Influence of irrigant viscosity on torsional fracture resistance of rotary nickel-titanium instruments

Influência da viscosidade da substância química auxiliar na resistência à fratura por torção de instrumentos rotatórios de níquel-titânio

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ABSTRACT

Objective
The main goal of the study was to evaluate the influence of the torsion caused by chemical substances with different viscosity levels on the fracture strength of nickel-titanium rotary dental instruments.

Methods
Tapered Instruments K3 #25 and 0.04 were used to prepare simulated canals with: Endo PTC, modified Endo PTC and distilled water. After 12 consecutive preparations using each instrument, they were submitted to the fracture test by torsion, which determined the resistance, in degrees, of each instrument in each experimental situation. Data were collected, analyzed and submitted to statistical analysis using the Kruskal-Wallis test.

Results
The statistical data analysis showed that there were no statistically significant differences as regards resistance to torsion of rotary instruments, with changes in level of viscosity of the substance that helps instrumentation.

Conclusion
Viscosity level of the chemical substance used during root canal preparation does not interfere in resistance to torsion of rotary instruments up to 12 consecutive times of use.

Indexing terms*: Dental pulp cavity. Endodontics. Root canal irrigants.*

RESUMO

Objetivo
Avaliar a influência de substâncias químicas, utilizadas durante o preparo do canal, com diferentes viscosidades na resistência à fratura por torção de instrumentos rotatórios de níquel-titânio.

Métodos
Instrumentos K3 #25 e conicidade 0.04 foram utilizados no preparo de canais simulados com: Endo PTC, Endo PTC modificado e água destilada. Após 12 preparos consecutivos com cada instrumento estes foram submetidos ao teste de fratura por torção em um troptômetro, que determinou a resistência, em graus, de cada instrumento em cada situação experimental. Os dados foram tabulados e submetidos à análise estatística pelo teste de Kruskal-Wallis.

Resultados
A análise estatística dos dados apresentados revelou não haver diferenças estatisticamente significantes no que respeita a resistência à torção de instrumentos rotatórios ao variar-se a viscosidade da substância auxiliar da instrumentação.

Conclusão
A viscosidade da substância química utilizada durante o preparo do canal radicular não interfere na resistência à fratura de instrumentos rotatórios até 12 utilizações.

Termos de indexação: Cavidade pulpar. Endodontia. Irrigantes do canal radicular.

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IINTRODUCTION

The mechanization of root canal instrumentation has long been desired by dentists. After Walia et al.[1] demonstrated that a file made of Nitinol alloy is two to three times more flexible than a stainless steel file, has greater resistance to torsional fracture, in addition to the considerable memory effect of the alloy, the NiTi endodontic file became a promising instrument in the preparation of curved root canals.

These mechanical properties of flexibility, elasticity and torsional resistance to fracture resulted in encouraging the development of mechanized instruments for root canal preparation.

Studies appeared attesting to the various advantage of the use of these systems, pointing out the efficiency and centralization of the preparation[2], time saving and less risk of extravasation of the excised material[3-5]. Zuolo & Walton[6] demonstrated greater wear of stainless steel files in comparison with nickel-titanium files under the same conditions of clinical use and in the presence of 2.5% sodium hypochlorite. The NiTi files, however, represented the major portion of fractured instruments, probably caused by the torque of the motors, and researchers began to pay more attention to this aspect.

The main causes of fracture are as a consequence of deterioration of the cutting blades, cyclic fatigue of the instruments, associated with less predictable factors, such as the penetration force and speed and others, partially controlled, such as the torque of electric motors[7-8]. Whereas, the increase in taper and diameter promoted an increase in fracture resistance to torsion[9].

Thus, in addition to morphological alterations in the instruments[10], researches were directed towards finding safer means of instrumentation, such as determining the ideal speed for instrumentation[7], maximum limit of torque of each instrument[11], the effect of used associated with sodium hypochlorite[12], influence of sterilization and corrosion resistance of nickel-titanium rotary instruments[13] and more recently, the effects of ionic implantation on cyclic fatigue resistance[14] and flexion of nickel-titanium rotary instruments[15].

To diminish torsional fatigue and prevent the increase in temperature generated by friction of the file, a low speed should be used (300 rpm) and the instrument should not remain in the canal for more than 20 seconds. The importance of using a lubricant to maintain a low file temperature is also pointed out, thereby attenuating the friction of the instrument during endodontic therapy[16].

