RGO DESDE 1953

Revista Gaúcha de Odontologia

Original

http://dx.doi.org/10.1590/1981-86372024002120240013

Dentinal defect formation during root canal preparation by Trunatomy files with and without the glide path

Formação de defeitos dentinários durante o preparo do canal radicular por limas Trunatomy com e sem glide path

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How to cite this article

Rodrigues L, Bueno CES, Martin AS, Stringheta C, Fontana CE, Pelegrine RA, et al. Dentinal defect formation during root canal preparation by Trunatomy files with and without the glide path. RGO, Rev Gaúch Odontol. 2024;72:e20240021. http://dx.doi.org/10.1590/1981-86372024002120240013

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ABSTRACT

Objective: The aim of the present study is to evaluate the occurrence of dentinal defects on the apical surface after rotary instrumentation at different working lengths with Trunatomy Prime system, with or without the use of a glide path file. **Methods**: Twenty human single-rooted mandibular premolars were selected and divided into 2 experimental groups (n=10). GTP group (Glide Path + Trunatomy Prime), the TP group (Trunatomy Prime). **Results:** To check the agreement between the examiners, the Kappa test was performed. Subsequently, the results were subjected to the Shapiro-Wilk normality test. The sample showed abnormal behavior and were subjected to the non-parametric Mann Whitney test with a significance level of 5%. No significant difference was found between the groups. **Conclusion:** It is concluded that there was no causal relationship with the formation of dentin defects with and without the use of glide path files at different limits of instrumentation with Trunatomy files.

Indexing terms: Tooth apex. Endodontics. Root canal preparation.

RESUMO

Objetivo: O objetivo do presente estudo é avaliar a ocorrência de defeitos dentinários na superfície apical após instrumentação rotatória em diferentes comprimentos de trabalho com o instrumento Trunatomy Prime, com ou sem o uso de lima glide path. **Métodos:** Vinte pré-molares inferiores humanos unirradiculares foram selecionados e divididos em 2 grupos experimentais (n=10). Grupo GTP (Glide Path + Trunatomy Prime), grupo TP (Trunatomy Prime). **Resultados:** Para verificar a concordância entre os examinadores, foi realizado o teste Kappa. Posteriormente, os resultados foram submetidos ao teste de normalidade de Shapiro-Wilk. A amostra apresentou comportamento anormal e foi submetida ao teste não paramétrico de Mann Whitney com nível de significância de 5%. Não foi encontrada diferença significativa entre os grupos. **Conclusão:** Conclui-se que não houve relação causal com a formação de defeitos dentinários com e sem o uso de instrumentos de glide path em diferentes limites de instrumentação com instrumentos do sistema Trunatomy.

Termos de indexação: Ápice dentário. Endodontia. Preparo de canal radicular.

INTRODUCTION

Endodontic treatment aims to minimize the number of microorganisms and pathological residues in the root canal system. Despite the large number of studies on this topic, the apical limit of root instrumentation is still very controversial [1]. A study, [2] suggested that instrumentation should be terminated 2 to 3 mm anterior to the apex for vital pulp, and 0 to 2 mm from the apex for infected canals. On the other hand, Souza [1] recommended instrumentation 1-2 mm beyond the foramen in periapical lesions. Endodontic treatment has a better prognosis when adequate instrumentation and obturation are performed in the apical constriction [3]. However, some studies [4,5] have demonstrated the presence of microorganisms in the apical third, including the cementum canal, in necrotic pulp with periapical lesion.

The root canal must be enlarged sufficiently to remove debris and allow adequate irrigation of the apical third of the canal [6]. On the other hand, apical preparation with small dimensions is recommended to avoid instrumentation errors such as apical transport and to preserve maximum root dentin [7] and reduce susceptibility to fracture [8]. Thus, there are two main concerns when instrumenting the most apical portion of the canal: the potential formation of microcracks in the root and the possibility of foraminal deviation.

