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Original Research Article

Efficiency of dental operating microscope over stereomicroscope in early detection of surface defects of Ni-Ti rotary instruments

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Abstract

Introduction: Endodontics often involves operating without direct visual access, making instrument integrity crucial. Advances in biomaterials and nickel-titanium (Ni-Ti) rotary systems have improved treatment, but these instruments are prone to fatigue and fracture, especially in curved root canals where stress is concentrated. Instrument separation is a common and challenging complication that can compromise treatment outcomes. Since fatigue-related microcracks in Ni-Ti files are difficult to detect visually, especially without magnification, careful inspection is essential. While stereomicroscopy (STM) is the gold standard for identifying such defects, the dental operating microscope (DOM) is more widely available in clinical settings. This study compares the effectiveness of the naked eye, DOM, and STM in detecting early signs of instrument fatigue, with the null hypothesis stating no difference among these methods

Aim and Objective: The Aim is to evaluate the efficiency of a dental operating microscope over stereomicroscope in detecting early surface defects of Nickel titanium (Niti) rotary instruments after multiple use and the Objective is to compare the efficiency of a dental operating microscope over a stereomicroscope in detecting early surface defects of Nickel titanium (Niti) rotary instruments after multiple use.

Material and Methods: 30 unused heat-treated 6% Niti Rotary (Edge endo) files of size 20 with a standardized length of 25 mm were selected. Prior to use each file were view under a stereomicroscope (STM) of 40X magnification and dental operating microscope (DOM) of 14 X magnification to ensure the absence of manufacturing defects. They were then used to shape mesial roots of molars. After a cycle of usage and sterilization at the first, third and sixth use the files were viewed with the naked eye, DOM and STM. The defects observed were recorded and classified.

Result: The results show that magnification significantly enhances defect detection in endodontic files. No manufacturing defects were found initially. After one use, both the dental operating microscope (DOM) and stereomicroscopy (STM) detected defects in 10% of the files, while the naked eye detected none. After three uses, defect detection rose to 46.6% with DOM and STM, compared to 10% with the naked eye. By the sixth use, DOM and STM identified defects in 66% of files, while the naked eye detected only 16%. DOM proved as effective as STM in identifying instrument fatigue.

Conclusion: The number of defects of Ni-Ti rotary instruments increases with increase in clinical usage. DOM was as effective as STM in detecting defects on the rotary files. Both magnification tools proved to be significantly more reliable than the naked eye for detecting defects after use.

Keywords: Dental operating microscope, Stereomicroscope, Surface defects, Ni-Ti rotary instruments

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1. Introduction

Endodontics is a discipline that often demands working without direct visual access to the operative field. Advances in biomaterials and clinical techniques have facilitated the integration of nickel-titanium (Ni-Ti) rotary instruments operated using electrically powered devices. However, these instruments, are subject to fatigue, which occurs with repeated loading thus creating defects on the instrument

which eventually lead to its fracture within the root canal.⁴ The risks are more in curved root canals as the instruments are subjected to pressure and a tensile load that is localized at the point of curvature in the canal.^{5,6}

Instrument separation is a relatively common complication in endodontic procedures. The removal of a broken instrument is extremely demanding and can compromise the favourable outcome of the treatment.⁷

*Corresponding author: Rishana P Email: rishanap497@gmail.com Therefore, it is important to visually inspect the instrument before and during root canal instrumentation especially in teeth with complex anatomy. Endodontic tools are small and the microcracks due to fatigue are hard to detect especially in Niti files. Unwanted instrument separation may be prevented if the clinician is forewarned on seeing these defects.

The dental operating microscope is now widely used by specialists and general practitioners. While STM is the gold standard for examining endodontic instruments, the utility of the DOM in this regard remains underexplored. This study aimed to evaluate and compare the efficiency of these two magnification tools in detecting early signs of fatigue in endodontic files over the naked eye. The null hypothesis was there is no difference in the ability to detect file defects between the naked eye, DOM or STM.

2. Materials and Methods

Thirty new heat treated 6% Niti Rotary files (Edge endo) of sizes 20 with a standard length of 25 mm were used in this in- vitro study. They were examined with naked eye, STM and DOM before use to rule out the presence of observable manufacturing defects. 180 extracted human molars were decoronated to a standard length of 15mm. The working length was measured by negotiating a 10 K file through the canals until the tip was visible at the apical foramen and 1mm subtracted from this length. All the files were used to shape the mesial root of the extracted molars to working length, following the standard protocol of cleaning and shaping up to apical size of the selected Niti file. After each usage the files were cleaned and sterilized before using again which was considered as one cycle. Following the first, third and sixth cycle the files were examined again with naked eye and both the magnification tools and photographed. The number and type of defects seen were recorded. The data collected were arranged into 3 main groups depending on the mode of examination of the files and each main group was sub-divided based on the usage cycle.

