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A review on the effect of using rotary hyflex electrical discharge machining endodontic files on the formation of dentinal microcracks in straight root canals

Abstract

Endodontic therapy is based on cleaning and shaping the canal system till the apex with total obturation of the canal. However, it is not always straightforward. Endodontics specialists face many complicated cases as sever curved canals, calcified canals and canals with previously initiated therapy which require to deal with. dental professionals pay attention to create new methods or to improve the already developed equipment and procedures to facilitate their work. Rotary endodontics files are in the center of attention. nowadays, recent files with extraordinary properties have been revolutionized. The standard Nickel Titanium rotary endodontic files are not always preferred. It cannot serve well in the aforementioned complex cases due to its larger tapers and unique shape memory property. Moreover, these files have led to several dentinal microcracks formation during canal preparation using the flaring instruments. Microcracks are evaluated through the accurately presented sliced images using Micro-Computer Tomography (micro-CT) done before and after root canal preparation. This has led to the invention of new generations of rotary endodontics files, with unique properties improving its behavior during the instrumentation, including Controlled Memory (CM) files and Electrical discharge Machine (EDM) files, opening the door for a new era in the field of endodontics dentistry. The present study aims to review HyFlex EDM files, including their properties, clinical dental usage, and the role of micro-CT in analyzing dentinal micro cracks formed with HyFlex EDM files.

Keywords: root canal preparation, microcracks, HyFlex, Micro–Computed Tomography, endodontics files

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Introduction

Endodontic procedures are based on using different instruments, starting with debridement and disinfection of the canal system ending with complete obturation. In some instances of tight canals, curved canals, commonly in old age patients treating dentists can face significant challenges.[1] Many endodontic procedures end with failure, especially when the treating physician fails to respect the canal system by preserving the original canal curvature, centering, and general outline.[2]

A remarkable shift in the field of endodontics with the evolution of rotary endodontic instruments to achieve the prerequisites of optimal instrumetation.[3] Dental professionals, are aware that despite the property of fast cutting developed files like nickel-titanium (NiTi) Files, this advantage, along with others, is paralleled by several drawbacks.[4] During the past few years, numerous studies were conducted to evaluate the shaping memory of NiTi instruments and have concluded a significant association between the instrumental preparation of the root canal system NiTi instruments and the formation of dentinal microcracks, which can result in substantial complication of vertical root fracture.[3] This instrument's limitations also resulted in numerous other procedural errors in different parts of the root canal system, including strip perforations, ledge formation, transportation in the apical third, coronal part weakening by aggressively cutting the cervical dentin. This has resulted in labeling them as aggressive files and led dental professionals worldwide to find the possible causes behind such significant concerns. Fortunately, this has resulted in the revolution of new technologies improving the performance of rotary endodontic files in root canal instrumentation through changes in instrument kinematics, alloys, and design.[3,5] These newly evolved files have 'Controlled memory' while the previously classical types have 'Shape memory'. The Controlled memory feature allows the file to retain the canal shape when it moves out the canal. This property is responsible for preventing those mentioned above several procedural errors. The heat-treated new Niti rotary instrument files have outstanding clinical fatigue resistance and flexibility with ease of bending, making them ideal for complex cases like curved canal cases compared to traditional NiTi files with better mechanical and physical properties.[3,5] It also has a unique ability to return to its original shape once heated above the transformation temperature.

These controlled memory files, including HyFlex CM, and Coltene are developed from the controlled memory wire subjected to a thermomechanical processing procedure making it stable under different clinical conditions. Lately, significant transformation manufacturing technology took the endodontics file to a higher level by introducing the EDM. The unique Electrical Discharge Machining uses electric discharge machining to generate a potential resulting in sparks, resulting in melting and evaporation of the wire and creating a unique surface, making the HyFlex EDM files fracture-resistant through the great combination of fracture resistance and flexibility. This feature made this new design better, easier, and faster in root canal shaping. This feature makes it possible to use a minimal number

of files during the root canal treatment while preserving the root canal system anatomy. In the present study, straight root canals were investigated to detect HyFlex EDM's performance, including the frequency of dentinal microcracks resulting.

HyFlex EDM files

HyFlex EDM is unique in having variable cross-sections along its entire length with three cutting edges contributing also to lesser chances of dentinal microcracks. According to,[2,5,6] in its coronal part, it is triangular, which progresses to trapezoidal design and finally at the apical third with quadratic design. The files have a tip size of 25 (0.08) tapers, the taper in the apical 4mm, and reduces to 0.04 in the coronal part as described in.[5,7] According to,[6] when this file gets inserted in the canal, it touches the walls with four contact points. The file is made of memory alloy with additional regenerative properties. Compared with the conventional NiTi files that prone to break suddenly without 'warning sign', HyFlex files have unique characteristics of rewinding after autoclaving. Therefore, an indication criterion for the clinician to evaluate the file status. In general, dental professionals should put some technical considerations while dealing with HyFlex files. The treatment and procedure determine the number of times the instruments can be used. It is also essential to checked and inspected these instruments before use. Another criterion is that the instrument did not regain its shape; this is considered another indication to discarded the file.

