EDITORIAL

Torsional Behavior of Nickel-titanium Rotary Instruments: What's New?

Federico V Obino[1], Maurilio D'Angelo[2], Franco M Di Russo[3], Andrea Cicconetti[4], Alberto De Biase[5], Shilpa Bhandi[6], Shankargouda Patil[7]

World Journal of Dentistry (2022): 10.5005/jp-journals-10015-1921

As demonstrated by several studies, the two main causes of intracanal separation are undoubtedly the cyclic fatigue and the torsional stress to which the endodontic rotary instruments are subjected during the shaping of root canal system.[1,2] The first one occurs when the instrument rotates in a canal curvature, undergoing to repetitive tensile and compressive stresses accumulated at the point of maximum curvature.[3] Instead, the second one is a direct consequence of the blocking of a part of the instrument in the dentinal walls whilst the coronal part continues to rotate.[4] This leads to a ductile fracture of the instrument due to an exceeding of its elastic limit.

Data in the literature and more recent studies reveal as the percentage of intracanal failure of nickel-titanium (Ni-Ti) rotary instruments ranges from 1,3 to 10,0% with a decrease of the percentage of endodontic treatment ranging from 19 to 53%.[5,6] In order to reduce this inconvenience, manufacturers and researchers have focused on the factors directly involved in the determination of the cyclic fatigue and torsional resistance. Despite the most significant parameters affecting cyclic fatigue resistance have been thoroughly determined several years ago, those regarding the torsional resistance have been deeply discussed and it seems that only recently the topic has been clarified.[7,8]

According to recent published studies, the factors related to the endodontic instruments directly involved in the torsional resistance determination can be divided in longitudinal parameters, cross-sectional parameters, alloy-related parameters, and the parameters of use of the instrument.

The longitudinal parameters have been demonstrated to be the pitch, the helix angle, the taper, the number of threads, and the length of the instrument. Increasing the taper, the number of threads and the length of the instruments the torsional resistance increases, whilst it has been demonstrated that an increase of the pitch leads to a deduction of the stiffness of the instrument.[9,10]

Regarding the cross-sectional parameters of endodontic rotary instruments, recently Zanza et al. demonstrated the significant role of polar moment of inertia above the other parameters such as metal mass, inner core area, volume, and diameter in determining their torsional resistance.[11] In that study, the authors stated that the metal mass and the volume of an instrument are not so important in terms of absolute value but more for their distribution in relation to the center of rotation of the instrument. In other words, the more the mass and the volume are concentrated far from the pivot center, the more the polar moment of inertia is greater and the more the torsional resistance is higher.[11] Moreover, the results of that research are consistent with other research that demonstrated the importance of the cross-sectional design in terms of torsional behavior of endodontic rotary instruments.[9,12]

Another aspect that influences the torsional behavior of Ni-Ti rotary instruments is the alloy.[13] In the last decades, different heat treatments have been developed in order to obtain more flexible instruments, more resistant to cyclic fatigue. This improvement, however, reduces their stiffness. Actually, the data in the literature are not consistent since different studies found out that martensitic instruments tested are comparable to austenitic instruments in terms of torsional resistance, even if the latter are stiffer.[8,14,15] Undoubtedly, further studies are needed in order to clarify the relationship between the alloy and the torsional resistance, especially regarding the austenite and the martensite.

The last group of factors directly related to the determination of the torsional resistance are those regarding the use of the instruments. It has been demonstrated that increasing the rotational speed the torque generated during canal shaping decreases.[16] This is due to the fact that an increased speed increases the cutting efficiency of an instrument, facilitating the overcome of the friction force represented by the dentinal walls.[17] However, this phenomenon is related to the dynamic behavior of the instrument and it does not depend on its intrinsic torsional resistance but on a generation of torque. Another important factor affecting the torsional resistance of Ni-Ti instrument is the type of motion

[1,2,4,5]Department of Oral and Maxillofacial Sciences, Sapienza, University of Rome, Rome, Italy

[3]Department of Mechanical and Aerospace Engineering, Sapienza, University of Rome, Rome, Italy

[6]Department of Restorative Dental Sciences, Division of Operative Dentistry, College of Dentistry, Jazan University, Jazan, Saudi Arabia

[7]Department of Maxillofacial Surgery and Diagnostic Sciences, Division of Oral Pathology, College of Dentistry, Jazan University, Jazan, Saudi Arabia

Corresponding Author: Maurilio D'Angelo, Department of Oral and Maxillofacial Sciences, Sapienza, University of Rome, Rome, Italy, Phone: 3473261393, e-mail: maurilio.dangelo@uniroma1.it

How to cite this article: Obino FV, D'Angelo M, Di Russo FM, *et al.* Torsional Behavior of Nickel-titanium Rotary Instruments: What's New? World J Dent 2022;13(4):305–306.

