

Comparative Analysis of Cyclic Fatigue Resistance of NeoEndo Flex Vs Protaper Gold Rotary Files: An In-Vitro Study

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Abstract

Background: During the endodontic process, cleaning and shaping are essential steps. The fracture of nickel-titanium (NiTi) tools is a procedural issue that significantly impedes therapy in normal endodontic therapy. Efficient and reliable endodontic therapy requires rotary NiTi files that demonstrate superior cyclic fatigue resistance to prevent file separation within the canal. This study aimed to investigate the in-vitro cyclic fatigue resistance of two commonly used rotary NiTi files: NeoEndo Flex file and ProTaper Gold file.

Methods: The cyclic fatigue tests were carried out by determining the lifespan of each file type in a controlled environment mimicking a curved root canal. A total of 30 files (15 NeoEndo Flex and 15 ProTaper Gold) were subjected to continuous rotation until fracture occurred. The numbers of cycles until failure (NCF) were recorded for statistical comparison.

Results: The ProTaper Gold files showed significantly higher NCF, indicative of stronger cyclic fatigue resistance when compared to NeoEndo Flex files ($p < 0.05$). The variance in fatigue resistance is attributable, in part, to differences in alloy composition and proprietary heat treatment processes.

Conclusion: ProTaper Gold rotary NiTi files exhibited enhanced cyclic fatigue resistance in comparison to NeoEndo Flex, suggesting that they may be the preferred choice for clinical procedures where greater stresses are anticipated on the file. However, clinicians should balance file strength with other clinical factors when choosing the appropriate file for endodontic treatment.

Keywords: Cyclic fatigue, Rotary NiTi files, NeoEndo Flex, ProTaper Gold

Introduction

Endodontic therapy centers around the removal of infected tissue, shaping, cleaning, and obturation of the root canal system.¹ The shaping process is critical and is aided by the advent of rotary nickel-titanium (NiTi) files.²⁻⁴ These files have revolutionized endodontics by drastically improving the efficiency and quality of canal preparation.⁵⁻⁷ However, their susceptibility to cyclic fatigue – the stress generated from rotating inside the curvature of a canal leading to eventual fracture – remains a matter of concern for practitioners.⁸ The cyclic fatigue resistance of a NiTi file is a pivotal property influencing its clinical reliability.⁵ Even as manufacturers innovate to produce more resilient files, the dynamic environment of the root canal system remains a challenge with varying anatomical intricacies.⁹⁻¹⁰ NeoEndo Flex and ProTaper Gold represent two commercially available rotary NiTi file systems with different manufacturing philosophies designed to enhance cyclic fatigue resistance.¹¹⁻¹⁴

NeoEndo Flex files employ a thermal treatment process, which is speculated to develop a more flexible file that can better withstand the stresses encountered in narrow and curved canals. On the other hand, ProTaper Gold builds upon the legacy of the ProTaper family by incorporating a novel gold finishing process that asserts to offer a balance between strength and flexibility, thereby potentially extending the file's functional lifespan.^{11,12,14}

The objective of this research is a detailed in-vitro assessment of the cyclic fatigue resistance of NeoEndo Flex and ProTaper Gold rotary NiTi files. In-vitro testing facilitates the replication of consistent and controlled conditions that may not be readily achievable in live clinical scenarios. Specifically, we examine whether the proprietary technologies applied in NeoEndo Flex and ProTaper Gold files result in a measurable difference in their endurance when subjected to stresses mimicking clinical situations.

This study will adopt a rigorous methodological approach to quantify the number of cycles to failure (NCF) – an operational definition of cyclic fatigue resistance in which the file is subject to rotational motion until fracture. The NCF measurement provides a comparative benchmark and a direct indicator of the expected clinical performance of each file system.^{16,17}

The significant contribution of this evaluation lies in its potential to direct clinical decision-making. Selecting files with superior cyclic fatigue resistance can minimize the risk of file separation in the canal, reduce the overall cost by prolonging file lifespan, and potentially lead to better clinical outcomes. Hence, our investigation is expected to yield critical insights that could influence the choice of NiTi rotary systems for endodontic therapy.^{18,19}

As a prerequisite, we propose the null hypothesis that no significant difference exists in the cyclic fatigue resistance between the NeoEndo Flex and ProTaper Gold NiTi file systems. This study will thus focus on either confirming or rejecting this hypothesis based on empirical data, aiming to provide a basis for recommending the use of one system over the other for endodontic procedures.

Materials and Methods

Sample Preparation: A total of 30 rotary NiTi files were acquired for testing: 15 files from the NeoEndo Flex series (Group I) and 15 from the ProTaper Gold series (Group II). Each subgroup was comprised of the files commonly used in endodontic practices (sizes and tapers as per manufacturer's specifications).

