Original Article / Özgün Araştırma

A CBCT-assisted Evaluation of Single Reciprocating File Instrumentation in Curved Root Canals with a Prior Glide Path Preparation

Eğimli Kök Kanallarında Rehber Yol Oluşturularak Tek Eğeli Resiprokal Eğe ile Gerçekleştirilen Enstrümantasyonun CBCT ile Değerlendirilmesi

Seniha Miçooğulları Kurt, Burcu Şerefoğlu

Ege University Faculty of Dentistry, Department of Endodontics, İzmir, Turkey

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Anahtar Kelimeler
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Address for Correspondence/Yazışma Adresi:
Lect. Seniha Miçooğulları Kurt, MD,
Ege University Faculty of Dentistry,
Department of Endodontics, İzmir, Turkey
Phone :+90 533 650 99 20
E-mail : senemico@hotmail.com
ORCID ID: orcid.org/0000-0001-7843-5686

Abstract

Objective: The primary aim of the current study was to compare the centering ability and transportation of the Reciproc Blue system in curved root canals with and without prior glide path preparation, using cone beam computed tomography (CBCT). Additionally, the amount of time required for root canal instrumentation was also compared.

Materials and Methods: Forty root canals of maxillary molar teeth with curvature angles 30°-40° were included in this *in vitro* study. All root canals were divided randomly into 2 experimental groups (n=20) as follows: group 1: the root canals were instrumented with a Reciproc Blue R25 instrument, and group 2: glide path was prepared with path-file and the root canals were instrumented with a Reciproc Blue R25 instrument. Working times with Reciproc Blue files were recorded for each group. All teeth were scanned with CBCT before and after instrumentation to evaluate the centering ability and transportation. The data were statistically analyzed using the Shapiro-Wilk test and t-test ($p<0.05$).

Results: No significant difference was observed between the tested groups regarding the centering ability and transportation ($p>0.05$). The time required for instrumentation using Reciproc Blue after glide path preparation was statistically less than that without the glide path preparation group ($p<0.001$).

Conclusion: In curved root canals, glide path preparation before instrumentation with the Reciproc Blue file had no effect on the centering ability and transportation. However, the amount of time required for root canal instrumentation with the Reciproc Blue files was significantly decreased when the files were used after the preparation of the glide path by path-files.

Öz

Amaç: Bu çalışmanın birincil amacı, şekillendirme öncesi rehber yol hazırlanan ve hazırlanmayan eğimli kök kanallarında Reciproc Blue sisteminin merkezleme kabiliyetini ve meydana gelen transportasyon miktarını konik ışınlı bilgisayarlı tomografi (KIBT) kullanarak karşılaştırmaktır. Ayrıca her iki grupta kök kanal genişletme süreleri kıyaslanmıştır.

Gereç ve Yöntemler: Bu *in vitro* çalışmaya kırk adet 30°-40° eğrilik açısına sahip kök kanalı dahil edildi. Tüm kök kanalları 2 deney grubuna ayrıldı: 1. grup: path-file ile rehber yol oluşturulduktan sonra Reciproc Blue kanal eğesi ile kök kanal şekillendirmesi gerçekleştirildi, 2. grup: Rehber yol oluşturmaksızın Reciproc Blue kanal eğesi ile kök kanal şekillendirmesi gerçekleştirildi. Her grup için Reciproc Blue eğeleri ile çalışma süreleri kaydedildi. Merkezleme kabiliyetini ve transportasyonu

değerlendirmek için tüm dişler şekillendirmeden önce ve sonra KIBT ile tarandı. Veriler Shapiro-Wilk ve t-testi ile istatistiksel olarak analiz edildi.
Bulgular: Merkezleme kabiliyeti ve transportasyon açısından test edilen gruplar arasında anlamlı bir fark tespit edilmemiştir (p>0,05). Rehber yol oluşturulan grupta Reciproc Blue kanal eğesi ile şekillendirme için gereken sürenin, rehber yol oluşturulmayan gruptan istatistiksel olarak daha az olduğu gözlenmiştir (p<0,001).
Sonuç: Eğimli kök kanallarında, Reciproc Blue eğesi ile şekillendirme öncesinde rehber yol oluşturmanın merkezleme kabiliyeti ve transportasyon üzerinde hiçbir etkisi olmamıştır. Ancak, path-file ile rehber yol oluşturulduğunda Reciproc Blue eğesi ile kök kanalı içindeki çalışma süresi önemli ölçüde azalmıştır.

Introduction

Cleaning and shaping of the root canals are the most important stages that affect the success of the root canal treatment. However, the shaping process may not always be completed in ideal conditions. Although preserving the original root canal anatomy is substantial, deviations from the root canal anatomy such as root canal straightening, transportation and ledging may occur depending on the severity of the root canal curvature and characteristic features of the instruments (1).

