Atatürk Üniv Diş Hek Fak Derg (*J Dent Fac Atatürk Uni*)
Cilt:30, Sayı:4, Yıl: 2020, Sayfa: 594-8

Araştırma/ Research Article

EFFECTS OF SODIUM HYPOCHLORIDE ON CYCLIC FATIGUE RESISTANCE OF BIORACE ROTARY INSTRUMENT WITH DIFFERENT TIP SIZES

SODYUM HİPOKLORİTİN FARKLI BOYUTLARDAKİ BIORACE DÖNER ALETİNİN DÖNGÜSEL YORGUNLUK DİRENCİNE ETKİSİNİN DEĞERLENDİRİLMESİ

Dr. Öğr. Üyesi Ayfer ATAV ATEŞ* **Dr. Öğr. Üyesi Burçin ARICAN***

Makale Kodu/Article code: 4285
Makale Gönderilme tarihi: 23.01.2020
Kabul Tarihi: 13.08.2020
DOI : *10.17567/ataunidfd.780113*

Ayfer Atav Ateş: *ORCID ID:* 0000-0003-0270-8646
Burçin Arıcan: *ORCID ID:* 0000-0001-5757-0571

ABSTRACT

Aim: The aim of the present study was to determine the effect of sodium hypochloride solution on the cyclic fatigue resistance of BioRace (BR) NiTi instrument with different tip size.
Methods: Eighty BioRace instrument with two different size (BR4-35.04 and BR5-40.04) were used. These instruments were randomly divided into four group, each containing 20 files. The cyclic fatigue resistance were than tested in the following conditions; group 1, BR 4 with no immersion; group 2, BR 4 with dynamic immersion in 5.25% NaOCl at 37°C ± 1°C for 5 minute; group 3, BR 5 with no immersion; group 4, BR 5 with dynamic immersion in 5.25% NaOCl at 37°C ± 1°C for 5 minute. Then the instruments were used in stainless steel artificial root canal with a curvature of 60° and 5 mm radius. Number of cycle to failure (NCF) were measured for each group. The time to failure (TTF) in seconds were also recorded. Data were subjected to the statistical analysis.
Results: Nonimmersion groups were statistically superior to immersion groups (group1>group 2 and group 3>group4) both regarding TTF and NCF. However, no significant difference was found between instruments with different tip size regardless of the immersion procedure.
Conclusion: The cyclic fatigue resistance of BR instrument was affected by NaOCl immersion but not with tip size.
Keywords: BioRace, cyclic fatigue resistance, sodium hypochloride

ÖZ

Amaç: Bu çalışmanın amacı sodyum hipokloridin aynı taper değerine sahip ancak farklı uç boyutları olan BioRace (BR) döner alet sistemi eğelerinin döngüsel yorgunluğuna etkisini değerlendirmektir.
Gereç ve yöntem: Bu çalışmada toplam seksen adet BioRace (BR4-35.04 ve BR5-40.04) aleti kullanıldı. Eğeler, her bir grupta 20 adet olacak şekilde rastgele 4 gruba ayrılmıştır. Daha sonra aletlerin döngüsel yorgunluğu şu şekilde test edildi; Grup 1, BR 4 hiç bir solüsyonda bekletilmeden; Grup 2: BR 4 5 dakika boyunca %5,25 NaOCl solüsyonunda 37°C ± 1°C'de dinamik uygulama sonrası ; Grup 3: BR 5 hiç bir solüsyonda bekletilmeden; Grup 4: 5 dakika boyunca %5,25 NaOCl solüsyonunda 37°C ± 1°C'de dinamik uygulama sonrası 60° kurvatür açılı ve 5 mm kurvatür yarıçaplı paslanmaz çelik bloktan üretilmiş eğimli olukta test edildi. Her bir eğenin kırılana kadarki döngü sayısı (NCF) ölçüldü. Kırılana kadarki süresi (TTF) ise saniye cinsinden kaydedildi. Elde edilen veriler istatistiksel analizler ile değerlendirildi.
Bulgular: TTF ve NCF değerleri göz önüne alındığında sodyum hipokloritte bekletilmeyen gruplar bekletilen gruplardan daha dirençli bulundu. Bununla beraber, aletlerin uç boyutlarındaki farkın kırılma dirençleri üzerinde istatistiksel olarak anlamlı bir etkisinin olmadığı görüldü.
Sonuç: BioRace döner aletinin döngüsel yorgunluk direnci sodyum hipokloritten etkilenirken, farklı uç boyutlarının böyle bir etki yaratmadığı görüldü.
Anahtar Kelimeler: BioRace, döngüsel yorgunluk direnci, sodyum hipoklorit