Paiva & Antoniazzi[17] have affirmed the importance of using a lubricant substance during chemical-surgical root canal preparation, when they began to use a substance composed of a combination of urea peroxide and detergents used as a vehicle in Carbowax-based lubricants (Endo-PTC). They explained that by reducing the risks of instruments sticking to the canal wall would lead to consequent reduction in the risk of instrument fractures.

At present, the concepts of lubrication are very well defined by engineering. It is known that adequate lubrication diminishes the friction between surfaces in contact, consequently leading to an increase in their useful life due to less wear of the cutting blades.

It is also known that one of the major problems with rotary instrumentation is fracture by torsion caused by the difference in speeds along the cutting blade as a result of friction. Therefore, this study sought to evaluate the influence of the consistency of the chemical substance on the torsional fracture strength of nickel-titanium rotary instruments during chemical-surgical root canal preparation, taking into consideration the fact that substances with different viscosities present different lubricating capacities.

In view of the foregoing discussion, the aim of this study was to evaluate the fracture resistance to torsion of nickel-titanium rotary endodontic instruments when chemical substances with different viscosities are using during chemical-surgical root canal preparation.

METHODS

A total of 288 simulated canals were fabricated with Polyester resin 5061 (AG Brasil Compósitos, São Caetano do Sul, Brazil), mixed with its catalyzer Oximek PAM (AG Brasil Compósitos, São Caetano do Sul, Brazil), so that single straight canals with a working length of 16 millimeters were obtained.

The canals were made with 0.5 mm orthodontic wire (Morelli Ortodontia, São Paulo, Brazil) and so that the apical diameter would be compatible with the instrument selected for performing the work, the wires were previously worn with a low speed motor (Cordeless Mini Drill BMD-1) and file for iron, fine grain 150, (3M, Campinas, Brazil) until it reached a diameter compatible with 0.3 mm, according to a cone calibrating ruler (Maillefer, Switzerland).

The working length was confirmed with the use of a #15, 21 mm K type file (Maillefer, Switzerland), simultaneously verifying the shape and absence of interferences within the simulated canal. To do this, the instrument was introduced into the canal with penetrative movements until the tip was verified in the escape orifice of the simulated canal.

Twenty-six Type K[3] instruments (Sybron Endo, USA) #25, with 0.04 taper, 21 mm, were used and divided into 4 groups, as follows:

Group 1 was composed of 8 type K[3] instruments and 96 simulated canals. Each instrument was used to work in 12 simulated canals. Each instrumentation was performed with a Quantec motor (Tycon, USA), and the chemical substances used were Endo-PTC (Farmácia Fórmula e Ação, São Paulo, Brazil) and distilled water. The canal was filled with Endo-PTC and the distilled water was dripped onto the cream, so that these substances remained in the canal throughout the preparation performed with the instrument.

For Group 2, in the same way, 8 type K[3] instruments were used in 96 simulated canals, so that each instrument was used to work in 12 simulated canals. Instrumentation was performed making use of modified Endo-PTC (Farmácia Fórmula e Ação, São Paulo, Brazil) and distilled water dripped in the same way as in Group 1, ensuring that the substances were present in the canal throughout the entire preparation.

Modified Endo-PTC consisted of an oil formed of urea peroxide (10%), Tween 80 (15%) and polyethylenoglycol 400 (75%). Its effectiveness was previously tested by mixing it with 0.5% sodium hypochlorite by verifying the effervescence with a duration similar to that of the Endo-PTC and 0.5% sodium hypochlorite mixture.

Group 3, was also formed of 8 type K[3] instruments and 96 simulated canals, with 12 simulated canals instrumented with each instrument. In this group, instrumentation was performed using distilled water as the chemical substance, with presence of the substance in the canal throughout the entire preparation time.

Group 4, control, was composed of 2 type K[3] instruments that were submitted to the fracture test in a new condition, without ever having been used for the preparation of simulated canals.

After performing the preparations, the instruments were submitted to fracture by torsion, which was carried out in the following manner: a pen with indelible black ink (Pilot, model Hi-Tec-C, Japan) was used to mark the final three millimeters at the tip of each instrument. After this, the instrument was fixed by its handle in the chuck of a troptometer modified by Santos and Bombana[18] (Figure 1), according to the Craig & Peyton[19] model, and its final 3 millimeters held firmly in place by a vise at the base of the appliance. The instrument scale was initially calibrated to zero degrees. The handle coupled to the side of the troptometer was activated, twisting the instrument in the clockwise direction, until the characteristic sign of fracture was noted, thus recording the values for each instrument.

After tabulating the values, these were submitted to statistical analysis by the Kruskal Wallis test, with the level of significance established at 5%.