The glide path is defined as an access route to the root canal up to the apical foramen (2,3). Glide path creating provides an understanding of the root canal anatomy, permits safer and faster action during root canal instrumentation (4). Glide path creation can be performed with stainless steel hand files as well as using nickel titanium (NiTi) files designed for this purpose. There are several NiTi glide path files (PF) produced with different alloy and cross-section properties. PF; Dentsply Maillefer is a rotary glide path system and manufactured from a conventional NiTi alloy. The system includes three files with .02 taper and ISO 13, 16, 19 tip sizes (1). PF are claimed to better preserve the original root canal anatomy by creating less irregularity in the root canal while preparing the glide path (5).

Reciproc Blue (VDW, Munich, Germany) is a reciprocating NiTi instrument and have S-shaped cross-section. Reciproc Blue files (R25, R40 and R50) are produced with a heat treatment that changes the molecular structure of the alloy and gives the tool a blue color (6). The heat treatment process improves the flexibility and strength of the Ni Ti files.

The aim of this study was to compare centring ability and transportation of Reciproc Blue files with and without glide path by using cone beam computed tomography (CBCT) imaging and to evaluate time required for root canal instrumentation with Reciproc Blue files. The null hypothesis of the study was that preparation of glide path prior to root canal instrumentation would not effect the centring ability and canal transportation of Reciproc Blue system.

Materials and Methods

The current study was approved by the Ege University Faculty of Medicine Clinical Research Ethics Committee (approval number: 18-10.2/42, date: 30.10.2018) and was funded by University Scientific Research Project Fund. An initial power analysis was performed according to a previous study (7) and it was confirmed that a minimum sample size of 16 teeth per group is required (80% power, α=5%).

Selection of Teeth

Mature extracted human maxillary molars without calcified root canals, internal or external resorption, or root fractures were included.

Access cavities were prepared using diamond burs, and the apical patency was confirmed using 10# K-file. In order to measure the root canal curvature, K-type files #10 was placed in the root canals and digital radiographs were taken from all teeth and root canal curvature was measured following Schneider's (8) method using AutoCAD 2007 program (Autodesk Inc., San Rafael, CA, USA). As a result, a total of 40 mesial or distal root with single canal (with canal curvature of 30°-40°) were selected. In order to provide standardization of the position of the teeth before and after root canal preparation, the teeth were placed in a custom-made specimen holder and all radiological and clinical procedures were performed without removing the teeth from this holder.

The teeth were divided into 2 groups as follows:

Group 1. Reciproc Blue: Reciproc Blue files #25 were directly used in root canals without glide path preparation.

Group 2. PF - Reciproc Blue: Reciproc Blue files #25 were used in root canals after creating a glide path by PFs.

CBCT Before Root Canal Instrumentation

The teeth were positioned with the custom-made specimen holder in which each root could be aligned perpendicularly to the beam and placed in the same position on the CBCT device before and after instrumentation, so that reproducible images could be obtained. In order to determine the scanning direction, a small notch was prepared on the crown of each tooth. The roots were scanned before and after instrumentation by using the CBCT [Kodak 9000 three-dimensional (3D)] operating at 64 kV and 6.3 mA; volumes were obtained with 5x3.8 cm field of view (FOV) and with a spatial resolution of 76 mm was selected.

Root Canal Instrumentation

Group 1 (Reciproc Blue): The root canals were prepared directly by using Reciproc Blue #25 files in the Reciproc all mode with an X-Smart plus motor (Dentsply, Maillefer Ballaigues, Switzerland). No glide path was created in this group. A 10 K-file was used with the purpose of determining full working length (WL) according to the manufacturer instructions. Then, root canal instrumentation was performed using the Reciproc Blue R25 instrument with a slow in-and-out pecking motion. The amplitude limit of the file was approximately 3-4 mm with a very light pressure. After every third pecking, the file was removed from the canal and the root canal was rinsed with 2 mL 2.5% sodium hypochlorite. This procedure was followed until WL was reached.

Group 2 (PF - Reciproc Blue): path-files #1-3 were used for glide path creation with copious 2.5% sodium hypochlorite irrigation. Next, the root canals were prepared using Reciproc Blue #25 files as same as group 1.

One experienced operator completed all root canal instrumentation (S.M.K.). During the instrumentation procedure, each root canal was irrigated at 2 mm shorter than the WL using a closed ended side-vented needle (30-G) (Kerr Hawe Sa, Bioggio, Switzerland). Time required for root canal instrumentation with Reciproc Blue files were also recorded and compared.

CBCT After Root Canal Instrumentation

The teeth with the custom-made specimen holder were placed at the same position on the CBCT device and were scanned under the same conditions used before instrumentation. For both groups, the degree of transportations and centring ability that were created during instrumentation were measured using the CS 3D imaging software program (Figure 1).