* Department of Endodontics, Faculty of Dentistry, Istanbul Okan University, Istanbul, Turkey

Kaynakça Bilgisi Atav Ateş A, Arıcan B. Sodyum hipokloritin farklı boyutlardaki biorace döner aletinin döngüsel yorgunluk direncine etkisinin değerlendirilmesi**.** Atatürk Üniv Diş Hek Fak Derg 2020; 30: 594-8
Citation Information: *Atav Ates A, Arican B. Effects of sodium hypochloride on cyclic fatigue resistance of biorace rotary instrument with different tip sizes. J Dent Fac Atatürk Uni 2020; 30: 594-8.*

INTRODUCTION

One of the most fearful complication for the clinicians is the separation of endodontic instruments. Fracture of NiTi instruments can take place as a result of cyclic or tensional fatigue.[1,2] Cyclic fatigue failure occurs because of metal fatigue.[3] Repeated cycles of tension and compression of the metal, increase the cyclic fatigue of the instrument and cause failure of the instrument without any sign of previous deformation.[3,4] One potential factor that affect the resistance of the file may be the presence of sodium hypochlorite (NaOCl).[3,5,6]

Although NaOCl is the most commonly used and preferred irrigation solution in root canal treatments, it has some disadvantages such as bad odour, toxicity and corrosion effect.[3,7] NiTi instruments come into contact with this solution during irrigation and instrumentation procedures.[6,8] The corrosive effect of NaOCl cause microstructural defects which weaken the structure of the instruments and accordingly affect the fatigue resistance.[9] The affect of NaOCl on the cyclic fatigue resistance (CFR) of files were studied before but contradictory results were shown due to the test conditions.[3,5,10-12]

BioRace instruments (BR; FKG, La Chaux-de-Fonds, Switzerland) are manufactured from conventional austenite nickel titanium. This system includes six rotary instruments with various tapers of 0.02 to 0.08 and tip size #0.15 to #0.60.[13] The files have electropolished surfaces, safety tips, triangular cross-sections with alternating cutting edges.[14,15] Lopes et al. showed that the CFR of this instruments was significantly effected by electropolishing surface treatment.[16] However, there is not any study in the literature about the CFR of BioRace instrument that was treated with any irrigation solution. We aimed to evaluate the effects of sodium hypochloride immersion of cyclic fatigue resistance of BioRace NiTi instruments which had different tip size.

The null hypotheses were as follows;

1. The CFR of the file is not affected by different tip size
2. The CFR of the file is not affected by immersion in NaOCl solution.

MATERIAL AND METHODS

A total of 80 new 35.04 BR 4 and 40.04 BR 5 were selected and examined under 20 X magnification with a surgical microscope (Leica M320, Leica microsystems, Wetzlar, Germany) to determining the defects and deformities. None of the instruments were discarded.

The files were than divided randomly in 4 group (n; 20); group 1, BR 4 with no immersion; group 2, the working part of BR 4 (16mm) dynamically immersed in 5.25% NaOCl at 37°C ± 1°C for 5 minute; group 3, BR 5 with no immersion; group 4, the working part of BR 5 (16mm) dynamically immersed in 5.25% NaOCl at 37°C ± 1°C for 5 minute. For the dynamic immersion, the instruments were rotated freely at 600 rpm in a small glass container fulled with NaOCl solution. After the immersion procedures, the instruments were rinsed with 10 ml distilled water in order to neutralize the effect of the irrigation solution. Cyclic fatigue test was performed in artificial root canal with 1.5 mm wide and 3.0 mm depth, milled in stainless steel blocks with a curvature of 60° and 5 mm radius. The center of the curvature was 5 mm from the tip of the instrument and the curved segment of the canal was 5 mm in length. The artificial canal was covered with the glass. The block was fixed inside a cabinet that was filled with 37°C distilled water. The hand piece of the rotary motor (XSmart Plus, Dentsply Mailleffer) was fixed to the system and all instruments were rotated freely according to the manufacturer instructions at 600 rpm and 1 N/cm inside the canal until fracture occurred.

The time to failure in seconds (TTF) and the number of cycles to failure (NCF) was recorded both visually and audibly. All procedures were performed by a single operator. Shapiro-Wilk test was used to verify the assumption of normality of the data. The one-way analysis of variance and Tukey multiple comparison tests were then performed using NCSS™ 2007 Software (NCSS, Kaysville, UT) at the significance level of %5. The predicted cycles and time for 99% survival of the instruments were calculated by Weibull Analysis which were described by Nguyen et al.[17]

RESULTS

The mean and standart deviation of NCF and TTF was presented in Table 1 and Table 2.

