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CANAL PREPARATION**

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# BEYOND THE SURFACE: EXPLORING MICROCRACKS WITH GEN ENDO FILE SYSTEM VS. HYFLEX EDM IN ROOT CANAL PREPARATION

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**ABSTRACT** - *Aim: This study aimed to assess and compare microcracks formed during root canal preparation using two rotary file systems in mandibular molars. Materials and Methods: 202 extracted human permanent mandibular teeth meeting inclusion criteria were collected. Teeth were decoronated, disinfected, and sectioned to prepare samples for root canal preparation. Two groups, each comprising 101 specimens, were prepared using HyFlex EDM and Gen Endo rotary files. Microcracks were examined at 3, 6, and 9mm from the apex using scanning electron microscopy (SEM). Results: Microcracks were observed in both rotary file systems. Statistical analysis revealed a significant difference between the two groups ( $P=0.049$ ). HyFlex EDM exhibited fewer microcracks compared to Gen Endo at all levels examined. Conclusion: Rotary endodontic preparation methods can induce dentinal defects, as evidenced by the presence of microcracks. HyFlex EDM demonstrated superior performance in minimizing microcracks compared to Gen Endo. These findings underscore the importance of careful selection of rotary instruments to mitigate the risk of iatrogenic damage during root canal preparation.*

*Keywords: Microcracks, Rotary file systems, HyFlex EDM rotary files, Gen Endo rotary files, Scanning electron microscope (SEM).*

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## INTRODUCTION

Successful completion of root canal treatment hinges on the effective cleaning, shaping, and comprehensive obturation of the root canal system. Biomechanical preparation is a pivotal step in endodontics, allowing for the eradication of bacteria, removal of debris, and the facilitation of three-dimensional obturation.<sup>1</sup>

During the biomechanical preparation process, the shaping of the canal occurs through the interaction between instruments and dentinal walls. These

interactions create momentary stresses in the dentin, potentially leading to the development of defects such as microcracks or craze lines. These structural issues may increase the susceptibility to vertical root fractures, a complication that often necessitates tooth extraction.<sup>4</sup>

The cross-sectional shape of the canal is deemed more critical than dentin thickness in stress distribution. Therefore, efforts should be made to minimize the removal of root dentin. A circular shape is preferred as it minimizes stress concentration areas and ensures a more uniform distribution of stress. Procedural errors that induce stress concentration<sup>5</sup> areas on the canal wall, such as ledging, gouging, or crazing, should be avoided.<sup>4</sup>

Maintaining dentin thickness, particularly in proximal areas or thin parts of root dentin, helps minimize additional stress from bending mechanisms. Stiffer file designs tend to generate higher stress concentrations, and the use of lubricants during rotary instrumentation can aid in decreasing internal root stresses.

The introduction of rotary instrumentation has significantly increased stresses on dentin due to higher torque and taper. Various file systems, distinguished by design features such as NiTi core diameter, cross-sectional shape, rake angle, and flute depth, can impact file behavior and influence crack generation.<sup>3</sup>

The evolution of Ni-Ti files, from first to third generation, has seen improvements in cyclic fatigue resistance and reduction in broken files. Heat treatment technology, exemplified by brands like Hyflex, has contributed to these advancements. Reciprocation technology, introduced in the late 1950s, led to a fourth generation of instruments for shaping canals.<sup>1</sup>

In the fifth generation, canal shaping efficiency has been enhanced by offsetting the center of rotation. Offset-designed files create a mechanical wave of motion along the NiTi file's full length, improving cutting and debris removal. This offset design also reduces taper lock or the screwing effect, decreasing the risk of instrument separation. Notable files of the fifth generation include HyFlex/EDM (Coltene), Revo-S (Micro-Mega), One Shape (Micro-Mega), and ProTaper Next (Dentsply).