Each file was assessed for visible surface defects categorized based on Chakka et al.'s classification⁸

- 1. *Mild Damage*: Tip bending, dented cutting edge, straightening of twist contour
- 2. *Severe Damage*: Partial reverse twisting, change in length, visible crack propagation

3. Results

3.1. Defect progression

A progressive increase in the number and severity of defects was observed with an increasing number of usage cycles. The most common mild defects observed were tip bending and dented cutting edges seen after the 1st and 3rd cycles. Severe defects such as partial reverse twisting and change in instrument length were more evident by the 6th usage cycle. (Table 1 & 2)

3.2. Microscopic comparison

Both DOM at 14X and STM at 40X were effective in identifying the different types and early defects. DOM was found to be particularly efficient in real-time visualization and ergonomic usability. Though STM offered higher magnification, enabling detailed visualization of micro-level changes, it did not disclose defects that were not identified by DOM. It also lacked the operatory convenience offered by the DOM. (**Figure 1** &2)



Figure 1: Images of files viewed under DOM

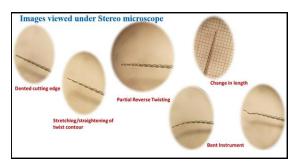


Figure 2: Images of files viewed under stereomicroscope

Table 1: Files showing defects under naked eye, DOM and stereomicroscope after 1,3 and 6 instrumentation cycles and sterilization.

	Without use	1st use(n)	3 rd use(n)	6 th use(n)
Naked eye	0	0	3 files	8 files
DOM	0	3 files	14 files	22 files
Stereomicroscope	0	3 files	14 files	22 files

Table 2: % of Files showing defects under naked eye, DOM and stereomicroscope after 1,3 and 6 instrumentation cycles and sterilization.

	Without	1^{st}	3 rd	6 th
	use	use(n)	use(n)	use(n)
Naked eye	0%	0%	10%	16%
DOM	0%	10%	46.6%	66%
Stereomicroscope	0%	10%	46.6%	66%

3.3. Statistical analysis

All statistical procedures were performed using Statistical Package for Social Sciences (SPSS) 20.0. Calculations for power (80%) of study were performed before commencement of the study. All quantitative variables as expressed in mean and standard Deviation. Chi square test wa

used for association between quantitative variables. Probability value p <0.05 were considered statistically significant.

3.4. Detection efficiency

Detection rates for mild defects were comparable between DOM and STM. No statistically significant difference within this qualitative framework was observed between DOM and STM in defect detection across the usage cycles (**Figure 3**). Naked eye examination was significantly less effective in identifying early-stage defects.

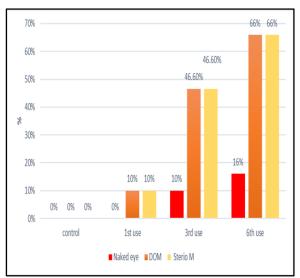


Figure 3: No statistically significant difference was observed between DOM and SM in defect detection across the usage cycles.

4. Discussion

The present study assessed and compared the effectiveness of a dental operating microscope and a stereomicroscope in detecting early signs of fatigue and wear in nickel-titanium rotary endodontic instruments over the naked eye. Niti files are, widely used for their superior flexibility and cutting efficiency. However, they are prone to sudden fracture without exhibiting visible signs of plastic deformation, a phenomenon attributed primarily to flexural and torsional fatigue arising from repeated clinical use.

In this study, both DOM and STM were equally effective in detecting such defects across varying stages of clinical use. These findings corroborate previous studies by Chakka et al. (2012) and Yamazaki- Arasaki et al. (2013), who reported that repeated usage significantly increases the risk and visibility of structural defects in Niti instrument.^{8,9}

Although the stereomicroscope offers higher magnification, and thereby potentially greater resolution for identifying minute structural changes, the dental operating microscope, despite its lower magnification to STM, proved to be equally effective in detecting early-stage surface defects on Nii rotary instruments. This observation aligns with findings from Sosik et al. (2021), ¹⁰ who demonstrated that

optical instruments, even with lower magnification, can reliably detect instrument fatigue features such as microcracks, dented edges, and subtle tip deformation when operated under appropriate lighting and magnification conditions.

