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NSK Reciprocating Handpiece: *In Vitro* Comparative Analysis of Dentinal Removal During Root Canal Preparation by Different Operators

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The purpose of this study was to assess dentin removal during root canal preparation by different operators using a NSK reciprocating handpiece. Eighty-four human single-rooted mandibular premolars were hand instrumented using Triple-Flex stainless-steel files (Kerr) up to #30, weighed in analytical balance and randomly assigned to 4 groups (n=21). All specimens were mechanically prepared at the working length with #35 to #45 Triple-Flex files (Kerr) coupled to a NSK (TEP-E10R, Nakanishi Inc.) reciprocating handpiece powered by an electric motor (Endo Plus; VK Driller). Groups 1 to 4 were prepared by a professor of Endodontics, an endodontist, a third-year dental student and a general dentist, respectively. Teeth were reweighed after root canal preparation. The difference between weights was calculated and the means of dentin removal in each group were analyzed statistically by ANOVA and Tukey's test at 5 % significance level. The greatest amount of dentin removal was found in group 4, followed by groups 2, 3 and 1. Group 4 differed statistically from the other groups regarding dentin removal means [$p<0.001$ (group 1); $p=0.005$ (group 2); and $p=0.001$ (group3)]. No statistically significant difference was found between groups 1 and 2 ($p=0.608$), 1 and 3 ($p=0.914$) and 2 and 3 ($p=0.938$). In conclusion, although the group prepared by a general dentist differed statistically from the other groups in terms of amount of dentin removal, this difference was clinically irrelevant. The NSK reciprocating handpiece powered by an electric engine was proved an effective auxiliary tool in root canal preparation, regardless of the operator's skills.

Key Words: root canal preparation, rotary instrumentation, reciprocating handpiece.

INTRODUCTION

The purpose of root canal preparation in endodontic treatment is to clean and shape the canal system. The development of preparation techniques as well as the substantial improvement in the properties of endodontic instruments has been well accepted within the dental community. More recently, the use of continuous rotary or reciprocating systems has been widely adopted by dentists, particularly endodontists.

During root canal preparation, the most time-consuming and demanding phase of endodontic therapy, the operator skills and the pathological conditions, which depend on dental anatomy and set limitations to the treatment, should be carefully evaluated. It is important that operators have thorough knowledge of dental anatomy and instrumentation techniques, know how to adapt the available instruments and materials to each case and develop satisfactory tactile sensation to control dentin removal by the action of endodontic files. All these factors are closely related with the root structure in different situations.

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The development of Endodontics as an area of specialization reflects the concern of researchers about the introduction of more efficient and less stressing preparation techniques for dentists and patients alike. Mechanized systems for root canal preparation are an alternative to reproduce hand movements. Following the evolution of Endodontics over the last decades, the physical properties and design of endodontic instruments have been the focus of investigations (1-3). Files with better flexibility, torsional properties and cutting action are currently available. Additionally, crown-down techniques have been proved more efficient than step-back techniques for root canal preparation (4).

In a study of the cutting efficiency of files according to the number of times of use, Webber et al. (1) found poorer results for triangular-bladed files compared to files with rectangular or round blades. In a comparative investigation of the efficacy of manual and automated root canal instrumentation (5), better cleaning results were obtained with the ProFile rotary system, and hand instrumentation with Hoedströen files was similar to Kavo-Endo Flash oscillatory system.

Baumann and Roth (6) compared the skills of third-year dental students and highly experienced dentists on the use of rotary instrumentation with NiTi files and found that all operators obtained a good shape of the root canal. Another study (7) showed that operators without experience in endodontic treatment performed a better root canal preparation with rotary systems than manual instrumentation techniques. Due to their high flexibility and good shaping results, nickel-titanium files are used with rotary movements in both hand and mechanized instrumentation. They have been shown to have lesser cutting efficiency than stainless steel files, although this difference was not statistically significant (8,9).