Transportation and Centring Ability Evaluation

Canal transportation was calculated at 3 mm and 5 mm distance from the apex according to the following formula;

Degree of canal transportation = (a1-a2) - (b1-b2)
= (c1-c2) - (d1-d2)

a1, b1, c1, d1: The shortest distance between the mesial, distal, buccal and palatal wall of the canal and the mesial outer surface of the root, respectively, before instrumentation.

a2, b2, c2, d2: The shortest distance between the mesial, distal, buccal and palatal wall of the canal and the mesial outer surface of the root, respectively, after instrumentation.

A result of 0 indicates that no transportation has occurred; all other results indicate that transportation has occurred.

Centring ability was calculated with the following formula:

(a1-a2)/(b1-b2) or (b1-b2)/(a1-a2) and (c1-c2)/(d1-d2) or (d1-d2)/(c1-c2)

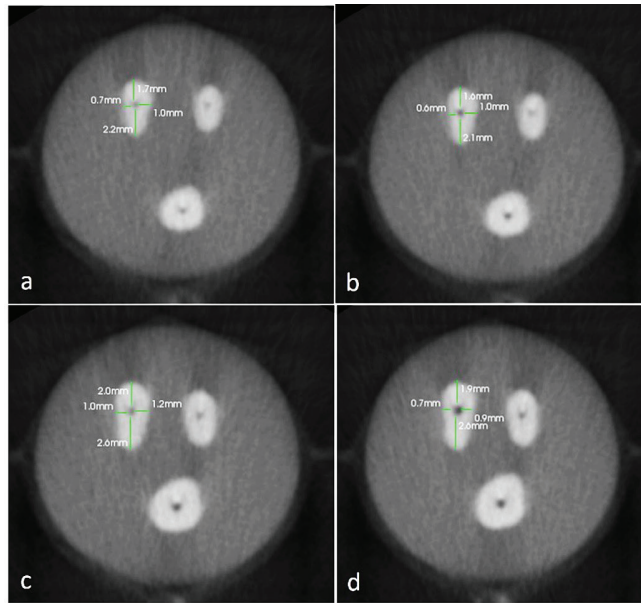

Figure 1. Representative CBCT images of 3 mm (a and b) and 5 mm (c and d) cross sections before (a and c) and after (b and d) preparation
CBCT: Cone beam computed tomography

According to this formula, a value of '1' indicates that the root canal remains completely in the centre, while other values indicate that the direction of the root canal has changed.

Statistical Analysis

The statistical analysis was performed with the GraphPad prism version 6.0 for Windows package program (GraphPad Software, LA Jolla California, USA). The Shapiro-Wilk test was used to determine the normal distribution of continuous variables. Centring ability, transportation and working time comparisons were analysed using the t-test. All analyses were performed at $p<0.05$ statistical significance level.

Results

Amount of time required for canal preparation: Time required for root canal instrumentation using Reciproc Blue after creating a glide path (66.2±11.8 seconds) was found to be statistically significantly lower than in the group without a glide path preparation (89.4±11.6 seconds) ($p<0.001$).

Transportation results: Mean, standard deviation and p-values of transportation for both 3 and 5 mm sections are shown in Table 1. No statistically significant difference was observed between the groups for both directions in transportation findings in both 3 mm and 5 mm sections ($p>0.05$).

Centring ability results: Mean, standard deviation and p-values of centring ratio for both 3 and 5 mm sections are shown in Table 2. There was no statistically significant difference between the groups in terms of centring ratio in each section ($p>0.05$).

Table 1. Mean canal transportation (mm ± standard deviation) at 3 and 5 mm after preparation with Reciproc Blue and path-file + Reciproc blue

	Direction	Reciproc Blue	Path file + Reciproc Blue	p-value
3 mm	Mesio-distal Bucco-palatal	0.030±0.172 0.040±0.169	0.035±0.159 0.005±0.198	0.924 0.446
5 mm	Mesio-distal Bucco-palatal	0.015±0.153 0.010±0.177	0.005±0.153 0.060±0.153	0.682 0.346

Table 2. Mean centring ability (mm ± standard deviation) at 3 and 5 mm after preparation with Reciproc blue and path file + Reciproc Blue

	Direction	Reciproc Blue	Path file + Reciproc Blue	p-value
3 mm	Mesio-distal Bucco-palatal	0.45±0.406 0.52±0.422	0.35±0.378 0.43±0.431	0.415 0.498
5 mm	Mesio-distal Bucco-palatal	0.54±0.391 0.47±0.45	0.40±0.377 0.44±0.46	0.227 0.851

Discussion

This *in vitro* study was carried out to examine whether the creating a glide path before instrumentation influences the level of transportation and centring ability of the Reciproc Blue file in curved root canals. According to the results, the null hypothesis was rejected in terms of time required for root canal instrumentation, which was significantly shortened by the prior preparation of glide path. However, null hypothesis was accepted regarding canal transportation and centring ability of reciprocal instruments with or without prior preparation of glide path.

