EDITORIAL

Mechanism of Fracture of Nickel–Titanium Rotary Instruments

Luca Testarelli[1], Alessio Zanza[2], Alessandro Mazzoni[3], Maurilio D'Angelo[4], Shilpa Bhandi[5], Gianluca Gambarini[6]

World Journal of Dentistry (2020): 10.5005/jp-journals-10015-1757

In the last 30 years, the introduction of Nickel–Titanium rotary (NTR) instruments in the endodontics daily practice completely modified the approach and the shaping procedure of the root canal treatment.[1,2] Indeed, NTR can produce a more tapered shaping allowing the irrigants to better flow in the apical part of the root canal system, which is known to be the most challenging to proper shape.[3]

Despite these improvements, NTRs have a major drawback: the increased risk of intracanal separation that add another iatrogenic error to the multitude of risks that could occur during a root canal treatment and could require surgical solution.[4,5] This issue slowed down the spread of NTR worldwide, although the manufacturer in the last years improved the alloy through proprietary heat treatment able to improve both torsional and flexural resistance of nickel–titanium instruments. Torsional and flexural resistance are two of the main cause related to instrument failure.[6] The torsional fracture occurs when the tip or another apical part of the instrument binds inside the root canal space, while the coronal part of the instrument continues to rotate.[7] This kind of fracture is easily reproduced in the torsional resistance test, which simulates the torsional overloading of the instrument by blocking the apical 3 mm of the NTR files during rotation. The flexural, cyclic fatigue, and fracture occurs when the instrument rotate inside a curvature in a root canal. This leads to repetitive tensile and compressive stresses accumulated to the point of maximum curvature. More precisely, the outer part of the instrument is subjected to tensile forces, while the inner part of the instrument to compressive forces.[3,8]

The abovementioned fracture have a peculiar pattern that can be easily highlighted by the use of scanning electron microscope:

All instruments fractured for torsional resistance overload show shear failure with centrifuge abrasion marks and microscopic dimples at the center of rotation. These are the clear microscopic sings of the fractographic patterns of torsional fracture.

All instruments fractured for cyclic fatigue resistance overload show the presence of crack initiation areas and overload on the outer surface of the instrument, with a centripetal direction of these cracks. These are the clear microscopic sings of the fractographic patterns of cyclic fatigue fracture.

These kinds of fracture pattern are the most studied because they are easily visible after the most common testing methods.[9] Despite that, in clinical practice, instruments could separate for the interaction of the torsional and flexural stresses.[10] This kind of event lead to a fracture pattern that cannot be easily recognized as one of the abovementioned. Indeed, this separation due to both torsional and flexural stresses show both sign of failure with centrifuge abrasion marks and presence of crack initiation areas.

In conclusion, although fracture pattern of NTR files have been deeply studied for both flexural and torsional stresses *in vitro*, more studies are needed and welcomed to better determine the pattern of fracture consequent to the combination the two abovementioned stresses that usually occur in clinical situation.

[1–4,6]Department of Oral and Maxillo-Facial Sciences, Sapienza University of Rome, Rome, Italy

[5]Department of Restorative Dental Sciences, Jazan University, Jazan, Kingdom of Saudi Arabia

Corresponding Author: Luca Testarelli, Department of Oral and Maxillo-Facial Sciences, Sapienza University of Rome, Rome, Italy, Phone: +39 3381504134, e-mail: luca.testarelli@uniroma1.it

How to cite this article: Testarelli L, Zanza A, Mazzoni A, *et al.* Mechanism of Fracture of Nickel–Titanium Rotary Instruments. World J Dent 2020;11(5):345.

Source of support: Nil

Conflict of interest: None

References

1. Gambarini G, Galli M, Seracchiani M, et al. In vivo evaluation of operative torque generated by two nickel-titanium rotary instruments during root canal preparation. Eur J Dent 2019;13(4): 556–562. DOI: 10.1055/s-0039-1698369.
2. Gambarini G, Galli M, Di Nardo D, et al. Differences in cyclic fatigue lifespan between two different heat treated NiTi endodontic rotary instruments: WaveOne gold vs EdgeOne fire. J Clin Exp Dent 2019;11(7):e609–e613. DOI: 10.4317/jced.55839.
3. Giansiracusa Rubini A, Plotino G, Al-Sudani D, et al. A new device to test cutting efficiency of mechanical endodontic instruments. Med Sci Monit 2014;20:374–378. DOI: 10.12659/MSM.890119.
4. Gambarini G, Plotino G, Grande NM, et al. Differential diagnosis of endodontic-related inferior alveolar nerve paraesthesia with cone beam computed tomography: a case report. Int Endod J 2011;44(2):176–181. DOI: 10.1111/j.1365-2591.2010.01816.x.
5. Gambarini G, Galli M, Stefanelli LV, et al. Endodontic microsurgery using dynamic navigation system: a case report. J Endod 2019;45(11):1397–1402. DOI: 10.1016/j.joen.2019.07.010.
6. Di Nardo D, Galli M, Morese A, et al. A comparative study of mechanical resistance of two reciprocating files. J Clin Exp Dent 2019;11(3):e231–e235. DOI: 10.4317/jced.55487.
7. Miccoli G, Gaimari G, Seracchiani M, et al. In vitro resistance to fracture of two nickel-titanium rotary instruments made with different thermal treatments. Ann Stomatol (Roma) 2017;8(2):53–58. DOI: 10.11138/ads/2017.8.2.059.
8. Gambarini G, Miccoli G, Seracchiani M, et al. Fatigue resistance of new and used nickel-titanium rotary instruments: a comparative study. Clin Ter 2018;169(3):e96–e101. DOI: 10.7417/T.2018.2061.
9. 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.
10. Gambarini G, Seracchiani M, Piasecki L, et al. Measurement of torque generated during intracanal instrumentation in vivo. Int Endod J 2019;52(5):737–745. DOI: 10.1111/iej.13042.