Reciprocating handpieces have gained importance in Endodontics as auxiliary devices for canal instrumentation. ProFile (Dentsply-Maillefer, Maillefer Instruments S.A., Ballaigues, Switzerland), Quantec (Analytic Endodontics, Mérida, México), Pow-R (Moyco Union Broach, York, PA, USA), Lightspeed (Lightspeed Technology Inc., San Antonio, TX, USA), Endo Gripper (Moyco Union Broach) M4 (Sybron/ Kerr, Orange, CA, USA) and NSK (Nakanishi Inc., Tokyo, Japan) are examples of automated systems for root canal preparation that offer more comfort, require lesser operative time and reduce operator's fatigue (10,11). However, because of the high cost of nickel-titanium files, rotary systems are still not widely used in Brazil. On the other hand, reciprocating handpieces are used with conventional files, which lessen the operational costs of these systems in comparison to continuous rotary instrumentation (12). Reciprocating handpieces offer even greater clinical advantages when powered by an electric motor rather than used according to the manufacturer's instruction (i.e., coupled to a compressed air-driven motor).

The purpose of this study was to evaluate the efficiency of a NSK (TEP-E10R, Nakanishi Inc.) reciprocating handpiece in root canal preparation by measuring the amount of dentin removed during instrumentation of extracted teeth by different operators.

MATERIAL AND METHODS

Eighty-four human single-rooted mandibular premolars donated by public dental services in Santa Cruz do Sul, RS, Brazil, were selected after radiographic examination to exclude teeth with canals that were too wide or atresic. The teeth were decoronated at the cementoenamel junction and root length was standardized at 14 to 17 mm, measured with a digital pachymeter. The specimens were randomized and placed in numbered flasks with 5 mL of saline to be kept hydrated until initial weight measurement.

The root canals were cleaned with a # 15 Triple-Flex file (Kerr-Sybron Dental Specialties, Orange, CA, USA) inserted millimeter by millimeter into the canal with 1% sodium hypochlorite until the instrument tip reached the apical foramen, which was confirmed by visualization at X16 magnification using a surgical microscope (Microscópio Operatório DF Vasconcelos, São Paulo, SP, Brazil). A silicone stopper was placed at the cervical margin to determine the canal length, and the working length (WL) was established at 1 mm short of the apical foramen. A clamping device was used to hold the specimens during preparation. Each file was used at the most five times.

Root canal preparation of all teeth followed the conventional serial technique, which consists of instrumentation with #15 to #40 files at the WL. Preparation was carried out in two phases: hand instrumentation, performed by the same calibrated operator, and mechanized instrumentation, performed by four other operators.

The first phase consisted of hand instrumentation

of the root canals to a #30 Triple-Flex file (Kerr Sybron Dental Specialties) at the WL with irrigation at each instrument change. A silicone stopper limited the penetration of a 25/2 irrigation needle to 3 mm short of WL. Aspiration was performed with a 40/20 aspiration cannula. A total of 2 mL 17% EDTA were flushed for 3 min. Thereafter, 2 mL 1.0% sodium hypochlorite were used for irrigation and simultaneous aspiration. The canals were dried with sterile paper points and the teeth were allowed drying at 37°C for 5 h and then kept uniformly dry in a desiccating chamber.

The specimens were weighed three times in an analytical balance to the nearest 0.0001 g. Weight means were calculated and recorded as the initial weight for each group (W1). After weighing, the teeth were placed back in flasks with saline to be rehydrated.

The hand-instrumented teeth were randomly assigned to 4 groups (n=21), according to the operator in the second phase (automated instrumentation): group 1 was prepared by a professor of Endodontics, group 2 by an endodontist, group 3 by a third-year dental student and group 4 by a general dentist. The canals were instrumented at the WL with #30 to #45 files coupled to a NSK reciprocating handpiece (TEP-E10R, Nakanishi Inc.) powered by an electric motor (Endo Plus Driller; VK Driller, SP, Brazil). Files were changed whenever the operator felt by tactile sensation that the file was loose inside the canal. Each file was used at most five times. When mechanized preparation was completed, the teeth were reweighed in the same way as described for the initial weighing. Weight means were calculated and recorded as the final weight for each group (W2). The difference between final and initial weight (W2-W1) corresponded to the amount of dentin removed by each operator during root canal instrumentation. Data were analyzed statistically by ANOVA and Tukey's test.