The results as follows for the instruments;

1. Nonimmersion; Nonimmersion groups were statistically superior to immersion groups (group1 > group2 and group3 > group4) both regarding TTF and NCF. However there was no

statistically sinificant diference between nonimmersion groups (group 1 and group 3)

2. Immersion in NaOCl; there was no statistically significant difference between 35/.04 (group 2) and 40/.04 (group 4) both regarding TTF and NCF when they immersed in NaOCl solution.
3. Tip size; considering the TTF and NCF, no significant difference was found between instruments with different tip size regardless of the immersion procedure.

Weibull analysis was listed in Table 2 and Figure 1. According to the results, it was predicted that non immersion groups needed average 20 seconds and 200 rotations to failure in clinical conditions. On the other hand, the predicted cycles and time to %99 survival of the instruments were drastically reduced in NaOCl immersion groups.

Table 1. Comparison of Time to Fracture of Groups with Mean ± Standard Deviation
(Statistical level at P ≤ 0.05)

	No immersion	Immersion in NaOCl	*P* value
	Mean ±Sd	Mean ±Sd	
(BR 4)	Group 1: 34.95 (4.03)	Group 2: 28.71 (5.05)	0.000
(BR 5)	Group 3: 34.49 (4.33)	Group 4: 27.13 (2.98)	0.000
P value	0.741	0.263	

Table 2. TTF, NCF, Weibull modulus, predicted time and cycles for % 99 survival of the experimental groups

	TTF	NCF	Weibull Modulus	R2	Predicted cycles for % 99 survival	Predicted time (sec) for % 99 survival
Group 1	34,96	349,59	9,65	0,95	21,71	217,07
Group 2	28,71	287,09	6,41	0,95	14,00	140,00
Group 3	34,49	344,94	9,01	0,95	20,70	207,04
Group 4	27,14	271,36	10,18	0,99	17,27	172,68

Weibull calculations included Weibull modulus, coefficient of determination (R^2) , and predicted cycles for % 99 survival and time

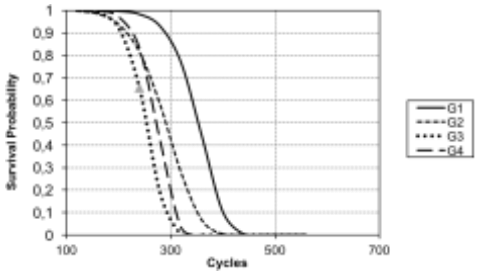

Figure 1. Survival probabilty of experimental groups

DISCUSSION

The purpose of the present study was to evaluate the effects of sodium hypochloride immersion of CFR of BioRace NiTi instruments with different tip size. The null hypotheses that immersion in NaOCl would not affect the CFR were rejected while the different tip sizes would not affect the CFR were accepted.

One of the main factor that affect the CFR of rotary instruments is the angle of the curvature of the root canal.[18] Although there is not any certain method for the studies on CFR of endodontic instruments, artificial root canals have been widely used instead of extracted human teeth. For this purpose, 45°, 60°, 75°, and 90° curved canals of 5-mm radius were used in prior studies.[5,11,19,20] We used artificial root canals with 60° curvature and 5-mm radius which are mostly used dimensions in these kind of studies.[2,3,21,22]

Although NiTi instruments are used in root canals at body temperature in clinical conditions, some studies tested the CFR of NiTi instruments at room temperatures.[23,24] However, NiTi instruments may have different behaviours at different temperatures. [10] Jamleh et al. showed that surrounding temperature had influence on the CFR of the instruments.[25] Concordantly, it was reported in several studies that the instruments are more resistant to cyclic fatigue at low surrounding temperatures. [10,12,22] From this point of view, to mimic the clinical conditions, the block was fixed inside a cabinet that was filled with 37°C distilled water. By this way, we aimed to perform the experiment at body temperature. On the other hand, in the present study a closed system was created. To prevent instrument slippage, the artificial canal was covered with a glass. This method was used in several studies before. [22,26]

The cross sectional design, speed and rotation type, immersion in irrigation solutions, thermo-mechanical surface treatment, type of alloy, manufacturing process of NiTi instruments are the possible factors that may affect its CFR.[11,12,19,22] Plotino et al. compared the CFR of Vortex Blue and Profile Vortex with different tip and taper size and could not found any significant difference between the instruments only with small sized tip and taper. They explained this fact with the higher flexibility of the smaller instruments. The mean NCF of 40/.04 of these two rotary instruments were reported as higher than 30/.06 but lower than 35/.06. [27] In our study, we compared the CFR of the BioRace 35/ .04 and 40/ .04

and concluded that instrument was not affected by the different tip size. The main reason could be the slightly less taper of the BR instrument.