More aggressive apical instrumentation can lead to the formation of cracks [9], which can weaken the tooth structure and develop into vertical root fractures [10]. Foraminal transport favors the preservation of necrotic tissue, contaminated dentin, and microorganisms in the uninstrumented walls [11].

TruNatomy instruments [Dentsply Sirona] are rotary instruments designed to shape the root canal system with maximum preservation of pericervical dentinal. TruNatomy instruments have high flexibility due to heat treatment, as well as a regressive taper that favors more conservative canal preparation. The system consists of a sequence of 5 instruments, including an orifice shaper [Orifice Modifier 20.08], a glide path instrument [Glider 17.02v] and three root canal shaping instruments: small [20.04v], prime [26.04v] and medium [36.03v]. The shaping files have a parallelogram cross-section, which provides cutting efficiency and resistance to cyclic fatigue [12]. The Orifice Modifier and Glider files have a modified triangular and a centralized parallelogram cross-section, respectively [13].

To date, no studies have investigated the occurrence of dentinal cracks during instrumentation with Trunatomy, with or without the use of the glide path, at different working lengths (WL). Therefore, the aim of this study was to investigate the occurrence of dentinal defects on the apical surface after rotary instrumentation with Trunatomy Prime, with or without the use of the glide path at different WL. The null hypothesis was that the studied groups would show similar behavior.

METHODS

This study was submitted to the local ethics committee for evaluation and registered. The sample size calculation considered the design of the experiment, in which the sample size would be at least 10 sample elements per group studied, because there would be two possibilities of response (absence and presence) and four levels-the initial image before instrumentation (0) and 3 different WL (1 mm from the apex, at the apex, and 1 mm beyond the apex). Thus, mathematically, there would be all possible permutations between the results of the responses and the levels. The sample calculation was performed (G Power 3.1.9.4, Franz Faul, College of Kiel, Germany) with an α-error of 0.05 and a β-type error of 0.80.

The cusp of all teeth was ground with a diamond disk (Discoflex KG-Sorensen, Barueri, SP, Brazil) using a low-speed to form a reference plane. The coronal approach was performed with a diamond drill and the tooth length (TL) was measured by inserting a K# 10 file into the canal using an optical microscope (8x) (Alliance Microscopia S.A, São Paulo, SP, Brazil) until the tip of the file was visible through the main apical foramen. The distance between the tip of the file and the reference plane was defined as the TL. Only teeth where the #10 K file reached the TL without encountering resistance were used to standardize the anatomical diameter of the specimens and consequently the caliber of the instrument to be used for canal shaping.

To simulate a closed instrumentation environment, teeth were placed in a PVC container (with a diameter of 25 mm and a depth of 22 mm) and a periodontal ligament was simulated using an impression material (Precise Sx Dentsply, Petrópolis, RJ, Brazil) processed according to the manufacturer's recommendations. A thin layer of cyanoacrylate (Super bonder-Loctite, São Paulo, SP, Brazil) was applied to the cervical part of the tooth to strengthen the fixation to the silicone. The tooth was removed from the PVC cylinder along with the silicone. The silicone was cut horizontally at the apical end with a #24 scalpel blade (Embramac, Itajaí, SC, Brazil), exposing 3 mm of the apical root to obtain images before and after instrumentation in different WLs. The apical end of the silicone was put back into the PVC cylinder and fixed with cyanoacrylate. Then, the tooth/silicone set was placed in the initial position to obtain images of the apical region. During instrumentation, each PVC cylinder with simulated ligament and inserted root was fixed in a vise (Mini Torno Western, São Paulo, SP, Brazil). The teeth were divided into 2 groups (n=10) according to the files used for instrumentation. The files were used with a speed of 500 rpm and torque of 1.5 Ncm. The VDW Dentsply Sirona motor was used. The order recommended by the manufacturer is to use the Orifice Modifier 20.08 file for the cervical and middle third and then the remaining instruments up to WL. For the GPT group, the Glide Path file was used up to the foramen and then the Trunatomy Prime file (26.04) was used to the WL; for the TP group, only the Trunatomy Prime file (26.04) was used. The teeth were instrumented in three WLs, 1 mm short of the foramen (TL-1 mm), at the foraminal limit (TL) and 1 mm beyond the foramen (TL +1 mm), consecutively. The files were used with a back-and-forth motion until they reached each WL. After each three movements, with a maximum amplitude of 3 to 4 mm, the files were cleaned with gauze and the root canal was irrigated. Each file was used to instrument four root canals. Each specimen was irrigated with a total of 15 mL of 2.5% sodium hypochlorite (NaOCl) solution using a 5 mL disposable syringe and an Endo-eze irrigation needle inserted at 3 mm below the WL. The needle was inserted with a back-and-forth motion so that the solution was aspirated simultaneously with the endo-tip attached to an aspiration cannula. After completion of instrumentation in each WL, all canals were aspirated and dried with a paper cone. All procedures were performed by an endodontist.