RESULTS

Means of dentin removal by each operator during automated root canal preparation with the NSK reciprocating handpiece are shown on Figure 1.

The difference between initial and final weight means showed that group 4 (prepared by a general dentist) had the greatest amount of dentin removal, followed by group 2 (prepared by an endodontist), group 3 (prepared by a third-year dental student) and group 1 (prepared by a professor of Endodontics).

The results of Tukey's test revealed statistically significant difference in dentin removal means between group 4 and the other three groups [$p<0.001$ (group 1); $p=0.005$ (group 2); and $p=0.001$ (group3)]. No statistically significant difference was found in dentin removal means between groups 1 and 2 ($p=0.608$), 1 and 3 ($p=0.914$) and 2 and 3 ($p=0.938$).

DISCUSSION

Root canal preparation is an extremely important step of endodontic treatment, but it is also time-consuming and causes great fatigue to the operator. Therefore, several studies have been conducted with the purpose of optimizing the steps of endodontic therapy and enhancing its effectiveness. New instruments and systems have been launched to the market and have been the focus of a number of studies in Endodontics. However, several factors remain uninvestigated and further research is required as new technologies are introduced. In the light of innovative biological and mechanical principles, the search for new methodologies has increased substantially over the last decade, with emphasis on development of materials and instruments with improved properties, as well as more conservative techniques.

Nevertheless, it is well known that dental anatomy sets limitations to the operator and is a determinant factor in the settlement of a correct diagnosis. Operator's manual ability and knowledge of dental anatomy are

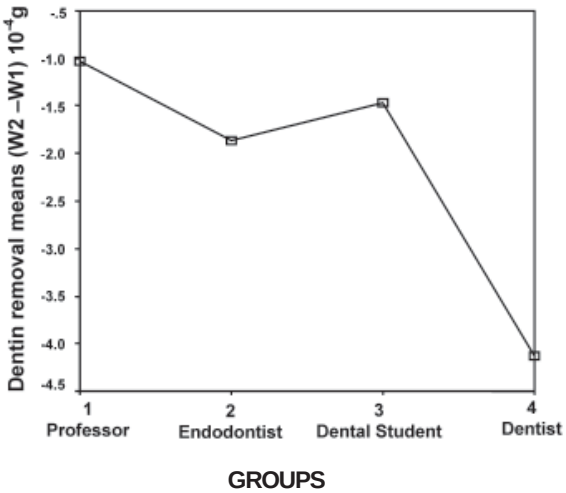

Figure 1. Means of dentin removal by each operator during preparation of root canals with a NSK reciprocating handpiece. W1= initial weight; W2= final weight.

essential for treatment success, which justifies the compulsory use of hand instrumentation (10).

Currently, several authors question whether endodontists should make exclusive use of hand files. Others are more emphatic and affirm that mechanized systems are an undisputable reality in Endodontics and no longer just an alternative for canal preparation (10,13,14). However, it is important to investigate the association of operator's skills and dentin removal in mechanized instrumentation. Therefore, these concerns should be dealt with in studies with these systems so that reliable information can be provided to dental professionals, especially dental students and general dentists. Moreover, dental students should become familiar with all resources available for endodontic treatment.

Controlling the amount of dentin removal during root canal instrumentation is not an easy task; rather, it depends on dental anatomy, operator's experience and pulp conditions. In teeth with necrotic pulp and contamination of the root canal system, greater removal of dentin is required to ensure disinfection, whereas less dentin can be removed when the pulp is vital and the canal is not contaminated. In clinical practice, making the right decisions in hand and mechanized instrumentation requires good skills and professional experience. Root canal preparation has been changing greatly, not in terms of its principles, but in terms of replacement of hand instrumentation by reciprocating and rotary systems. The use of automated systems, however, are only part of root canal therapy (9,10,11,15).

