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A comparative Study to Evaluate the Effect of Sodium hypochlorite Temperature on Cyclic Fatigue Resistance of Three Types of Rotary Instrument

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Abstract

Background: The fracture of instruments within root canal during endodontic treatment is a common incidence, fracture of fatigue through flexure occurs because of metal fatigue, NaOCl used for irrigation may have an effect on corrosion that decrease fracture resistance. This study aimed to assess the effect of NaOCl temperature on the cyclic fatigue of different type of Endodontic NiTi Rotary Instruments and compare among them.

Materials and method: three types of rotary instruments with tip size 0.25: ProTaPer F2 (Densply,Malifier) Revo-S SU (0.06 taper, MicroMega) and RaCe system (0.06 taper, FKG,Dentaire), Thirty file of each instrument type were used within canal with 60° angle of curvature , undiluted NaOCl (5.25%) were used. Ten file without immersion in NaOCl, ten were immersed at room temperature (21°C) for 5 minute and ten with immersion in NaOCl at 60°C for the same time. Nine group were formed for all instruments (total number=90). The testing canal customized within stainless steel block covered with glass face, the time to fracture recorded and the mean of cycles to fracture (MCF) detected for each instrument .Data were analyzed statistically by ANOVA, LSD and Independent T-test at 5% significant level.

Result: there was a highly significant difference in mean of cycles to fracture for each rotary instrument when temperature of NaOCl increased that the Number of cycles to fracture decreased as the temperature increased. RaCe revealed the best fracture resistance followed by ProTaper then Revo-s that showed the less resistance.

Conclusion: the rotary instruments more prone to fracture when temperature of NaOCl increased, as well as the rotary instruments differ from each other according to manufacturing process, taper, cross section and other factors.

Key words :cyclic fatigue, NaOCl ,Temperature of NaOCl.

Introduction

The use of sodium hypochlorite (NaOCl) to irrigate root canals is currently the gold standard to achieve tissue dissolution and disinfection .It has been shown that the amount of available chlorine is important for the tissue dissolving and antibacterial effect of NaOCl. Several mechanisms have been suggested to increase that amount: the use of undiluted NaOCl (5.25%), increasing volume turnover and heating NaOCl solutions. Immersion in 1% NaOCl at 60°C results in significantly more effective tissue dissolution compared with a 5.25% solution. Similarly, an increased killing capacity of Enterococcus faecalis was observed **(1)**

Sodium hypochlorite is present in root canals before inserting any rotary file to provide disinfection but also lubrication (**1**). The time course and extent of action of NaOCl on NiTi surfaces is currently unclear. This partly stems from the fact that NaOCl is used for canal disinfection but also for cleaning of used rotary files to remove organic matter (**2**).

Peters et al. in 2007(**1**) concluded that there was a risk of corrosion of NiTi rotary files in contact with NaOCl, especially when heated solution is used. Under the conditions of their in vitro study, both ProFile and RaCe rotaries showed a reduction in fatigue resistance but not in torsional strength. Visual inspection is recommended when re processing files with NaOCl to detect signs of gross corrosion. However, single use of NiTi rotaries may be indicated to reduce the danger of premature fatigue failure after contact with NaOCl.

Materials and Methods

Three brands of rotary instruments with tip size 25 were used: **ProTaper** (F2, variable taper), **Revo-S** (SU, 0.06taper) and **RaCe** (0.06 taper). Thirty file for each instrument type were used also undiluted NaOCl (5.25%)were used, file were immersed in NaOCl at room temperature (21±1) for 5 minutes, ten file immersed also but at (60 ±1) and ten file without immersion in NaOCl (Total =90) rotated at **250 RPM** .Nine group were formed, ten instrument for each group. Cyclic fatigue testing was conducted with the instrument rotating freely within an artificial canal defined by both the angle and radius of curvature according to **Pruett et al., 1997**(**3**). Instrument were tested within a canal with **60°** angle of curvature and radius of curvature **5** mm, the width of canal was **1.5** mm in a Stainless Steel block covered with a swiveling glass cover allowed visualization the file rotating in the canal and the removal of broken instruments after fracture. A marker of permanent red ink placed at **19** mm on the glass cover of metal block to standardize instrument placement(**4)**. The dental hand-piece was mounted upon a surveyor that allowed for precise and simple placement of each instrument inside the artificial canal, ensuring three-dimensional alignment and positioning the instruments to the same depth for standardization (**5**).

The Stainless Steel block also mounted and fixed by bench vise to prevent its movement and to obtain fixed relation between the block and the surveyor through hand-piece. Each canal filled with glycerin completely to the coronal orifice of the canal, before introducing each instrument to the required length (19mm) inside a canal to reduce friction and heat release **(6).** The electric motor adjusted to the desired speed **250 RPM** and fixed by surveyor to follow the curvature of the canal then operated. In order to make standard tests, no pecking motion was used (**9**). To set the temperature at 60℃ , baby bottle warmer was used.

In order to understand the effect of NaOCl and temperature on MCF Independent t-test were used as in Table 3.

