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. 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.

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. 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. 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. 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.

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. Despite that, in clinical practice, instruments could separate for the interaction of the torsional and flexural stresses. 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 of the two abovementioned stresses that usually occur in clinical situation.

### References