This study investigated whether canal preparation with an NSK reciprocating handpiece powered by an electric motor would be performed in distinct ways by operators with different skills, background knowledge and experience. This system uses hand files, similarly to the system evaluated by Tepel et al. (16). Mandibular premolars were chosen for this study because of certain anatomic features, such as easy-to-negotiate, wide and straight canals that are slightly flattened proximally. These characteristics allow standardizing the assessment of the behavior of mechanized systems used by different operators (17). The teeth were decoronated to eliminate the cervical curvature and the canals were standardized before initial weighing by hand instrumentation up to a #30 file. These procedures were intended to rule out some potentially confusing factors that might have interfered with the results (18).

Mechanized preparation with a NSK reciprocating handpiece coupled to an electric motor was chosen because the rotation provided by an electric engine is smoother than the motion provided by compressed air-driven motors, recommended by the manufacturer. Air-driven motors cause excessive vibration and, consequently, lead to less control of instrumentation and more operator fatigue. Furthermore, speed control at 10,000 rpm during preparation with the reciprocating handpiece is efficient and reduces vibration. The NSK handpiece uses conventional hand files, which are still the most widely used file type, especially by general dentists and are less expensive than rotary instruments. The serial technique was used for root canal preparation because it is easily performed, accessible to all operators and the most widely used technique in dental offices.

The findings of this work are consistent with those of previous studies (6,7), which found that students lacking endodontic experience achieved good canal shaping when mechanized instrumentation systems were used, i.e., operator's skills were not a determinant factor for the success of root canal preparation.

An important issue observed in the present study should be further investigated in future works. During mechanized instrumentation, the files make specific and repeated movements in contact with root canal walls. Therefore, it is somewhat surprising that the general dentist removed more dentin than the other operators. This may be explained by the fact that preparation time was not controlled and the operators were only instructed to change to files of greater size when they felt that the instrument in use became loose inside the canal. However, in milligrams, the statistically significant difference observed for the general dentist was not clinically relevant. Koch et al. (13) also found that very small differences in the amount of dentin removal in milligrams were clinically irrelevant when hand instrumentation was compared to continuous rotary instrumentation.

It is important to point out, however, that canal instrumentation using mechanized systems without time control can possibly lead to greater dentin removal than hand instrumentation because it is more comfortable to work with a reciprocating handpiece. Operators might therefore tend to extend the time working inside the root canal. On account of this, even experienced operators should be trained before using a mechanized system for root canal preparation. It is also important to note that this system is only an auxiliary tool in endodontic

treatment, and that hand instrumentation is indispensable in the initial and final phases of root canal preparation.

This work was not intended to advocate changes in the principles and techniques of root canal instrumentation, but to present options for general dentists and dental students based on the understanding that the resources available in the market should be further investigated prior to their recommendation for clinical practice.

Based on the outcomes of this study, the following conclusions may be drawn. Dentin removal occurred in all groups. Although the group of teeth prepared by a general dentist differed statistically from the other groups in terms of amount of dentin removal, this difference was clinically irrelevant. The NSK reciprocating handpiece coupled to an electric engine was proved an effective auxiliary tool in root canal preparation, regardless of the operator's skills; operators should, nonetheless, be previously trained to use it.

RESUMO

Este estudo avaliou a perda de massa dentinária durante o preparo do canal radicular por 4 diferentes operadores utilizando o sistema de rotação alternada NSK (TEP-E10R, Nakanishi Inc.). Após a instrumentação manual de 84 pré-molares inferiores humanos com limas de aço inoxidável Triple-Flex (Kerr) até a lima #30, os espécimes foram pesados e divididos aleatoriamente em 4 grupos (n=21). Os canais foram preparados mecanicamente até o comprimento de trabalho com limas Triple-Flex #35 a #45 acopladas ao sistema de rotação alternada NSK acionado por motor elétrico (Endo Plus; VK Driller). Os grupos 1 a 4 foram preparados por professor de Endodontia, um endodontista, um estudante do 3º ano de Odontologia e um clínico geral, respectivamente. Após o preparo mecânico, os espécimes foram novamente pesados. A diferença entre o peso inicial e o peso final foi obtida e as médias de perda de massa dentinária em cada grupo foram submetidas à análise estatística por meio da ANOVA e Teste de Tukey com nível de significância de 5%. A maior quantidade de perda de massa dentinária foi observada no grupo 4, seguido pelos grupos 2, 3 e 1. Houve diferença estatisticamente significante o grupo 4 e os outros três grupos [p<0,001 (grupo 1); p=0,005 (grupo 2) e p=0,001 (grupo 3)]. Não houve diferença estatisticamente significante entre os grupos 1 e 2 (p=0,608), 1 e 3 (p=0,914) e 2 e 3 (p=0,938). Conclui-se que embora o grupo preparado pelo clínico geral tenha diferido estatisticamente dos demais grupos em termos de quantidade de dentina removida, essa diferença não foi clinicamente relevante. O sistema de rotação alternada NSK mostrou-se um recurso auxiliar eficiente no preparo do canal radicular, independentemente da experiência do operador.