Conflicting results about the effect of irrigation solutions on the CFR of NiTi instruments have been stated in previous studies.[3,5,6,10,28] Immersion time [5,28] static or dynamic immersion type[3], concentration and heat of the irrigation solution [6,20,29], test mechanism[16,22], manufacturing process of the tested instruments[27] could cause these differences. Alfawaz et al. tested the CFR of Protaper Gold which was immersed in either NaOCl solution or distilled water at various temperature conditions. They reported that sodium hypochloride solution and high surronding temperature reduced the fatigue resistance.[10] Keleş et al evaluated the CFR of several NiTi instruments which were immersed in NaOCL solution with different surronding temperatures and reported that high temperature of sodum hypochloride solution reduce the fatigue resistance.[30] Beside this, Pedulla et al. immersed only the working part of Twisted file, Revo S and Mtwo files, size 25./06, statically or dynamically in NaOCl solution at 37°C for 1 minute or 5 minute and did not find any reduce in the CFR of the instruments. They attributed this result to the type of analysis.[3] Darabara et al. immersed both stainless steel and NiTi instruments statically in NaOCl for 1 hour and found no corrosion sign. However, this study did not reflect clinical conditions in terms of duration of use and immersion method.[28] To mimic clinical conditions, the instrument dynamically immersed in sodium hypochloride solution and 5 minute contact time with solution was selected to push the limits of the instrument in our study. In order to avoid galvanic corrosion phenomena, only the 16 mm working part of the instruments were immersed in NaOCl.[31] In this experimental conditions, dynamic immerison in NaOCl for 5 minute significantly reduced the CFR of the files with different tip sizes. These result may be the because of alloy type and immersion style.

CONCLUSION

Under the limitation of this study, the immersion in sodium hypochloride solution decreased the CFR of the instrument. The CFR of BR instrument was affected by NaOCl immersion but not with tip size.

Acknowledgements
The authors declare that there were no other contributors involved in this work.
Conflicts of interest statement
The authors declare no conflict of interest.

REFERENCES

1. Sattapan B, Nervo GJ, Palamara JEA, Messer HH. Defects in rotary nickel–titanium files after clinical use. J Endod 2000;26:161–5.
2. Pruett JP, Clement DJ, Carnes DL. Cyclic fatigue testing of nickel titanium instruments. J Endod 1997;23:77–85.
3. Pedulla E, Grande NM, Plotino G, et al. Cyclic fatigue resistance of three different nickel titanium instruments after immersion in sodium hypochlorite. J Endod 2011;37:1139–42.
4. Parashos P, Gordon I, Messer HH. Factors influencing defects of rotary nickel titanium endodontic instruments after clinical use. J Endod 2004;30:722–5.
5. Elnaghy AM, Elsaka SE. Effect of sodium hypochlorite and saline on cyclic fatigue resistance of WaveOne Gold and Reciproc reciprocating instruments. Int Endod J 2017;50:991-8.
6. Peters OA, Roehlike JO, Baumann MA. Effect of immersion in sodium hypochlorite on torque and fatigue resistance of nickel-titanium instruments. J Endod 2007;33: 589–93.
7. White RR, Hays GL, Janer LR. Residual antimicrobial activity after canal irrigation with chlorhexidine. J Endod 1997;23:229–31.
8. Bystrom A, Sundqvist G. Bacteriologic evaluation of the effect of 0.5 percent sodium hypochlorite in endodontic therapy. Oral Surg Oral Med Oral Pathol 1983;55:307–12.
9. Oshida Y, Sachdeva RC, Miyazaki S. Microanalytical characterization and surface modification of TiNi orthodontic archwires. BioMed Mater Eng 1992;2:51–69.
10. Alfawaz H, Alqedairi A, Alsharekh H, Almuzaini E, Alzahrani S, and Jamleh A. Effects of sodium hypochlorite concentration and temperature on the cyclic fatigue resistance of heat-treated nickel-titanium rotary ınstruments. J Endod. 2018;44(10):1563-6.
11. Saber SMS, Seeda MMA, Hassanien E. The effect of instrument material, taper and degree of root canal curvature on cyclic fatigue of rotary nickel-titanium instruments. ENDO (Lond Engl) 2013;7:59–64.
12. Plotino G, Grande NM, Cordaro M, et al. Influence of the shape of artificial canals on the fatigue resistance of NiTi rotary instruments. Int Endod J 2010;43:69–75.