Images of the specimens were taken by microphotographs of the foramen to assess the presence of apical dentin defects. A first (control) image of the apical surface around the apical foramen of each specimen was taken with a digital microscope (50x) (Digital microscope 307-1000x- HD, China) and a new image was taken for each WL reached. To obtain these images, the simulated tooth/ligament set was removed from the PVC cylinder and placed in another PVC cylinder but inverted so that the apical region was facing the digital microscope, always taking care to maintain the same position for the acquisition of the next image (figure 1).

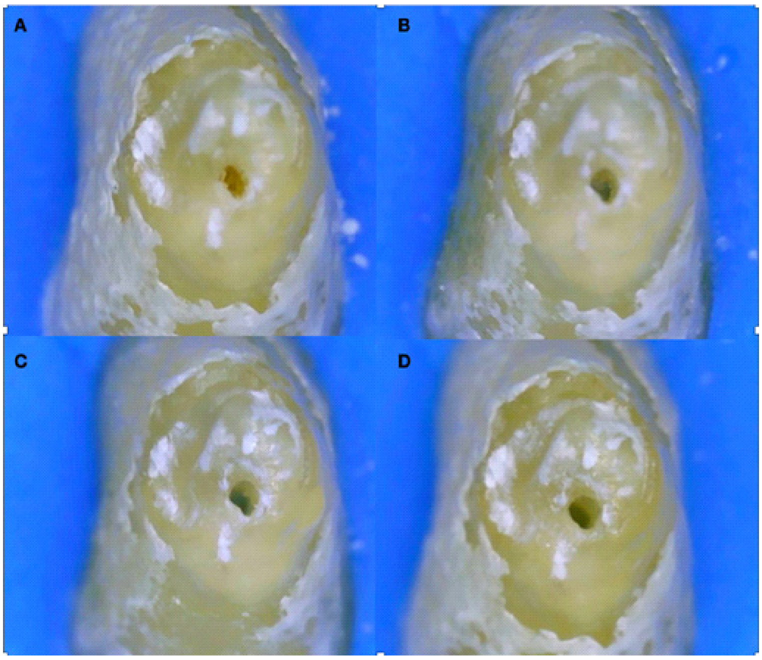

Figure 1. Microscopic images (50x) of sample 1 of group TP. Experimental images of group TP: A: Initial/ before instrumentation; B: Instrumentation 1mm short; C: Instrumentation at apical limit; D: Instrumentation 1mm beyond.

Any visible discontinuity on the apical surface that was not present on the baseline image was defined as a dentinal defect. Each photomicrograph was compared to the baseline image, and if a dentinal defect was present, it was recorded. Image evaluations were performed by two investigators with PhDs in endodontics who were unaware of the procedures related to all experimental groups.

Statistical analysis

To check the agreement between the examiners, the inter- and intra-examiner kappa test was performed. The result was 1, i.e., excellent reproducibility. The results were subjected to the Shapiro-Wilk normality test. The sample showed abnormal behavior. The results were subjected to the non-parametric Mann Whitney test with a significance level of 5%.

RESULTS

The results showed 100% absence of defects in both groups with no significant difference between groups ($p > 0.005$).