In the current study, mesio- and disto-buccal roots of extracted maxillary molars were included. Schneider's (8) method is one of the methods frequently used in studies was preferred for canal curvature measurement (9,10), where root canal curvature greater than 25° is defined as severely curved root canals. Since the severity of the root canal curvature carrying a potential complication risk during root canal instrumentation (11); teeth with a curvature of 30°-40° were included. Nevertheless, radius of curvature was not measured, only teeth with visually similar radii of curvature were included. Due to the roots measured at the same angle in degrees can have different radii or abrupt curvature, using Schneider method can be seen as a possible limitation of the present study.

The most used method to compare before and after instrumentation is obtaining standard periapical radiographs and overlapping these radiographs with computer programs (12,13), however, the most important disadvantage of the method is that the radiographs are 2D. In most studies, this disadvantage has been avoided by using CBCT and micro-CT as imaging methods (9,10,14,15). Although micro-CT is considered as the most valid method in this field, it was reported that it is possible to examine and compare root canal anatomy before and after instrumentation using CBCT (14). For this reason, in the current study, CBCT, which is a more accessible method, allows 3D imaging and is frequently used in transportation studies, was preferred to use (7,15,16). It was observed that different analysis parameters

(FOV area, section thickness) were used in studies where instrumentation efficiency was examined using CBCT. Elnaghy and Elsaka (15) determined the FOV area to be 8x8 cm please and the slice thickness to be 0.125 mm, while Mouro-Netto et al. (16) determined the FOV area as 16x4 cm and the section thickness as 0.125 mm. In our study, the FOV area was used as 5x3.8 cm and the section thickness as 0.076 mm, providing higher resolution than thicker slices and larger FOVs.

When the time required for canal instrumentation was evaluated Reciproc Blue files was found to be significantly faster if the glide path was prepared. Similar to our study, Vorster et al. (17), was evaluated the duration for WaveOne Gold file instrumentation in root canals, reported that time required for instrumentation with the Wave One Gold files was significantly reduced after a glide path preparation.

In studies focusing transportation, the measurement regions differ while there are studies (15,18,19) that take cross-sections from apical, middle, and coronal parts, there are also studies that evaluate apical 1, 2, 3, 4, 5 mm sections by considering only apical transportation (20). In a study transportation was evaluated using 3, 5, 7 mm sections but, the degree of transportation was measured in apical 3 and 5 mm sections only (15). Bucco-palatal transportation in addition to the mesio-distal direction were also examined in the current study. In each group, small transportation with no significant differences between the groups were obtained both at 3 mm and 5 mm cross sections. Preparation of the glide path using the path-files had no effect on the transportation values at the apical 3 and 5 mm after the instrumentation using the Reciproc Blue files. While in some studies, it was reported that Reciproc and Reciproc Blue files would cause less transportation when a glide path was created before instrumentation in curved root canals (4,7), de Carvalho et al. (9) concluded that performing a glide path before using the Reciproc file had no effect on transportation like our study. The reason for the lack of difference between the groups and the very low transportation degrees in the current study may be the use of the Reciproc Blue canal file, which works with reciprocating motion and has advanced metallurgical properties. Additionally, no significant difference was observed between the groups in terms of centring ability both in mesio-distal and bucco-palatinal directions at both levels of cross sections which means that the use of path-file has no effect on centring ability of Reciproc Blue instrument. While Hage et al. (7) reported that glide path creation improved the centring ability of Reciproc and Reciproc Blue files, some studies showed that a glide path preparation has no effect on centring ability of reciprocating instruments (9,17). Actually, results of present study are in line with the manufacturer instructions in which M-Wire Reciproc Blue instruments are recommended to use without any prior step for root canal instrumentation.

Conclusion

Within the limitations of the current study, glide path preparation prior to shaping with Reciproc Blue file had no effect on centring ability and transportation. However, time required for root canal instrumentation was significantly decreased when the Reciproc Blue file was used after glide path preparation using path files.

Ethics

Ethics Committee Approval: The current study was approved by the Ege University Faculty of Medicine Clinical Research Ethics Committee (approval number: 18-10.2/42, date: 30.10.2018)

Informed Consent: *In vitro* study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: S.M.K., B.Ş., Concept: S.M.K., Design S.M.K., Data Collection or Processing: S.M.K., B.Ş., Analysis or Interpretation: S.M.K., B.Ş., Literature Search: S.M.K., Writing: S.M.K., B.Ş.

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