REFERENCES

1. Webber J, Moser JB, Heuer MA. A method to determine the cutting efficiency of root canal instruments in linear motion. J Endod 1980;11:829-834.
2. Arroyo MA, Arroguia JJH, Barbero EG. Ayudas en la instrumentación: la pieza de mano Safety-M4. Endodoncia 1998;8:78-82.
3. Haïkel Y, Serfaty R, Bleicher P, Lwin TTC, Allemann C. Effects of cleaning, chemical disinfection, and sterilization procedures on the mechanical properties of endodontic instruments. J Endod 1997;23:15-18.
4. Marshall FJ, Pappin J. A crown-down pressureless preparation root canal enlargement technique. Technique Manual. Portland: Oregon Health Sciences University; 1980.
5. Shäfer E, Zapke KA. A comparative scanning electron microscopic investigation of the efficacy of manual and automated instrumentation of root canals. J Endod 2000;26:660-664.
6. Baumann MA, Roth A. Effect of experience on quality of canal preparation with rotary nickel-titanium files. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;88:714-718.
7. Sonntag D, Guntermann A, Kim SK, Stachniss V. Root canal shaping with manual stainless steel files and rotary Ni-Ti files performed by students. Int Endod J 2003;36:246-255.
8. Kazemi RB, Stenman E, Spangberg LSW. Machining efficiency and wear resistance of nickel-titanium endodontic files. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;81:596-602.
9. Gambill JM, Alder M, Del Rio CE. Comparison of Ni-Ti and stainless steel hand-file instrumentation using computed tomography. J Endod 1996;22:369-375.
10. Sydney GB, Batista A, Melo LL, Matos NHR. Sistemas de rotação alternada em endodontia. J Bras Endod 2000;3:59-64.
11. Koch FB, Barletta FB, Oliveira EPM, Vier FV. Análise *in vitro* da capacidade de corte em função da perda de massa dentinária de limas de NiTi em relação do número de uso. J Bras Endod 2004;5:249-254.
12. Zanetini PR, Barletta FB, Rhade N. *In vitro* comparison of hand and mechanical instrumentation for removal of filling material from root canals. Aust Endod J 2006 (in press).
13. Roane JB, Sabala CL, Duncanson MG. The "balance force" concept for instrumentation of curved canals. J Endod 1985;11:203-211.
14. Chan AWK, Cheung GSP A comparison of stainless steel and nickel-titanium K-files in curved root canals. Int Endod J 1996;29:370-375.
15. Poulsen WB, Dove SB, Del Rio CE. Effect of nickel-titanium engine-driven instrument rotational speed on root canal morphology. J Endod 1995;21:609-612.
16. Tepel J, Schafer E, Hoppe W. Properties of endodontic hand instruments used in rotary motion. Part 1. Cutting efficiency. J Endod 1995;21:418-421.
17. Masiero AV, Barletta FB. Effectiveness of different techniques for removing gutta-percha during retreatment. Int Endod J 2005;38:2-7.
18. Barletta FB; Lagranha, SB. Analisis comparativo in vitro de diferentes tecnicas de desobturación de conductos radiculares. Endodoncia 2002;20:189-196.

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