The instruments were also submitted to scanning electron microscopy at 200x magnification before and after the preparations, to verify the wear of the instrument tip.

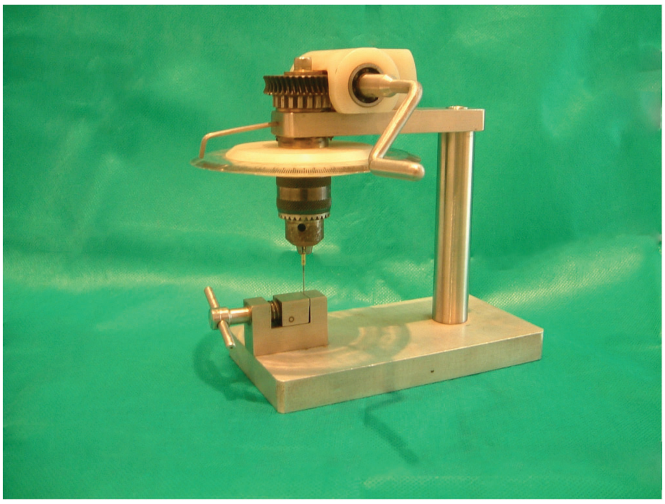

Figure 1. Instrument being submitted to the torsional resistance test in a troptometer modified by Santos[18].

RESULTS

The results obtained in this study are shown in Table 1.

The normality test presented a non normal result, which led to the choice of the Kruskal Wallis test for statistical analysis.

Comparison among the means of the groups and determination of the degree of significance, at a level of 5%, is shown in Table 2.

The values allowed one to verify that the lubrication provided by Endo PTC modified attained lower loss of resistance of the rotary instruments when compared with Endo PTC, however, without statistically significant differences between the two chemical substances used for canal preparation.

Whereas lubrication with water led to greater loss of resistance of the instrument.

Table 1. Mean and standard deviation of the results obtained (in degrees) by the different groups.

	Endo-PTC	Endo-PTC mod	Water	Control
Means	611.25	686.25	540	775
Standard Deviations	37.58	120.00	99.71	35.00

Table 2. Two-by-two Comparison between the sampling means and the respective degree of significance

Compared samples (two by two comparisons)	Differences among means	Critical values			Significance
		0.05	0.01	0,001	
Endo PTC x Endo PT mod	5.4375	6.4047	8.7053	11.7100	ns*
Endo PTC x water	4.3125	6.4047	8.7053	11.7100	ns*
Endo PTC x control	11.7500	10.1267	13.7643	18.5151	5%
Endo PTC mod x wat	9.7500	6.4047	8.7053	11.7100	5%
Endo PTC mod x control	6.3125	10.1267	13.7643	18.5151	ns*
Water x Control	16.0625	10.1267	13.7643	18.5151	5%

*Not Significant at level of 5%.

DISCUSSION

Concern about improving the performance of rotary instruments in Endodontics has led to this being the goal of innumerable researches, particularly with respect to reducing their fracture rate[7,9,11-13].

From this aspect, the aim of the present study was to verify the conditions provided by altering the consistency of the chemical substance, and by changing the viscosity of the lubricant, seek to minimize the friction so that there would be less demand on the instrument during root canal preparation, and this consequently would lead to fewer fractures.

In Engineering, it has been noted that the lubricant is of the utmost importance to the good performance of machinery during the fabrication of parts[20]. Similarly, the durability of rotary instruments may be improved when they are adequately lubricated during the work of root canal preparation in Endodontics.

There is great scarcity on this topic in endodontic literature, which prevented comparison of the results obtained with the chemical substances used in this study with others that have different viscosities. The majority of studies that have been conducted have investigated other questions, finding defects in the cutting angles and oblique cracks in the active part of instruments[21]. However, Peters et al.[22] evaluated the effect of lubrication on the torque used by rotary instruments in human teeth. The authors used EDTA in aqueous (EDTA 15%) and paste form (Glyde, Dentsply, USA) to lubricate instrumentation of the Protaper and Profile systems. They verified that the paste form was less efficient, especially for Profile. Perhaps the use of EDTA had been favorable because of better action on the dentinal magma formed, however, when Glyde was used, the impaction of debris added to the inactivation of sodium hypochlorite harmed the performance of this material. In the present study, Endo PTC, even when modified, allowed the sodium hypochlorite to react with urea peroxide, and favored solubilization of the material to be excised. It is also worth observing that the antimicrobial potential of sodium hypochlorite reacting with Endo PTC is of great interest in disinfection of the root canal. Moreover, Peters et al.[22] also pointed out less expressive results for the Protaper instruments, alleging that the cross sectional design could influence the results, and in the present study the option was to use the K3 instrument that has a smaller area for debris accumulation than Profile.