The time to fracture recorded then the number of cycles to fracture (NCF) calculated by multiplying the time to fracture in minute by the speed used (RPM). The data were collected and analyzed using software program (SPSS18) for statistical analysis. One way analysis of variance (ANOVA) and SD test were used to determine whether there was statistical difference among the mean of cycles to fracture for rotary instruments used.

Results

Descriptive statistical analysis showed that the highest Mean of Cycles to Fracture(MCF), more fracture resistant, represented by C (RaCe) followed by A (ProTaper) and then B (Revo-S) without immersion in NaOCl and the MCF for three types of instrument used decreased after immersion in NaOCl at room temperature for 5 minute and when the temperature increased to 21℃ at the same period more decrease in MCF were noticed, the highest MCF reprecented by C1(RaCe)without immersion and the lowest MCF showed by B3(Revo-S) after immersion in NaOCl at 60℃ for 5 minutes as in Bar chart (**Fig.1**) and Table 1.

To show the statistical effect for temperature of NaOCl ANOVA test were used for each type of rotary instrument and showed a highly statistical difference in MCF among three groups, without immersion and immersion in NaOCl at (21℃ and 60℃) as in Table 2

From Table 3 it's clear that among the control groups(A1, B1, C1)and (A2, B2, C2) respectively was no statistical difference when the instrument of the three types immersed in NaOCl for 5 minutes at room temperature 21 ℃ , but there was highly significant difference when immersed in NaOCl at 60 ℃ (A3, B3, C3) respectively.

Table 4 showed highly statistical difference among three types of rotary instruments, for more comparision among fracture resistance for rotary instruments LSD were used as in Table 5 which showed that for all tests used the higher MCF showed by RaCe followed by proTaper then Revo-S (B). Thus RaCe (C) was the more fracture resistant followed by proTaper(A) and then Revo-S (B).

Discussion

A NaOCl with 5.25% concentration was used in present study because this concentration adopted in clinical practice for two basic required properties, disinfection and dissolution of organic material**(7)**. Heating NaOCl solutions up to 60°C has been suggested to increase reactivity, antimicrobial and tissue-dissolving action (**1**).

In the presence of an electrolytic solution such as NaOCl galvanic reactions and corrosion processes may occur. NaOCl may be present in the pulp chambers of teeth with restorations of different metals (amalgam restorations, gold crowns, etc.) and this may trigger galvanic reactions and thus corrosion processes. Galvanic corrosion cause pitting and cracks that alter the integrity of the instrument surface, decreasing its resistance to fracture because of cyclic fatigue **(8**).

The result of present study (**Table-1**& Figure1) showed that when the temperature increased from (21c° ±1 to 60c° ±1) the MCF for all rotary instruments: **ProTaper** (**A**), **Revo-S**(**B**) and **RaCe** (**C**) decreased and there was statistically high significant difference between instruments immersed in 60c° temperature with that immersed in NaOCl at room temperature (21c°), in addition with instruments without immersion

(Table-2). The increase in temperature of NaOCl lead to decrease fracture resistance for all rotary instruments (NCF) and this come in **consistent** with **Peters et al. in 2007(1)** who found that the increase in temperature enhance the corrosive potential of commercial NaOCl solutions and adversely affect mechanical properties of NiTi rotaries. Such an effect of heating of NaOCl on NiTi file integrity was first described for ProTaper files by **Berutti et al. in 2006 (8)**when immersed for 5 min in 5% NaOCl at 50 c° produced marked effervescence in the solution, with formation of visible dark particles in suspension lead to decrease in fracture resistance. This finding come in contrast with **Barbosa et al.(7)** who mentioned that the resistance to flexural fatigue of the NiTi files was not affected by exposure to Naocl solution and they attributed that to the non-observing pitting corrosion of files exposed to Naocl, while **Ametrano et al. in 2010**(**9**) showed that the short-term contact between NaOCl and EDTA solutions (5 or 10 minute) and ProTaper instruments indicating deterioration on the surface leads to localized surface pitting and cracks that modifies the integrity and resistance to fracture of NiTi instruments.

From **LSD** (**Table-5**) it's clear that the MCF for RaCe (C) was more than that of ProTaper F2 (A) and that for Revo-S (B). Thus the RaCe had more fracture resistance than ProTaper and Revo-S and this was in consistent with **Kim et al. in 2010** (**10**) who explained that the high fracture resistance of RaCe over ProTaper and Revo-S was due to the lower flexural rigidity for RaCe cross section (triangular) and nearly the absence of machining marks on the RaCe instrument after electro polishing. For the cyclic fatigue resistance, residual stresses of machining marks have been considered as an important factor. When an instrument is machined, plastic deformation occurs at the surface of the metal, resulting in residual stresses that remain at the surface.

