Cyclic Fatigue of Glide Path Rotary NiTi Files in a Double (S-Shaped) Simulated Curvature

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Introduction

One of the main goals of the manufacturers of Nickel-Titanium (NiTi) rotary instruments is to reduce the likelihood of instrument separation and improve safety through innovative design and manufacturing processes [1,2]. Cyclic fatigue and torsional fracture are the two main mechanisms that may lead to instrument separation, mainly caused by bending and torsional stress [3]. Canal curvature is the predominant risk factor for increased bending stress and a clinician may have no influence on this parameter [4]. One of the recommendations to reduce fracture risk of NiTi instruments is to create a glide path during the initial preparation [5]. The endodontic glide path, which has been described as having sufficient patency from the canal orifice to the apical foramen, is performed using small-sized and slightly tapered NiTi rotary instruments or stainless-steel manual files [5]. The creation of a glide path may facilitate root canal preparation when NiTi instruments with larger tapers are used and reduce the incidence of procedural errors [6,7].

Recently, considerable focus was given to NiTi rotary instruments designed for glide path preparation. PathFile (Dentsply-Maillefer, Ballaigues, Switzerland) is an endodontic rotary pathfinding system consisting of 3 instruments of different tip size and same .02 constant taper manufactured from conventional NiTi with a four cutting edges square cross-section [7]. ProGlider (Dentsply-Maillefer, Ballaigues, Switzerland) is a novel single-file rotary pathfinding instrument manufactured from heat-treated M-wire alloy with a progressive taper manufactured from conventional NiTi with a four cutting edges square cross-section [7].

The fracture resistance of pathfinding instruments is just as important as that of instruments used to shape the root canals [8]. Consequently, endodontic instruments used for the negotiation of narrow and curved root canals should have mechanical properties that allow for safe apical progression and efficient performance [9-11]. The aim of the present study was to compare the cyclic fatigue resistance of PathFile (PF) and ProGlider (PG) NiTi (Nickel-Titanium) rotary files in a double (S-shaped) curvature artificial root canal.

Materials and Methods

The cyclic fatigue resistance of the following rotary NiTi pathfinding instruments was tested in a double curvature artificial canal, PF (tip size .16 and .02 taper) and PG (tip size .16 and variable taper). Twenty instruments for each group were tested to fracture in continuous rotary motion at 300 rpm. The number of cycles to failure (NCF) was calculated and the length of the fractured fragment was measured. Data were statistically analyzed with a level of significance set at 5%.

Results: There was no significant difference in cyclic fatigue resistance between the PF and the PG in the apical curvature (p>0.05). However, in the coronal curvature the NCF value was significantly higher for the PF than for the PG (p<0.05). The NCF values were significantly lower (p<0.05) in the apical curvature of the artificial canal than in the coronal curvature for both instruments. No differences in the length of the fractured fragments were found (p>0.05).

Conclusion: The instruments were found to be less resistant to cyclic fatigue in the apical curvature of the artificial canal than in the coronal curvature. PG instrument showed significantly greater cyclic fatigue resistance in the coronal curvature.
Table 1: Mean (SD) of NCF and Fragment Length (FL) in mm registered during Cyclic Fatigue Testing in the Double (S-shaped) curvature.

| Instrument size | Double Curvature | Apical curve | NCF (SD) | FL (SD) | Coronal curve | NCF (SD) | FL (SD) |
|-----------------|------------------|--------------|----------|---------|---------------|----------|---------|
| ProGlider 16/.04|                  |              | 231.1 (32.9) | 1.6 (0.25) | 1120 (49.9) | 4.3 (0.25) |
| PathFile 16/.02 |                  |              | 252.5 (82.9) | 1.7 (0.25) | 696 (104.1) | 4.6 (0.21) |

The results of the present study showed that there was no significant difference between PG and PF instruments in the most complex apical curvature. However, PG instruments had significantly greater resistance to cyclic fatigue in the coronal curvature than PF, despite its progressive taper, which is from 2% to 8% over its length. Alternatively, the fixed .02 taper of the PF file results in an instrument with a smaller metal core that usually leads to an enhanced cyclic fatigue resistance [4]. This could be attributed to the different manufacturing processes used for the instruments tested, thus confirming the results of several previous studies that compared M-Wire NiTi instruments with traditional NiTi rotary instruments and found that M-Wire improves resistance to fracture caused by cyclic fatigue stress [7,10,16-18]. In fact, these studies showed that the fatigue life of rotary instruments is extremely sensitive to the raw materials used in the manufacturing process. A study, reported that PG NiTi pathfinding instruments made of M-Wire alloy had enhanced mechanical properties, including higher flexibility and higher resistance to cyclic fatigue and torsional stress, than PF instrument made of conventional NiTi alloy [7,19]. However, the PF instrument manufactured from conventional NiTi also showed superior cyclic fatigue resistance in the apical curvature, this result is in accordance with the recent study by Capar et al. in which they attributed their results to the instrument design [7]. In the present study, despite the different manufacturing processes used for the instruments, both instruments have a square cross section. Under the experimental conditions and the limitations of the present study, the instruments were found to be less resistant to cyclic fatigue in the apical curvature of the double (S-shaped) artificial canal than in the coronal curvature. PG instrument showed significantly greater cyclic fatigue resistance than PF in the coronal curvature, while no significant difference was found in the apical curvature.

Conclusion

The results of the present study showed that there was no significant difference between PG and PF instruments in the most complex apical curvature. The instruments were found to be less resistant to cyclic fatigue in the apical curvature of the artificial canal than in the coronal curvature. PG instrument showed significantly greater cyclic fatigue resistance in the coronal curvature.
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