The HYFLEX EDM, is an advanced rotary file system designed for endodontic procedures, characterized by its controlled memory and Electrical Discharge Machining (EDM) technology. Manufactured by Coltene, this system aims to address challenges posed by fine and curved canals. The EDM process ensures a highly flexible and durable file, enhancing performance during root canal shaping. With its innovative

design and metallurgy, HYFLEX EDM has gained recognition for reducing the risk of file separation and improving overall efficiency in canal preparation.<sup>6</sup>

GEN ENDO is a rotary file system designed for efficient and safe root canal preparation. Manufactured by Ultradent Products, Inc., GEN ENDO files are characterized by their cutting-edge features and performance. This system incorporates proprietary technologies to enhance flexibility and minimize the risk of instrument separation. GEN ENDO aims to provide clinicians with a reliable and versatile solution for shaping root canals effectively while considering the preservation of dentin integrity.<sup>2</sup>

## **MATERIALS AND METHODS**

### **Materials:**

Our study enlisted 202 extracted human permanent mandibular teeth procured from the Department of Oral & Maxillofacial Surgery, Seema Dental College & Hospital, Rishikesh, Uttarakhand. Adhering to rigorous institutional protocols, only teeth meeting specific criteria were selected for inclusion. These criteria encompassed the absence of caries, periodontal compromise, and developmental anomalies, ensuring a homogeneous sample cohort.

### **Method:**

Preparation commenced with meticulous decontamination of the collected teeth, adhering to CDC guidelines for infection control in dental healthcare settings. Following sterilization via immersion in 10% formalin and autoclaving, the teeth underwent decoronation to establish a standardized working length. Mesial canals of the teeth were then instrumented using two distinct rotary file systems: HyFlex EDM and Gen Endo.

The instrumentation process entailed precise shaping of the root canals, facilitated by the rotary motion of the files, with due attention paid to maintaining aseptic conditions throughout. Following instrumentation, samples were rinsed with distilled water to remove residual debris, ensuring clarity of observation during subsequent microscopic analysis.

To unveil the presence and distribution of microcracks, each sample underwent sectioning perpendicular to its long axis at predefined intervals: 3mm, 6mm,

and 9mm from the apex. Utilizing a low-speed saw, sections were meticulously prepared, culminating in slices amenable to scanning electron microscopy (SEM). This advanced imaging modality provided unparalleled resolution, enabling the detection of microcracks invisible to the naked eye.

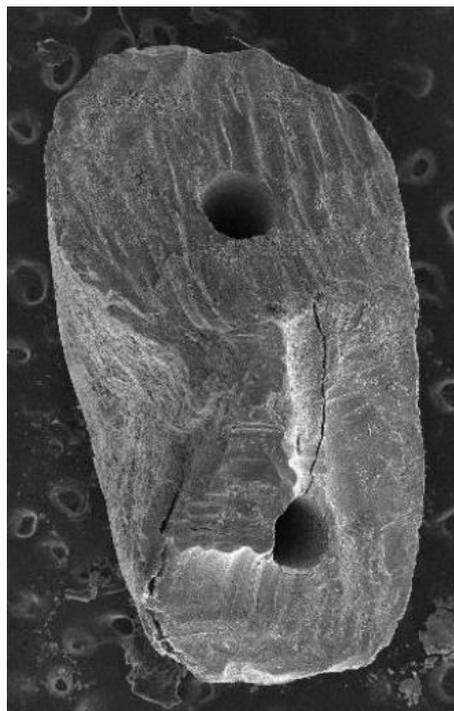
Statistical analysis served as the bedrock of our investigative approach, offering quantitative insights into the prevalence and distribution of microcracks induced by the two rotary file systems. Utilizing appropriate analytical tools, we discerned patterns and disparities between the HyFlex EDM and Gen Endo groups, shedding light on their respective efficacy and safety profiles.

By meticulously adhering to standardized protocols and employing cutting-edge methodologies, our study endeavors to illuminate the nuanced landscape of microcracks induced during root canal preparation. Through rigorous analysis and meticulous observation, we seek not only to expand the horizons of endodontic knowledge but also to forge a path towards safer and more efficacious clinical practices.