According to,[6] HyFlex EDM files have enhanced cutting efficiency through EDM technology and work in a rotation motion with a recommended speed of 500 rpm and 2.5 Ncm. This new NiTi file was invented by heating the alloy while manufacturing, causing further hardening of its material. Allows for thermal manipulation of the traditional files thus enhancing NiTi files ' flexibility and increased fatigue resistance.[1] Recent studies have evaluated the microcracks resulting from the different types of new heat-treated NiTi rotary files (HyFlex CM, HyFlex EDM, Vortex Blue, TRUShape) and declared no new microcracks reflecting its extra flexibility and excellent shaping ability in[7,8] studies. HyFlex EDM files have hard and rough surface that further supports its cutting efficiency and fracture resistance property, as suggested by.[5,6]

Dentinal microcracks

As discussed before, the design of the file plays a crucial effect through its mechanical forces, resulting in dentinal microcracks and root fractures. It is one of the most common complications of root canal preparation, which usually threatens permanent tooth loss. Dentinal root fracture or microcracks can result when tensile stress is exerted on the root canal wall exceeding the dentin tensile stress. according to[7] the large conventional NiTi files can add to these forces producing further increases in the friction and stress on the canal wall, causing the possible formation of dentinal microcracks. It is also suggested that these microcrack lines have occurred in 4% to 16% of cases, causing possible fractures during retreatment or other stresses, such as chewing. This finding confirmed the fact presented by[1,7] that several factors including root canal preparation with different NiTi rotary systems and any further endodontics procedure like retreatment or obturation can result in fractures or microcracks in all lines extending from the root canal lumen to the dentin and vice versa.[2] study finding claimed that the instrumentation with HyFlex EDM rotary files resulted in no new microcracks. The study attributed this result to the heat-treated structure of these files giving it the extra flexibility.[7] Contrary to[9] observations, studies suggest a lack of correlation between and root canal preparations with rotary systems and dentinal microcracks formation. Therefore, it is the dentists' primary aim to preserve the original anatomy of the canal during and endodontics procedures.

In a study by,[8] micro-CT was used to evaluate the use of HyFlex EDM files in the single straight canal. Before and after root canal system instrumentation, a scan was done for the teeth with a low isotropic resolution of micro-CT scanner at 50 kV and 800 mA, identifying the dentinal defect's presence, including microcracks. The results of this study indicated no new microcracks observed while instrumenting the straight root canal system with the HyFlex EDM system, nor further progression of the preexisting defects were observed.

The role of Micro-Computer Tomography straight root canal microcracks

Visualization using micro-CT allows dentists to detect the preexisting defects accurately and helps to demonstrate their location within the root canal. Micro-CT examination is considered a good technique for an examination compared to results obtained using studies of the destructive method.[5,8] indicated that using micro-CT, dentists can yield hundreds of cross-sections of the same sample pre- and post-operatively to determine the location of fracture/crack while avoiding tooth damage and therefore achieving targeted results. According to,[6,8] the advantage of high resolution and magnification of micro-CT images compared to stereomicroscopes made it a better alternative to decrease the risk of possible misinterpretations. As (De-Deus et al., 2016) study mentioned, micro-CT is considered a reliable method for evaluating various endodontic instruments while evaluating their performance accurately due to its noninvasiveness and usefulness. Micro-CT is also an ideal scanning method to obtain several slices by slice images for in vitro studies by yielding 3D imaging using X-rays to describe the inside of an object. An object's internal features are made by taking a series of 2D X-ray planar images and reconstructing the given data to 2D cross-sections. These slices can be further arranged into 3D images of X-rays for analysis through the power of the micro-CT technique. Therefore, this imaging modality is at the center of many types of research of endodontics. In[6,8] studies, micro-CT provided new possibilities of nondestructive assessment with or without contrast agents; done before and after using different types of endodontic mechanical instruments, including HyFlex EDM rotary files. According to,[9] micro-CT also has some limitations. The time used for scanning can be too much, made unsuitable in all clinical cases; equipment costs can be expensive. Most importantly, the technical procedures are complex, requiring an in-depth understanding of the software utilized.

Conclusion

Endodontics is witnessing massive revolutions in both technology and technique used in different clinical scenarios. Endodontic rotary files have been developing over several years as dental professionals need to manufacture safe and efficient endodontic techniques while dealing with root canal systems in the process of endodontic treatment. New generations of NiTi rotary files have been developed, including HyFlex EDM files assessing the practicing professionals in complex cases with less possibility of side effects like microcracks than conventional ones. Micro-CT has been an alternative source of accurate images used in clinical cases and in evaluating dentinal defects resulting from the newly developing instruments.

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Conflicts of interest

Not applicable.

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