Cyclic Fatigue Testing Apparatus: The cyclic fatigue resistance was assessed using a custom-made testing apparatus designed to simulate a curved root canal with a standardized curvature of 60 degrees and a radius of 5 mm. The apparatus incorporated a mobile piece to which the files could be firmly attached and rotated within an artificial canal made of a hard, wear-resistant material.

Rotation Protocol: Each file was then allowed to rotate at 400 rpm and 2.5 N/cm torque preset in endomotor and simultaneously a digital stopwatch was started. Files were rotated continuously until a fracture occurred.

Environmental Control: The entire experiment was conducted at a constant temperature of 37°C (98.6°F) to mimic intraoral conditions. The artificial canals were lubricated with water soluble gel to reduce friction and to simulate clinical situations.

Data Collection: Time taken (in seconds) until file fractured was recorded. The formula to calculate number of cycles to failure (NCF) is $NCF = \text{revolutions per minute} \times \text{time to failure (seconds)} / 60$.

Statistical Analysis: After collection, NCF data underwent statistical analysis utilizing suitable software. An independent t-test was used to determine the statistical significance of the differences between the mean NCF values for the two file systems. A p-value of less than 0.05 was considered indicative of a statistically significant difference.

All procedures were performed by a single operator to minimize variability. Each file was used only once to eliminate potential influences of work hardening on the results. Additionally, files were randomly selected and used in the series to reduce order effect biases. The study protocol was designed to eliminate external variability as much as possible, ensuring that differences in NCF could reliably be attributed to inherent properties of the files under examination.

Results

During the in-vitro testing, the ProTaper Gold files (740 ± 63), on average, withstood significantly more cycles until failure than the NeoEndo Flex files (490 ± 61). The mean number of cycles until failure (NCF) for ProTaper Gold was substantially higher ($p < 0.05$), indicating a robust resistance to cyclic fatigue (Table 1). Table 1 shows that time taken until fracture in group I was 25.21 ± 4.50 seconds and in group II was 45.39 ± 4.26 seconds which was found to be statistically significant ($p < 0.05$) (Table II).

Table 1: Mean and SD of NCF for the two test groups.

Group	Mean and Std Deviation	P Value
Group I Neoendo Flex File	490 ± 61	$< 0.05^*$
Group II Protaper Gold File	740 ± 63	

*Significant

Table 2: Mean and SD of Time to Fracture of file.

Group	Mean and Std Deviation	P Value
Group I Neoendo Flex File	25.21 ± 4.50	$< 0.05^*$
Group II Protaper Gold File	45.39 ± 4.26	

*Significant

Discussion

The comparison of NeoEndo Flex and ProTaper Gold rotary NiTi files has elucidated important differences in cyclic fatigue resistance, a key performance characteristic which directly relates to the potential for file separation during endodontic procedures. The present study's findings, displaying the superior cyclic fatigue resistance of the ProTaper Gold files, corroborate with the work of other researchers who have found similar durability in files with advanced metallurgical properties.²⁰

The importance of this study lies in its practical implications. Endodontic file failure is a significant concern, potentially leading to procedural complications, increased treatment time, and additional costs. Awareness of the different resistance to cyclic fatigue among file types assists in clinical decision-making. Factors such as the anatomical complexity of the tooth, the experience of the clinician, and the specific requirements of the endodontic treatment modality should influence file choice.²¹

The proprietary heat treatment that the ProTaper Gold files undergo may contribute to their enhanced performance. This process likely alters the crystal structure of the NiTi alloy, increasing flexibility and resistance to cyclic fatigue. The exact material composition and manufacturing processes play crucial roles in file durability and can vary significantly between brands, resulting in the observed differences in performance.²²

Despite the advanced performance of the ProTaper Gold files documented here, it should be noted that even the strongest files are not impervious to failure. Clinicians must therefore employ good judgment and consider employing adjunctive strategies such as glide path preparation, use of lubricants, and prudent file replacement practices to further minimize the risk of file separation.²³

Interestingly, while the present study focuses on cyclic fatigue resistance as a primary measure of endodontic file performance, it does not encompass all aspects of clinical efficacy. For instance, cutting efficiency, debris extrusion, and the ability to maintain canal anatomy are also vital components of clinical performance that were not examined. Further research incorporating these variables in conjunction with cyclic fatigue resistance could present a more holistic view of file performance.

Conclusion

In conclusion, while the ProTaper Gold files performed better in the in-vitro environment of this study, the translation of these results to clinical practice should not overshadow the multitudinous factors that influence endodontic success. Clinicians should continue to adopt a patient-centered approach that incorporates the best evidence regarding file performance, with the understanding that the choice of endodontic file systems is but one factor in the broader context of treatment outcomes.

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Conflict of Interest

The authors declare no conflict of interest.

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