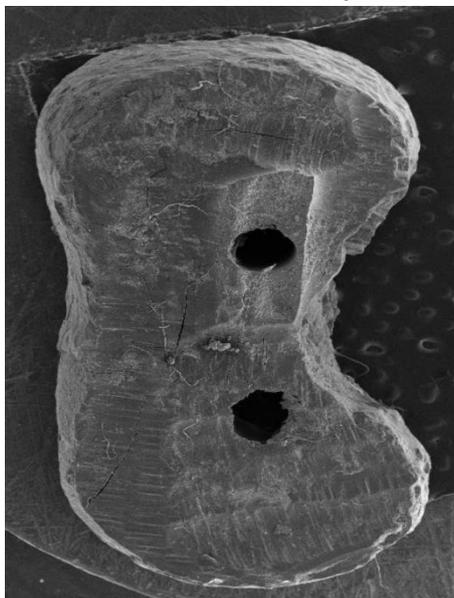
## **RESULTS**

A comprehensive examination of the 202 samples revealed the presence of dentinal defects induced by both the HyFlex EDM and Gen Endo rotary file systems. Through meticulous observation at predetermined intervals along the root canal, we discerned patterns of microcrack distribution, offering insights into the performance of each file system.

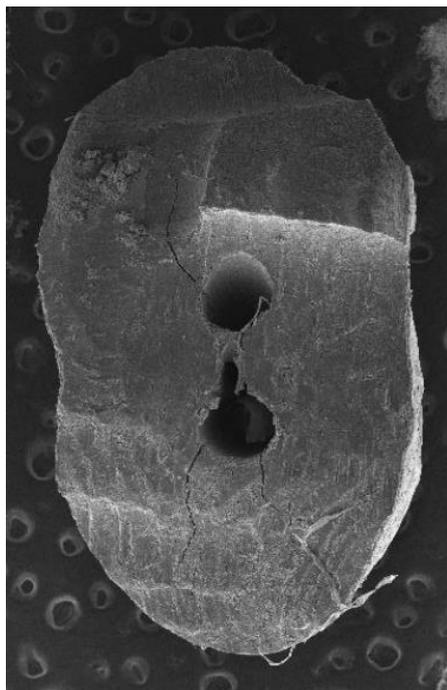
### **SCANNING ELECTRON MICROSCOPE IMAGE OBTAINED FOR GROUP I- HYFLEX EDM AT 3mm**



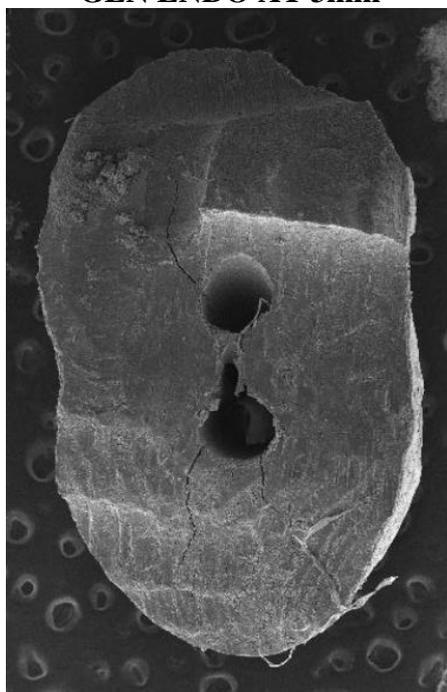
**SCANNING ELECTRON MICROSCOPE IMAGE OBTAINED FOR GROUP I-  
HYFLEX EDM AT 6mm**



