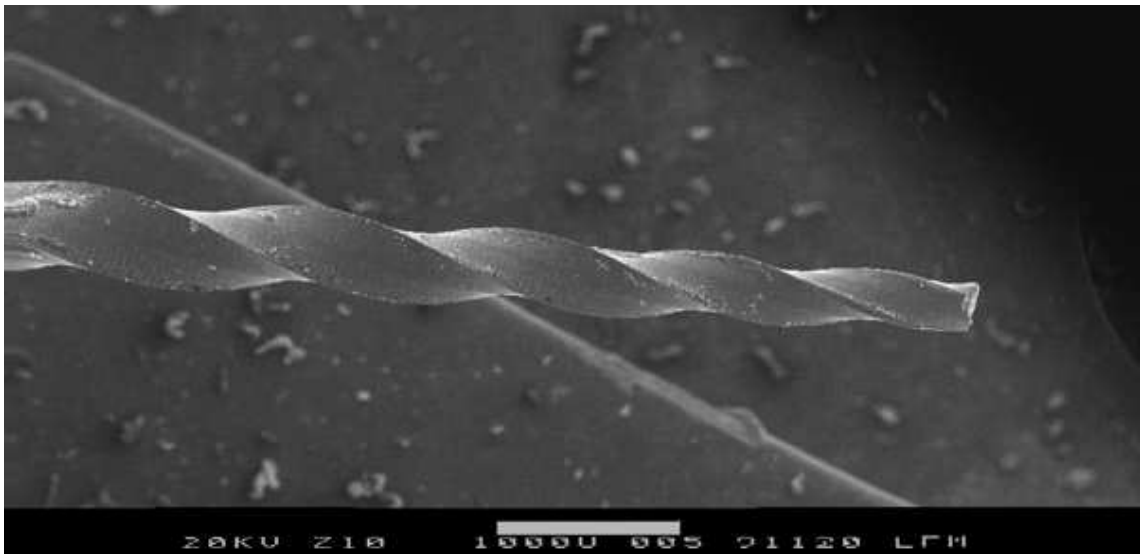


After estimating the overall percentage of alteration for instruments used, the following results were obtained: 26% stripes, 55% cracks and only 10% distortions and 3% fractures.