Nevertheless, Anderson et al.[23] working with GT and Profile instruments, lubricated with RC Prep and saline solution, verified that the use of a more viscous solution (RC Prep - EDTA in paste) reduced the stress on the instruments when compared with the use of an aqueous solution, which is confirmed by the data of this study.

However, when using aqueous solutions, whether they are chelating or sodium hypochlorite, one notes that lubrication is very important, and demands less torque for the action of Profile rotary instruments[24] which confirms the premise of this study, in the sense that more efficient lubrication could improve the performance of the instrument and diminish the risk of fracture.

The use of simulated canals for the purpose of this study appears to be most appropriate, since these canals are used in a large number of researches[25], and being duly tapered, would favor the instrument working to its full extension. Their fabrication was a handcrafted project, but with fully acceptable characteristics. The tip of the matrix instrument 0.03 mm in diameter was defined from an orthodontic wire 0.05 mm in diameter, which was activated at low speed on abrasive paper for metal so that the tip would wear, and this was checked with a gutta percha cone calibration ruler.

In order to confirm that the instrument would work in the full extension of the root canal, a pilot study was conducted, to verify the structure of the instruments in the light of scanning electronic microscopy at 200X magnification, which confirmed alteration in the shape of the tip after it was used 12 times, demonstrating wear of the instrument.

It was not possible to conducting the study with sodium hypochlorite, a substance extensively used worldwide, because the solution would react with the resin of the simulated canal, so that distilled water with a viscosity similar to that of sodium hypochlorite was used in the study.

Creamy substances, such as Endo PTC[14] or RC Prep[26], among other substances, have been proposed for lubricating instruments during their application, because they facilitate their use. In this study the option was to use Endo PTC + distilled water.

With the purpose of simulating situations similar to those in Engineering, a new substance was sought, namely modified Endo PTC, which only establishes the alteration of mixtures of molecular weights of polyethylenoglycols in the original formulation of carbowax by only 400, providing homogenization of the product and a viscosity similar to that of oil.

The results of this study demonstrated that modified Endo PTC + distilled water were shown to be as efficient as Endo PTC + distilled water for the lubrication of instruments allowing a similar loss of resistance in the test of fracture by torsion of the instrument. This appears to be easy to understand, since rotation of the instrument promotes the release of heat that acts on the polyethylenoglycol, making it less consistent and very similar to the modified Endo PTC proposed in this study. Once the surface area is increased by the presence of the lubricant, this acts to diminish the friction, largely responsible for fracture of the instrument.

An interesting observation, however was that the sticking of instruments that normally takes place during preparation with Endo PTC did not occur with modified Endo PTC. This allowed one to attest to greater ease for the operator, a factor with important influence at the time of selecting the substance to be used.

It is important to emphasize that the modified Endo-PTC requires further studies before being incorporated into clinical practice, because other properties of utmost important where chemical substances are concerned were not evaluated in this study, such as dentinal permeability of antimicrobial action, among others.

When Monteiro et al.[27] studied cleaning of the thirds of mandibular incisors, they confirmed one of the purposes of this study, by revealing the good cleaning capacity of Endo PTC with low viscosity.

Distilled water showed results in agreement with Engineering studies, ratifying that lubricants with less viscosity generate greater friction, leading to lower fracture resistance of the instrument.

This study therefore, adds important information to the use of lubricants with rotary instruments, showing that in addition to torque, the lubricant must be the target of interest in research, considering that when one works with chemical substances of greater viscosity, the instruments may be used more safely.

Therefore, when using rotary instruments it is necessary to make use of substances with a creamy or oily consistency.

CONCLUSION

After obtaining the results, it would seem admissible to conclude that there were no statistically significant differences between Endo PTC and modified Endo PTC.

The use of Endo PTC and /or modified Endo PTC offers less loss of resistance of rotary instruments during the preparation of simulated root canals when compared with water; moreover, further studies on modified Endo PTC are required for it to be applied in the endodontic clinic.

Collaborators

TAG SIQUEIRA contributed to the development of the experimental part, bibliographic survey and writing the article, M SANTOS guided the research, was responsible for the initial project, and participated in writing the article. EL SIQUEIRA contributed to the development of the experimental part, statistics and final writing of the article, C COSTA and MA NICOLETTI participated in the development of the experimental part and in writing the article.

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Received on: 18/5/2010
Final version resubmitted on: 4/4/2011
Approved on: 14/6/2011