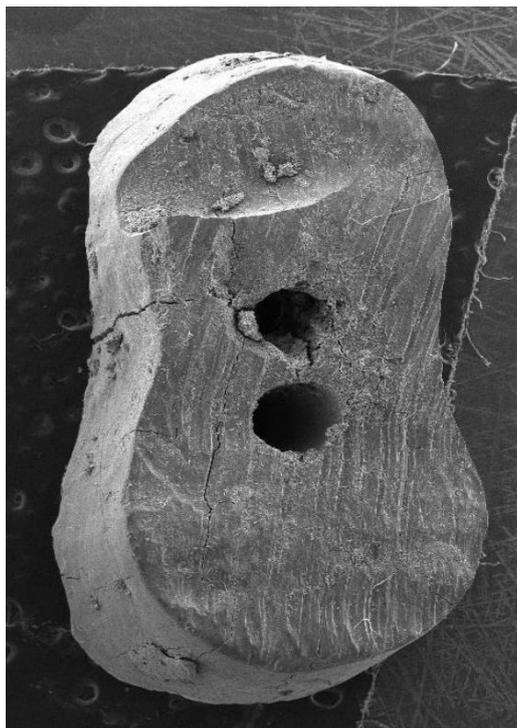
**SCANNING ELECTRON MICROSCOPE IMAGE OBTAINED FOR GROUP I-  
HYFLEX EDM AT 9mm**



**SCANNING ELECTRON MICROSCOPE IMAGE OBTAINED FOR GROUP II-  
GEN ENDO AT 3mm**



**SCANNING ELECTRON MICROSCOPE IMAGE OBTAINED FOR GROUP II-  
GEN ENDO AT 6mm**



**SCANNING ELECTRON MICROSCOPE IMAGE OBTAINED FOR GROUP II-  
GEN ENDO AT 9mm**

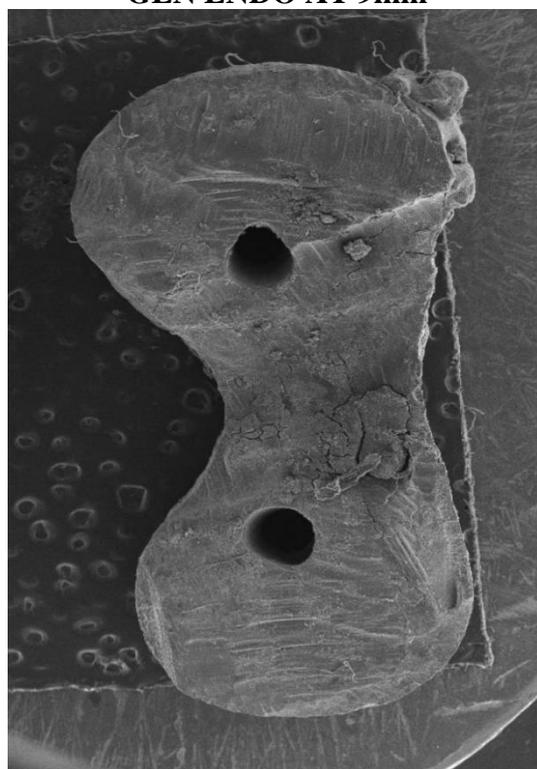


Table 1a and 1b presents a summary of the presence and absence of dentinal defects in both groups at 3mm, 6mm, and 9mm from the apex. This comparative analysis lays the groundwork for a deeper understanding of the efficacy and safety profiles of the two rotary file systems.

### **HYFLEX EDM FILE SYSTEM**

<b>SECTIONS</b>	<b>MICROCRACK PRESENT</b>	<b>MICROCRACK ABSENT</b>	<b>TOTAL</b>
3mm	10(50%)	10(50%)	20(100%)
6mm	10(50%)	10(50%)	20(100%)
9mm	2(10%)	18(90%)	20(100%)

Table 1(a)

### **GEN ENDO FILE SYSTEM**

<b>SECTIONS</b>	<b>MICROCRACK PRESENT</b>	<b>MICROCRACK ABSENT</b>	<b>TOTAL</b>
3mm	16(80%)	4(20%)	20(100%)
6mm	16(80%)	4(20%)	20(100%)
9mm	16(80%)	4(20%)	20(100%)