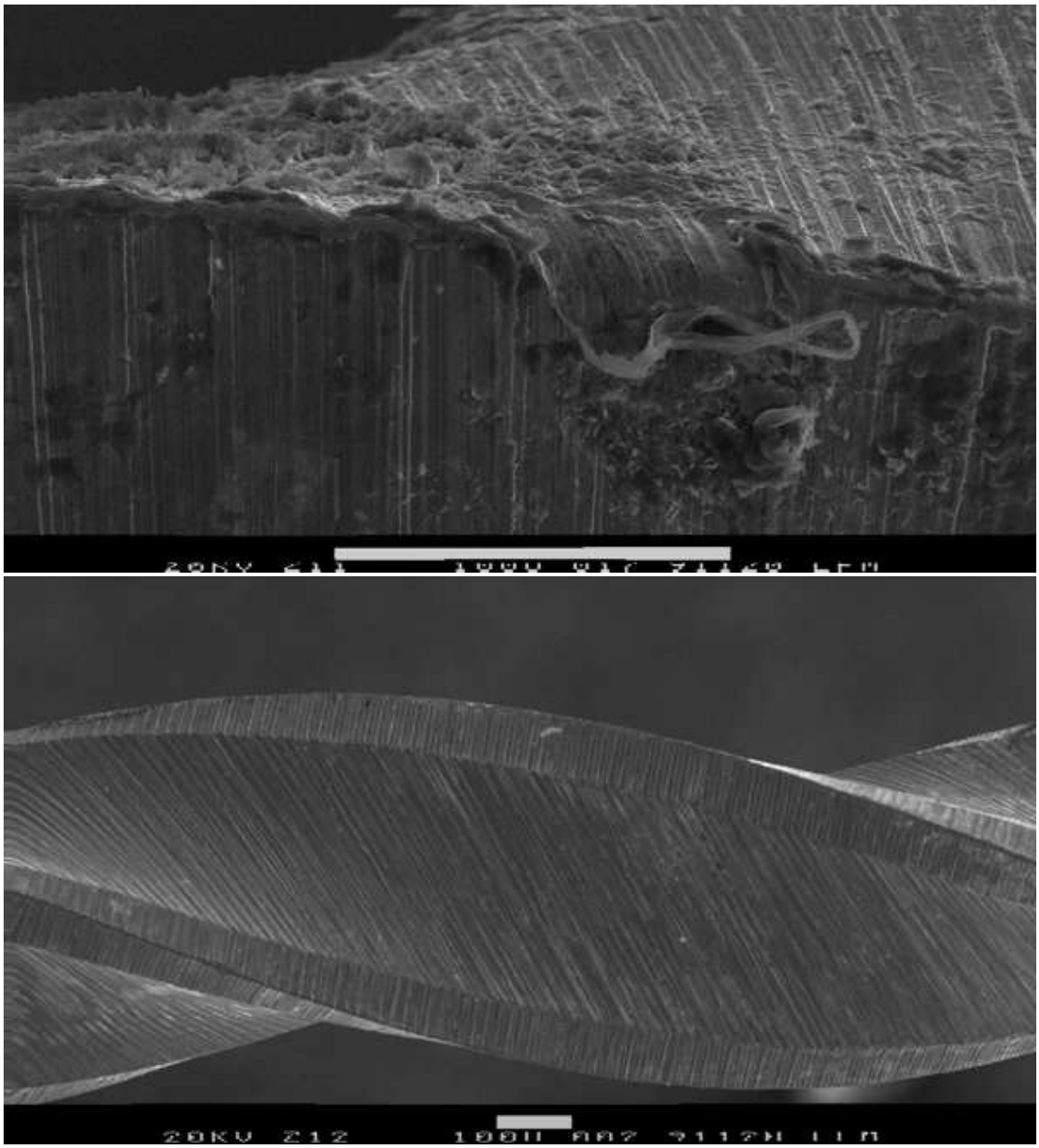


Qualitative Analysis

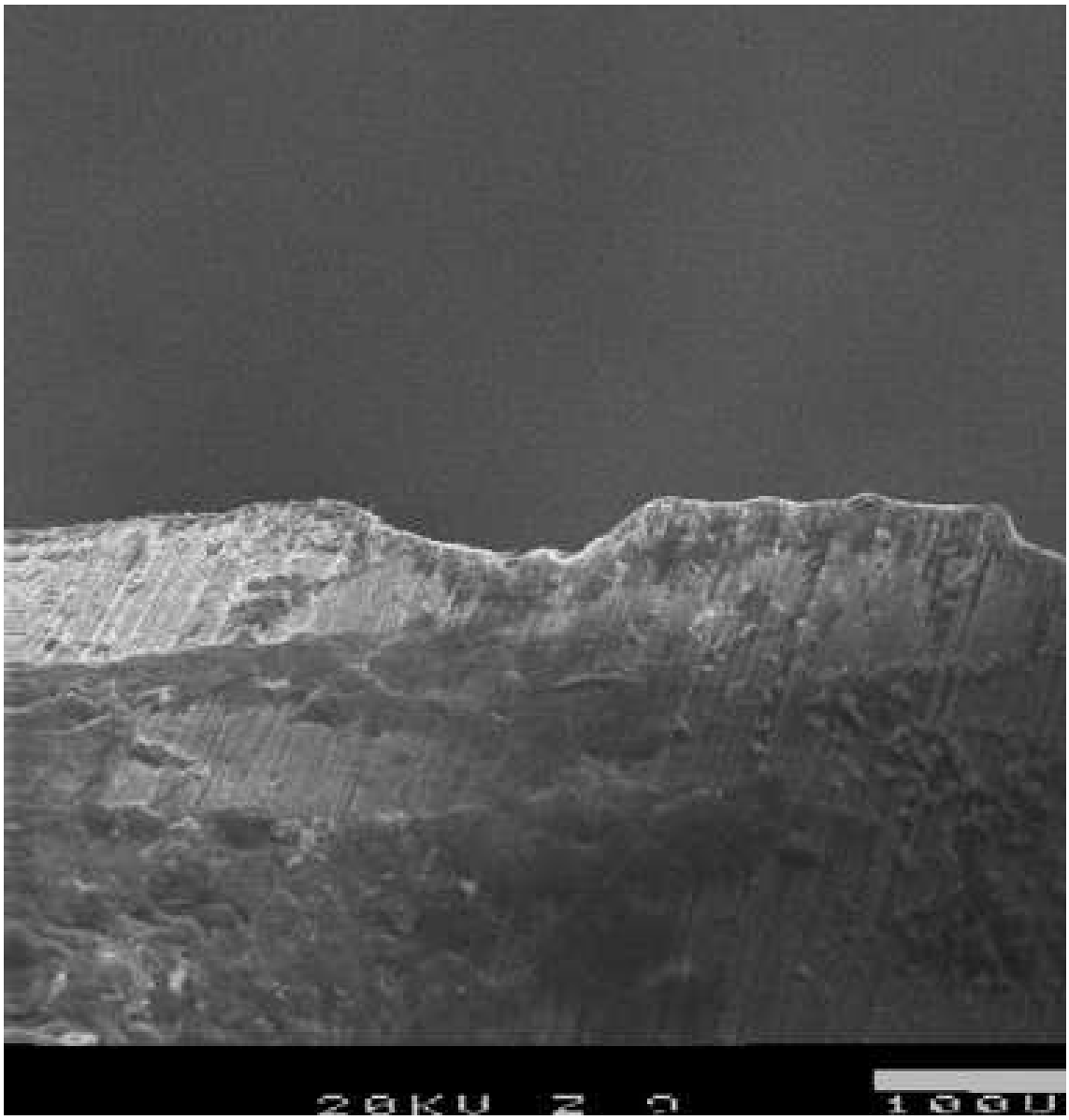
In the brand new instrument, SEM revealed marks from the manufacturing process and a continuous cutting edge.