Importantly, the DOM offers several advantages beyond magnification alone. Its ability to be used in real-time during clinical procedures enables continuous inspection of instruments without interrupting the operative sequence—a benefit not feasible with bench-top stereomicroscopes. Moreover, DOMs provide improved ergonomics, better posture for the clinician, and enhanced visual access to deep and complex anatomical areas, which are particularly valuable during endodontic procedures. ¹¹

Carr (1992) was among the first to emphasize the transformative role of the operating microscope in endodontics, advocating for its integration into routine care due to its capacity to enhance visualization and thus clinical precision. Subsequent studies have echoed this perspective. For instance, de Carvalho Maciel and Zaccaro Scelza (2006) highlighted that DOMs improve detection of canal orifice morphology, isthmuses, and even microfractures in dentin applications that translate well into early detection of wear in endodontic instruments.¹² Additionally, Baldassari-Cruz et al. (2002)¹³ reported that the use of magnification significantly increased the detection of procedural errors and defects, further supporting the DOM's role in clinical quality assurance. While stereomicroscopes are limited to postprocedure evaluation, DOMs offer an intraoperative solution, allowing clinicians to inspect and identify signs of wear or deformation immediately after use, potentially preventing reuse of compromised instruments. 13,14

Numerous in vitro studies have demonstrated that defects in nickel–titanium (NiTi) rotary files—such as microfractures, tip deformations, unwinding, and over-twisting—are invisible to the unaided eye, yet reliably identified under stereomicroscopic magnification ($\times 10-\times 40$). ¹⁵

Although stereomicroscopes effectively detect such hidden defects, their bulk and lack of portability limit their use in everyday dental practice. Recently, Manal Abdelbaky et al. (2022) evaluated 88 clinically used Twisted File (TF) NiTi instruments and found that the dental operating microscope (DOM)—despite its lower magnification (around ×21)—successfully identified deterioration modes (unwinding, tip separation, over-twisting) in 40% of the files discarded after clinical use. ¹⁷

These defects often accumulate over successive uses, increasing the risk of unpredictable file separation in procedural settings.¹⁸ Without magnification, such damage often goes unnoticed until catastrophic failure occurs. By incorporating DOM inspection into routine practice, clinicians can visually screen files between uses and detect

early signs of wear or distortion. This proactive screening enables timely disposal of at-risk instruments, thereby reducing the likelihood of intraoperative fracture and enhancing patient safety.

Despite the promising outcomes, the study is not without limitations. The qualitative nature of defect identification may introduce subjectivity, and no quantitative metrics were employed to measure the size or depth of observed defects. Future research should incorporate standardized scoring systems, blinded assessments, and advanced imaging techniques such as scanning electron microscopy (SEM) or micro-computed tomography (micro-CT) to validate and extend these findings. Additionally, studies involving a larger sample size and broader range of file systems could enhance the generalizability of the results.

5. Conclusion

The dental operating microscope (DOM) is an effective and clinically convenient tool for the early detection of defects in NiTi rotary instruments, offering a level of accuracy comparable to that of the more traditional and researchoriented stereomicroscope (STM). Its ability to reveal microcracks and signs of fatigue before they lead to instrument separation makes it a valuable asset in everyday clinical practice. Unlike STM, which is typically confined to laboratory settings due to its size and complexity, DOM is readily available in many dental offices and can be seamlessly integrated into routine procedures. Regular use of DOM not only enhances the clinician's ability to monitor instrument integrity in real time but also contributes to more informed decision-making during treatment. This can significantly reduce the incidence of procedural complications such as instrument fracture, thereby improving patient safety, treatment outcomes, and long-term tooth prognosis. Incorporating DOM into standard endodontic protocols represents an important advancement in clinical care and aligns with current trends emphasizing precision, safety, and evidence-based practice.

6. Ethical Committee Approval

The present study was approved by the Institutional Ethics Committee with an IEC/IRB No. KMCTDC/IEC/C/2024/03.

7. Author Contribution

1. Dr. Elsy P Simon: Methodology and Investigation

2. Dr. Rishana P: Data Collection

3. Dr. Nimmy Kurian: Data Acquisition

8. Conflict of Interest

None.

9. Source of Funding

None.

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