Table 1(b)

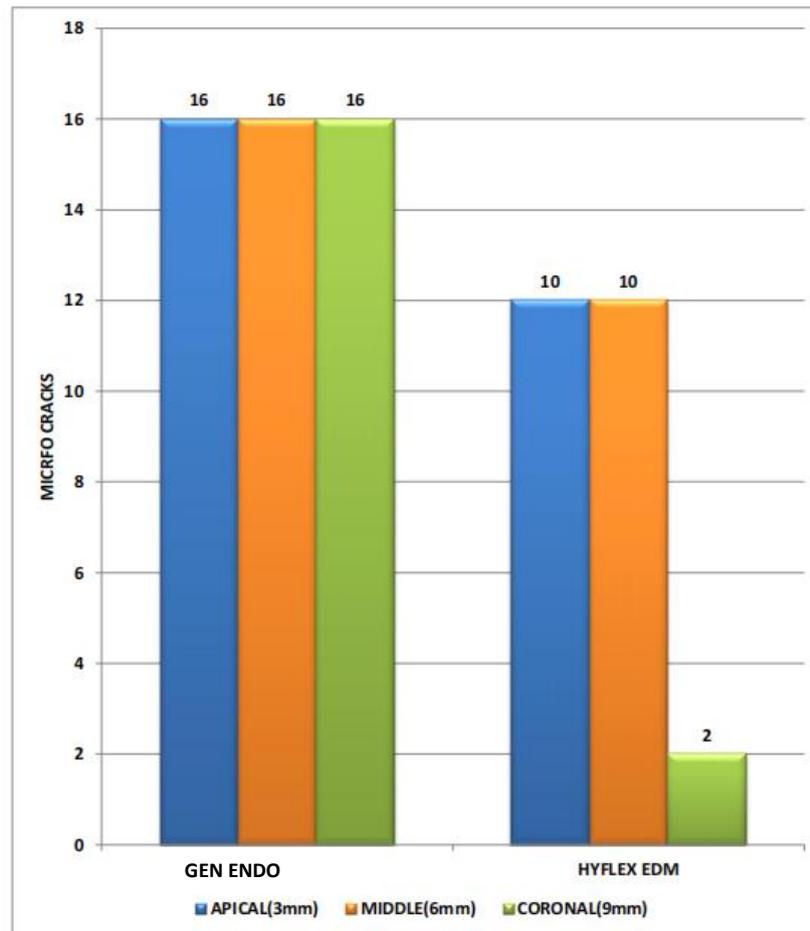
Further analysis revealed intriguing disparities in microcrack prevalence between the HyFlex EDM and Gen Endo groups. As illustrated in Table 2 and the accompanying graph, HyFlex EDM exhibited a notably lower incidence of microcracks across all measured intervals. Specifically, at the apical level

(3mm), HyFlex EDM demonstrated 50% fewer microcracks compared to Gen Endo. This trend persisted at the middle (6mm) and coronal (9mm) levels, with HyFlex EDM showcasing a 30% and 70% reduction in microcracks, respectively.

<b>GROUP</b>	<b>APICAL (3mm)  n=20</b>	<b>MIDDLE (6mm)  n=20</b>	<b>CORONAL (9mm)  n=20</b>	<b>TOTAL  n=60</b>
GEN ENDO	16(80%)	16(80%)	16(80%)	48(80%)
HYFLEX EDM	10(50%)	10(50%)	2(10%)	22(36.6%)

**p= 0.049 ( $\leq 0.05$ ) significant,  $\chi^2 = 6.02$**

Table 2



Statistical analysis corroborated these findings, unveiling a significant difference in microcrack formation between the two rotary file systems ( $P=0.049$ ). This statistical significance underscores the superior performance of HyFlex EDM in minimizing dentinal defects compared to its Gen Endo counterpart.