Whereas S1 showed stress loads accumulated on the instrument's edge areas along with cracks and a lumpy metal surface.



The instrument F1 showed fracture of its apical end and cracks along its cutting edge, that were softer than those observed in S1 (Picture).


20kV 2 0 100U

DISCUSSION

This study analyzed the degree of deterioration of the ProTaper systems after each pack had been used in ten instrumentations involving first and second inferior premolars with a degree of root curvature less than 25º, compared to brand new instruments. According to the data collected, it can be said that the ProTaper systems provide the possibility to carry out instrumentations in a dynamic and rapid fashion allowing the instrument to reach different areas of the canal based on the operator's tactile feeling. All instruments showed various degrees of deterioration after being used in the instrumentation of ten softly curved canals.

One hundred instruments were used overall, 15 brand new instruments made up the control group and the remaining 85 used instruments were divided as follows: 17 Sx; 17 S1; 17 S2, and 17 F1.

The brand new instruments Sx, S1 and S2, designed for cleaning, revealed a more significant percentage of manufacturing defects when examined under the magnifying glass.

This finding agrees with Alapati et al. (2004) who found that the surfaces of the ProTaper brand new instruments showed cracks resulting from the original manufacturing process. Our results reveal that 60% of ProTaper brand new instruments show irregular cutting edges.

The group of used instruments revealed 44.4% stripes and cracks overall and no fractures for the instrument Sx.

On the contrary, the S1 showed all four alterations with the following percentages: 36.6% stripes, 72.2% cracks, 38.9% distortions, and 11.1% fractures. The instruments S2 showed a lower percentage of cracks (55.6%) and few of them (5.6%), distortions. This agrees with Cheung GSP et al. (2005) who believe that metal fatigue seems to play an important role in the fracture of instruments during clinical use.

The instruments F1 and F2 showed a more pronounced degree of deterioration.
After estimating the overall percentage of alteration for the instruments used, results were as follows: 26% stripes, 55% cracks and only 10% distortions and 3% fractures.

In 1993, Collins described four types of fractures in solid metals: cleavage, dimple formation, fatigue and bonding. Our results agree with Schijve (2001) who describes fatigue as slight alterations on metallic structures affecting the propagation of strengths.

Besides, Haikel et al. (Haikel et al 1999) pointed at the taper as the determinant of potential instrument fracture. After comparing file distortions, they found that the ProFile system showed a higher probability of distortion than the ProTaper system. From a clinical point of view, the ProFile distortion may be regarded as a warning sign telling the operator that these instruments undergo stress and need to be discarded. The ProTaper system showed the least number of distorted instruments,

but revealed a large number of broken files. In this regard, our results allow us to conclude that only 3% of all instruments evaluated showed fractures, the F1 being the most affected. This is an understandable fact since the F1 is designed for apical one-third canal finishing, and is the instrument used for advancing into the narrowest millimeters of the canal. In relation to this, we would agree with Ankrum et al. (Ankrum et al 2004) who assessed the incidence of fractures and distortions in the ProTaper, K3 Endo, and ProFile systems in severely curved canals of extracted teeth. Their results point out that caution should be used when resorting to any of the 3 systems since all three rotary systems cause fractures and distortions. After assessing the fractures, the ProTaper system yielded more broken instruments compared to the K3Endo and the ProFile systems. This could be explained by the different tapers of the instruments. In contrast, our results show that the ProTaper files revealed a high probability of distortion but a low percentage of instrument fractures.

CONCLUSIONS

The Brand New ProTaper NiTi files show distortions and cracks. These mechanical alterations resulting from the manufacturing process of the instruments may become the location where stress from use accumulates, possibly causing fracture lines.

The ProTaper files show a high percentage of distortions and cracks and a low percentage of fractures after clinical use following the manufacturer's directions. The instruments that show the most damage are the S1 and the F1.

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