AL-hadlaq et al in 2010(11) confirmed the effect of electro polishing in enhancement of fracture resistance. When compared Revo-S with profile instruments. The more fracture resistance for RaCe than ProTaper may be attributed to the diameter of instrument at the point of maximum curvature that as the diameter increase the **NCF** decreased. when the point of maximum curvature in present study was near 5 mm from the tip of instrument (**D5**) for angle of curvature was 60° the diameter of ProTaper was 0.60 mm and 0.55 mm for RaCe (**Kim et al. ,2010 (10) and Necchi et al. 2008**(**12**)). The results of present study disagree with **Zhang et al. in 2010** (**13**) whom revealed that the triangular cross section (RaCe) showed the least resistance to torsional and cyclic breakage than convex-triangular cross section (**ProTaper**). This might be related to the deep flutes cut into these cross sections, resulting in a small inner core diameter.

In present study ProTaper was more fracture resistant than Revo-S and this come in consistent with **Necchi et al.** (**12)** who revealed that an instrument with convex triangular cross section (ProTaper) more fracture resistant than asymmetrical triple helix (Revo-S). this may due to a cross-sectional design that distributes the torsional stress well (convex) possessing high flexibility with relatively low reaction stresses on bending would be more suitable for preparing the more severely curved canals.

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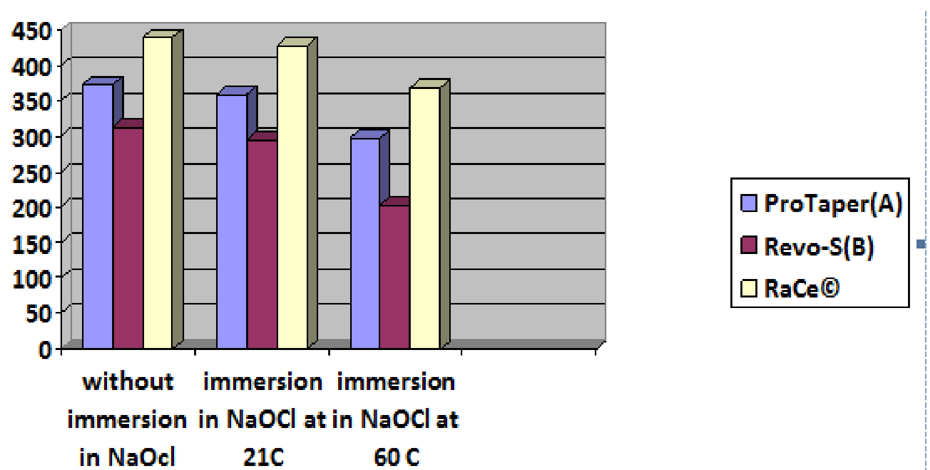

Figure 1: bar chart showing descriptive statistical analysis for the effect of temperature on the number of cycles to fracture for three types of rotary instrument.

Table 1: Descriptive statistical analysis for MCF for rotary instruments used without immersion, with immersion in NaOCl for 5 minute at(21 ℃ and 60 ℃) .

Group	Mini	Maxi	Mean	±SD
A1	329.17	420.83	372.54	30.35
A2	320.83	400.00	358.33	25.00
A3	250	345.83	297.91	31.80
B1	258.33	379.17	313.33	36.89
B2	250	341.66	295.83	35.40
B3	162.50	250.00	204.06	29.24
C1	370.83	483.33	439.16	40.45
C2	375.00	460.00	427.66	30.04
C3	329.33	404.17	369.59	27.33

Table 2: ANOVA for the MCF of three types of rotary instrument used without immersion and after immersion in NaOCl at (21 & 60) ℃

Groups	F	p-value	Degree of freedom	
ProTaper(A1,A2,A3)	18.438	.000	2	
Revo-S (B1, B2,B3)	29.747	.000	2	
RaCe (C1, C2,C3)	12.716	.000	2	

Table 3: Independent t-test showing the effect of temperature of NaOCl on mean of cycles to fracture.

Groups	t-test	p-value	Sig
A1&A2	1.143	.268	NS
A1&A3	5.368	.000	HS
A2&A3	4.722	.000	HS
B1&B2	1.082	.293	NS
B1&B3	7.340	.000	HS
B2&B3	6.319	.000	HS
C1&C2	.722	.480	NS
C1&C3	4.506	.000	HS
C2&C3	4.520	.000	HS

Table 4: ANOVA test for MCF among rotary instruments: Protraper (A), Revo-S (B) and Race (C) at different conditions.

Among three instruments	**F-value**	**P-value**	**df**
A1,B1,C1(without immersion in NaOCl)	30.338	.000	2
A2,B2,C2(immersion in NaOCl at 21℃)	46.903	.000	2
A3,B3,C3(immersion in NaOCl at 60 ℃)	46.903	.000	2

Table 5 : LSD showing the difference in MCF for three types of rotary instruments in different conditions.

	Variables	**Mean difference**	**p-value**	**Sig.**
Without immersion in NaOCl	A1-B1	59.21	.001	**HS**
	A1-C1	-66.61	.000	**HS**
	B1-C1	-125.83	.000	**HS**
Immersion in NaOCl at room temperature	A2-B2	62.49	.006	**HS**
	A2-C2	-69.66	.000	**HS**
	B2-C2	-131.83	.000	**HS**
Immersion in NaOCl at ℃ ٦٠	A3-B3	93.85	.000	**HS**
	A3-C3	-71.68	.000	**HS**
	B3-C3	-165.53	.000	**HS**