These findings underscore the critical role of rotary file selection in mitigating the risk of iatrogenic damage during root canal preparation. By demonstrating the superior safety profile of HyFlex EDM in inducing fewer microcracks, our study offers valuable insights for clinicians seeking to optimize patient outcomes and minimize the risk of untoward complications.

In summary, our results illuminate the nuanced landscape of microcrack formation induced by rotary file systems, paving the way for informed decision-making in endodontic practice. Through rigorous analysis and meticulous observation, we aim to empower clinicians with the knowledge needed to navigate the complexities of root canal preparation with confidence and precision.

## DISCUSSION

Our study delved deep into the realm of root canal preparation, shedding light on the nuanced interplay between rotary file systems and the induction of dentinal defects. The discussion segment serves as a platform for contextualizing our findings within the broader landscape of endodontic practice, elucidating their clinical implications, and identifying avenues for future research.<sup>7</sup>

The observed disparity in microcrack formation between the HyFlex EDM<sup>9,10</sup> and Gen Endo rotary file systems prompts a critical examination of their respective design features and operating characteristics. HyFlex EDM's superior performance in minimizing dentinal defects aligns with its unique manufacturing process, which imparts greater flexibility and resistance to cyclic fatigue.<sup>14</sup> This enhanced resilience likely translates into reduced stress transmission to the dentinal walls, thereby mitigating the risk of microcrack formation.<sup>11</sup>

Conversely, the higher incidence of microcracks observed with the Gen Endo system underscores the need for cautious consideration of its application in clinical practice. While both systems are renowned for their efficacy in shaping root canals, our findings suggest that factors beyond mere cutting efficiency warrant consideration. Clinicians must weigh the potential benefits of each system against the risk of iatrogenic damage, particularly in teeth predisposed to structural compromise.<sup>8,12</sup>

The clinical significance of microcracks extends beyond their mere presence, encompassing their potential to serve as precursors to more catastrophic complications such as vertical root fractures. While the immediate consequences of microcracks may be subtle, their cumulative impact over time can jeopardize the longevity of endodontically treated teeth. Thus, the imperative for clinicians to adopt strategies aimed at minimizing microcrack formation cannot be overstated.<sup>13</sup>

Our study's limitations merit acknowledgment and consideration in interpreting the findings. The inherent variability in human dentition and the complexity of root canal anatomy may introduce confounding factors that influence microcrack formation. Additionally, our investigation focused exclusively on mandibular molars, limiting the generalizability of our findings to other tooth types and anatomical locations.

Future research endeavors may seek to expand upon our findings by exploring the influence of additional variables, such as instrumentation technique, file design, and operator experience, on microcrack formation.<sup>15</sup> Longitudinal studies tracking the clinical outcomes of teeth prepared using different rotary file systems could provide valuable insights into the relationship between microcracks and long-term tooth survival.

## **CONCLUSION**

This study contributes to the evolving body of knowledge surrounding root canal preparation, offering empirical evidence of the differential impact of rotary file systems on dentinal integrity. By illuminating the intricate dynamics of microcrack formation, we empower clinicians to make informed decisions aimed at optimizing patient outcomes and preserving the vitality of endodontically treated teeth.

## **CLINICAL SIGNIFICANCE**

The presence and distribution of microcracks induced during root canal preparation carry profound clinical implications for endodontic practice. While often imperceptible, these microcracks serve as harbingers of potential complications, including vertical root fractures, which can compromise the long-term stability of endodontically treated teeth. Clinicians must navigate the delicate balance between efficacy and safety when selecting rotary file systems, recognizing the importance of minimizing iatrogenic damage to preserve dentinal integrity. Our findings underscore the critical role of careful instrumentation in optimizing patient outcomes and highlight the need for ongoing research to elucidate the complex interplay between rotary file design, technique, and clinical outcomes.

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