

DETECTION OF PROCEDURAL ERRORS DURING ROOT CANAL INSTRUMENTATION USING CONE-BEAM COMPUTED TOMOGRAPHY

Anna Laura Silva da Luz¹
Gabriel Ferreira Mendes²
Gabriella Fernandes Guimarães Posse³

ABSTRACT

This study investigated procedural errors occurring during root canal preparation with nickel-titanium (NiTi) instruments, using cone-beam computed tomography (CBCT) imaging. Materials and Methods: A total of 100 human mandibular molars were divided into five groups (n = 20) according to the NiTi system used for root canal preparation: Group 1 - BioRaCe, Group 2 - K3, Group 3 - ProTaper, Group 4 - Mtwo, and Group 5 - Hero Shaper. CBCT images were obtained to detect procedural errors committed during root canal preparation. Two examiners evaluated the presence or absence of fractured instruments, perforations, and canal transportation. The chi-square test was used for statistical analysis. The level of significance was set at $\alpha=5\%$.

Keywords: Cone-beam computed tomography; diagnostic imaging; root canal preparation; rotary instruments.

¹ Anna Laura Silva da Luz, UNIEVANGÉLICA, E-mail: aninhasilvaluz@gmail.com

² Gabriel Ferreira Mendes, UNIEVANGÉLICA, E-mail: gabrielferreiramendes117@gmail.com

³ Gabriella Fernandes Guimarães Posse, UNIEVANGÉLICA, E-mail: gabi_fgp@hotmail.com

INTRODUCTION

Modern root canal treatments prioritize cleaning and shaping the canal before filling. An important innovation that has transformed these procedures is the use of nickel-titanium (NiTi) rotary instruments. These instruments have specific designs, such as different cross-sections and cutting angles, which make them more effective in preparing root canals, especially in curved canals. Compared to stainless steel instruments, NiTi instruments better maintain working length and centralize canal preparation, resulting in fewer procedural errors and greater efficiency.

Several methods, such as histological, radiographic, and scanning electron microscopy analyses, have been used to evaluate the quality of root canal preparation with these instruments. However, many of these methods involve the destruction of samples, which limits the simultaneous evaluation of different aspects of the preparation.

Cone beam computed tomography (CBCT) has emerged as a powerful tool in endodontics, allowing detailed study of the root canal anatomy and its preparation, as well as being useful in the diagnosis and treatment of bone lesions. CBCT offers advantages over traditional methods, such as periapical films, by eliminating the overlap of surrounding structures and, when compared to medical tomography, uses less radiation and provides greater accuracy due to its high resolution.

Given the importance of minimizing errors during root canal preparation, this study aims to evaluate these errors when using NiTi rotary instruments, using CBCT as an imaging tool. The detailed analysis provided by CBCT can help improve the effectiveness of endodontic treatments and prevent future complications.

MATERIALS AND METHODS

This study investigated root canal preparation in lower molars using five different rotary instrumentation systems. One hundred extracted, preserved, and disinfected teeth were selected, all without previous treatments or significant anatomical alterations. Root curvature was classified as moderate, and the working length was defined as 1 mm before the apex. The teeth were randomly divided into

five groups, each with a specific instrumentation system: BioRaCe, K3, ProTaper Universal, Mtwo, and Hero Shaper.

The root canals were prepared with controlled rotation, irrigation with 1% sodium hypochlorite, and finished with EDTA to remove the smear layer. After instrumentation, images of the canals were obtained by cone beam computed tomography (CBCT), allowing a detailed assessment of possible procedural errors, such as instrument fractures and canal transportation. Image analysis was performed by two calibrated examiners, and in case of disagreement, a third observer was consulted.

Statistical analysis of the results was performed using IBM SPSS software, using the chi-square test to compare the different instrumentation systems. The study established a significance level of 5%, allowing a comparative analysis of the effectiveness of the systems used in root canal preparation.

DISCUSSION

Root canal preparation faces several challenges, such as canal curvature and anatomical diameter. To overcome these obstacles, NiTi instruments with different designs have been developed, although no system is perfect and complications may occur during the procedure. This study evaluated operational errors in root canal preparation using five types of NiTi rotary instruments, with the aid of cone-beam computed tomography (CBCT).

The use of CBCT provides a more accurate assessment of procedural errors, such as instrument fractures, perforations, and canal trajectory deviations. In the study, two specialists (a radiologist and an endodontist) analyzed the images to identify these errors, with the analysis focused on moderately curved root canals. A total of 300 canals were prepared, and 43 errors were identified (14.33%).

BioRaCe instruments had the lowest error rate (0.67%), while the Mtwo and ProTaper systems showed a higher frequency of failures, mainly root perforations. Instrument fractures occurred in 6.57% of cases, with no fractures reported for the BioRaCe system. Root canal transport was detected only in the K3 group, although previous studies have reported higher rates of this error.

The results indicate that, despite possible complications, canal preparation with NiTi rotary instruments is generally predictable. Further studies are needed to determine the best instrumentation system to minimize errors and improve treatment outcomes.

RESULTS

The study evaluated the occurrence of procedural errors during root canal preparation in 100 human mandibular molars using five different nickel-titanium (NiTi) rotary instrument systems: BioRaCe, K3, ProTaper, Mtwo, and Hero Shaper. Data analysis was performed using cone-beam computed tomography (CBCT), allowing for a detailed assessment of operational errors.

Of the 300 prepared canals, a total of 43 errors were identified, resulting in an overall error rate of 14.33%. The distribution of errors varied according to the instrumentation system used. The BioRaCe system had the lowest error rate, with only 0.67%, while the Mtwo and ProTaper systems showed a higher frequency of failures, especially in relation to root perforations. Instrument fracture occurred in 6.57% of cases, with no fractures in the BioRaCe system. Canal transportation was detected only in the K3 group.

These results indicate that, despite innovations in rotary instrumentation with NiTi alloys, root canal preparation still faces challenges, especially in moderately curved canals. The use of CBCT proved effective in detecting errors, suggesting that further studies are needed to optimize instrumentation systems and minimize complications during endodontic procedures.

CONCLUSION

This study demonstrated that, despite advances in rotary instrumentation with NiTi alloys, procedural errors still occur during root canal preparation, especially in cases with greater curvature. Evaluation by cone-beam computed tomography (CBCT) revealed that the incidence of fractures, perforations, and deviations varies according to the instrumentation system used. Among the instruments evaluated, the BioRaCe system had the lowest number of errors, standing out for its safety and predictability in the procedure, while systems such as Mtwo and ProTaper showed a higher rate of complications, mainly perforations.

Although NiTi rotary instrumentation offers an efficient and accurate solution for endodontic treatment, the study emphasizes the importance of carefully choosing the instrument system, considering the level of canal curvature and the operator's experience. Further research in this field is essential to refine techniques and minimize complications, contributing to improved clinical outcomes and prognosis in endodontic treatments.

REFERENCES

Santos SM, Soares JA, César CA, Brito-Júnior M, Moreira AN, Magalhães CS. Radiographic quality of root canal fillings performed in a post-graduate program in endodontics. *Braz Dent J* 2010;21:315-21. 12.

de Alencar AH, Dummer PM, Oliveira HC, Pécora JD, Estrela C. Procedural errors during root canal preparation using rotary NiTi instruments detected by periapical radiography and cone beam computed tomography. *Braz Dent J* 2010;21(6):543-9. 13.

Peters OA. Current challenges and concepts in the preparation of root canal systems: A review. *J Endod* 2004;30(8):559-67.