Source of support: Nil

Conflict of interest: None

used. Several studies demonstrated that the reciprocation, with its counter clockwise and clockwise movements, reduce the possibility of taper lock, leading to a lower solicitation of the instrument due to torsional stresses.[18]

In order to better understand the torsional behavior of Ni-Ti rotary instruments further studies are requested, particularly regarding the relationship between the alloy and the torsional resistance and the dynamic behavior during the cutting procedures.

References

1. Sattapan B, Nervo GJ, Palamara JE, et al. Defects in rotary nickel-titanium files after clinical use. J Endod 2000;26(3):161–165. DOI: 10.1097/00004770-200003000-00008
2. Gambarini G, Miccoli G, Seracchiani M, et al. Role of the flat-designed surface in improving the cyclic fatigue resistance of endodontic NiTi rotary instruments Materials (Basel) 2019;12(16):2523. DOI: 10.3390/ma12162523. PMID: 31398814; PMCID: PMC6720207.
3. Di Nardo D, Gambarini G, Seracchiani M, et al. Influence of different cross-section on cyclic fatigue resistance of two nickel-titanium rotary instruments with same heat treatment: an in vitro study. Saudi Endod J 2020;10(3):221–225. DOI: 10.4103/sej.sej_124_19
4. Sattapan B, Palamara JE, Messer HH. Torque during canal instrumentation using rotary nickel-titanium files. J Endod 2000;26(3):156–160. DOI: 10.1097/00004770-200003000-00007
5. Shen Y, Winestock E, Cheung GS, et al. Defects in nickel-titanium instruments after clinical use. Part 4: an electropolished instrument. J Endod 2009;35(2):197–201. DOI: 10.1016/j.joen.2008.11.012
6. Feghali M, Xhajanka E, Di Nardo D, et al. Incidence of different types of intracanal fracture of nickel-titanium rotary instruments: a systematic review. J Contemp Dent Pract 2021;22(4):427–434. DOI: 10.5005/jp-journals-10024-3015
7. Grande NM, Plotino G, Pecci R, et al. Cyclic fatigue resistance and three-dimensional analysis of instruments from two nickel-titanium rotary systems. Int Endod J 2006;39(10):755–763. DOI: 10.1111/j.1365-2591.2006.01143.x
8. Zupanc J, Vahdat-Pajouh N, Schäfer E. New thermomechanically treated NiTi alloys - a review. Int Endod J 2018;51(10):1088–1103. DOI: 10.1111/iej.12924
9. Baek SH, Lee CJ, Versluis A, et al. Comparison of torsional stiffness of nickel-titanium rotary files with different geometric characteristics. J Endod 2011;37(9):1283–1286. DOI: 10.1016/j.joen.2011.05.032
10. Gambarini G, Seracchiani M, Zanza A, et al. Influence of shaft length on torsional behavior of endodontic nickel-titanium instruments. Odontology 2021;109(3):568–573. DOI: 10.1007/s10266-020-00572-2
11. Zanza A, Seracchiani M, Di Nardo D, et al. A paradigm shift for torsional stiffness of nickel-titanium rotary instruments: a finite element analysis. J Endod 2021;47(7):1149–1156. DOI: 10.1016/j.joen.2021.04.017
12. Berutti E, Chiandussi G, Gaviglio I, et al. Comparative analysis of torsional and bending stresses in two mathematical models of nickel-titanium rotary instruments: ProTaper versus ProFile. J Endod 2003;29(1):15–19. DOI: 10.1097/00004770-200301000-00005
13. Gambarini G, Cicconetti A, Nardo DD, et al. Influence of different heat treatments on torsional and cyclic fatigue resistance of nickel-titanium rotary files: a comparative study. Appl Sci 2020;10(16):5604 DOI: 10.3390/app10165604
14. Di Nardo D, Zanza A, Seracchiani M, et al. Angle of insertion and torsional resistance of nickel–titanium rotary instruments. Materials 2021;14(13):3744. DOI: 10.3390/ma14133744
15. Zanza A, Seracchiani M, Reda R, et al. Role of the crystallographic phase of NiTi rotary instruments in determining their torsional resistance during different bending conditions. Materials (Basel) 2021;14(21):6324. DOI: 10.3390/ma14216324. PMID: 34771850; PMCID: PMC8585440.
16. Bardsley S, Peters CI, Peters OA. The effect of three rotational speed settings on torque and apical force with vortex rotary instruments in vitro. J Endod 2011;37(6):860–864. DOI: 10.1016/j.joen.2011.01.022
17. Gambarini G, Galli M, Cicconetti A, et al. Operative torque analysis to evaluate cutting efficiency of two nickel-titanium rotary instruments for glide path: an in vitro comparison. J Contemp Dent Pract 2021;22(3):215–218. DOI: 10.5005/jp-journals-10024-3061
18. Çapar ID, Arslan H. A review of instrumentation kinematics of engine-driven nickel-titanium instruments. Int Endod J 2016;49(2):119–135. DOI: 10.1111/iej.12432