13. Available at: (https://www.fkg.ch/sites /default/ files/fkg_br_brochure_an_lowr.pdf). Accessed December 19, 2019
14. Lopes HP, Elias CN, Vieira VT, et al. Effects of electropolishing surface treatment on the cyclic fatigue resistance of BioRace nickel-titanium rotary instruments. J Endod 2010;36:1653–7.
15. Freire LG, Gavini G, Branco-Barletta F, Sanches-Cunha R, dos Santos M. Microscopic computerized tomographic evaluation of root canal transportation prepared with twisted or ground nickel-titanium rotary instruments. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011:112;143-8.
16. Lopes HP, Elias CN, Vieira VT, Edson MJ, Raquel MV, Julio de Olimeria CM, Gilberto D, Jóse S. Effects of electropolishing surface treatment on the cyclic fatigue resistance of biorace nickel-titanium rotary ınstruments. J Endod 2010; 36: 1653-7.
17. Nguyen HN, Fong H, Paranjpe A, Flake NM, James JDOve PA. Evaluation of the resistance to cyclic fatigue among ProTaper Next, ProTaper Universal, and Vortex Blue rotary instruments. J Endod 2014;40:1190–3.
18. Adıgüzel M, Tüfenkçi P. Comparison of the cyclic fatigue resistance of Waveone, Reciproc and Twısted File adaptive files in canals with a double curvature (s-shaped) J Dent Fac Atatürk Üni 2018;28;199-203.
19. Kim HC, Kwak SW, Shun-Pan Cheung G, Ko DH, Chung S, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium ınstruments used in reciprocation motion: Reciproc Versus WaveOne. J Endod 2012; 38:541-4.
20. Palma PJ, Messias A, Cerqueira AR, Taveres LD, Caramelo F, Roseiro L, Santos JM. Cyclic fatigue resistance of three rotary file systems in a dynamic model after immersion in sodium hypochlorite. Odontology 2019;107:324-32.
21. Özyürek T, Yılmaz K, Uslu G. The effects of autoclave sterilization on the cyclic fatigue resistance of ProTaper Universal, ProTaper Next, and ProTaper Gold nickel-titanium instruments. Restor Dent Endod 2017;42:301–8.
22. Elnaghy AM, Elsaka SE. Mechanical properties of ProTaper Gold nickel-titanium rotary instruments. Int Endod J 2016;49:1073–8.
23. Tobushi H, Hachisuka T, Yamada S, Lin P-H. Rotating-bending fatigue of a TiNi shape-memory alloy wire. Mech Mater 1997;26:35–42.
24. Pereira ES, Gomes RO, Leroy AM, et al. Mechanical behavior of M-Wire and conventional NiTi wire used to manufacture rotary endodontic instruments. Dent Mater 2013;29:318–24.
25. Jamleh A, Yahata Y, Ebihara A, et al. Performance of NiTi endodontic instrument under different temperatures. Odontology 2016;104:324–8.
26. Lee MH, Versluis A, Kim BM, Lee CJ, Hur B, Kim HC. Correlation between experimental cyclic fatigue resistance and numerical stress analysis for nickel-titanium rotary files. J Endod 2011;37:1152–7.
27. Plotino G, Grande NM, Cotti E, et al. Blue treatment enhances cyclic fatigue resis tance of vortex nickel-titanium rotary files. J Endod 2014;40:1451–3.
28. Darabara M, Bourithis L, Zinelis S, Papadimitriou GD. Susceptibility to localized corrosion of stainless steel and NiTi endodontic instruments in irrigating solutions. Int Endod J 2004;37:705–10.
29. Berutti E, Angelici E, Rigolone M, Migliaretti G, Pasqualini D. Influence of sodium hypochlorite on fracture properties and corrosion of ProTaper rotary instruments. Int Endod J 2006;39:693–9.
30. Keleş A, Uzunoğlu-Özyürek E,Uyanık MO, Nagas E. Effect of temperature of sodium hypochlorite on cyclic fatigue resistance of heat-treated reciprocating files. J Endod 2019;45:205-8.
31. Angelini E, Zucchi F, Caputo A. Degradation processes on metallic surfaces. In: Barbucci R, ed. Integrated biomaterial science. Dordrecht: Kluwer Academic– Plenum Publishers; 2002: 308–23.

Sorumlu Yazarın Yazışma Adresi
Dr. Öğr. Üyesi Ayfer ATAV ATEŞ,
Istanbul Okan University, Faculty of Dentistry, Department of Endodontics,
Necmettin Erbakan St., No:2, Tuzla/Istanbul, Turkey
Phone: +905553844100
e-mail: ayfer.atav@okan.edu.tr