DISCUSSION

The use of the Trunatomy system for this study was decided due to its rotational kinematics and the use of a progressive sequence that makes the biomechanical preparation of the root canal system safe. The aim of this study was to evaluate the occurrence of dentinal defects on the apical surface after instrumentation of mandibular premolars on different WLs with Trunatomy Prime, with or without glide path. The null hypothesis was accepted because the groups showed no dentinal defects between the three instrumentation limits. Previous studies with different rotary systems showed a high incidence of dentinal defects caused by mechanical instrumentation of the root canals [14-16]. Unlike in this study, because the Trunatomy system has a reduced tip and taper, the preparation requirements in the apical third are not as invasive and thus greatly affect the outcome, do not interfere and produce dentinal defects. Much of the literature linking biomechanical preparation of the root canal to the development of dentinal defects is primarily based on cutting the roots for assessment [14-18]. Tooth cutting has a significant disadvantage in terms of its destructive nature, which may be one of the reasons for the high incidence of dentinal defects in the results reported in the literature [19]. However, in previous studies using the sectioning method, no cracks were detected in the unprepared group [control group], thus ensuring that all detected dentinal defects occurred during instrumentation [9,20]. However, this type of control does not consider the potential damage caused by the interaction of three sources of stress on root dentin: mechanical preparation, chemical attack with a sodium hypochlorite-based irrigation, and the sectioning procedure.

In this study, the apical region was examined for the development of dentinal defects by direct observation of the apical surface under magnification, and the roots were not cut. Studies that used micro-CT and stereomicroscopy to evaluate the appearance of defects in dentin after instrumentation showed controversial results. Reciproc, ProTaper Next, and Mtwo had no effect on the occurrence of root defects [21]. All microcracks that occurred after instrumentation with ProTaper Next, WaveOne Gold, ProTaper Gold, Hyflex, and Reciproc Blue were present before instrumentation [22,23]. Rotary and reciprocating systems did not result in dentinal defects, and the length of pre-existing defects was not altered [24]. Dentinal defects were observed after the use of Mtwo and Reciproc instruments, and the size of these defects increased after the use of larger instruments [25].

Previous studies have reported that instrumentation below the apical foramen significantly reduced the risk of dentinal defects [9,26]. In contrast, instrumentation of molars and lower incisors with Reciproc Blue did not cause microcracks [27]. No difference between the small, primary and large WaveOne instruments in terms of the presence of dentinal defects, nor between the teeth before and after instrumentation in the different WLs [28].

The apical surface in relation to the development of dentinal defects used a simulated ligament in their studies but left the apex open [9,14], which may influence the development of dentinal defects in this region. The method of including and simulating the periodontal ligament has a significant effect on fracture resistance in addition to maintaining hydration of the tooth during instrumentation [29]. The periodontal ligament acts as a buffer to the stresses generated and transmits the masticatory forces to the supporting tooth tissue, resulting in pattern changes and high resistance to restorative fractures [29]. In this study, it was decided to use the simulated periodontal ligament to make the in vitro study as close as possible to clinical conditions [26,29]. The discrepancy in the results can certainly be explained in part by differences in methodological design, and a direct comparison of the current results with those of previous studies was not possible. Further studies are needed to evaluate the influence on the occurrence of dentinal defects on the apical surface at different instrumentation limits.

Considering the results obtained and considering the methodological limitations used in the present study, it is concluded that biomechanical preparation with Trunatomy files on different WL has no causal relationship with the occurrence of dentinal defects on the apical surface.

Collaborators

L Rodrigues, principal investigator and initial writing of the manuscript. CES Bueno, AS Martin, C Stringheta, CE Fontana and RA Pelegrine, general supervision and final reading of the manuscript. AGS Limoeiro, WM Nascimento and MFV Marceliano-Alves, writing of the draft of the manuscript and final reading. DGP ROCHA, advisor and statistical analysis.

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Received on: 29/2/2024
Approved on: 27/6/2024

Assistant editor: Luciana Butini Oliveira