EFFECTIVENESS OF DIFFERENT SHAPING AND FILLING TECHNIQUES IN OVAL-SHAPED ROOT CANALS

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ABSTRACT

Background and Aim: The aim of this study was to compare the effectiveness of different shaping and filling techniques in oval shaped root canals.

Material And Methods: 150 single-root extracted premolar teeth with oval shaped canals were used in this study. The roots were instrumented using the Reciproc system (n:75) or step-back technique (n:75) and then, subdivided into five groups according to the filling technique; lateral condensation, Microseal, Obtura, System B, Soft-Core. The specimens were scanned using cone-beam computed tomography. Percentage volume of gutta-percha & sealer and void in the coronal, middle, apical thirds of each canal were measured using OnDemand3D-App software program.

Results: When shaping techniques were compared, the teeth shaped with step-back technique showed statistically higher percentage of filling material than teeth shaped with Reciproc system (p<0.05). In terms of obturation techniques, lateral condensation showed statistically the higher percentage filling material than Soft-Core technique in the middle and coronal sections and no statistically significant difference was detected among other groups (p<0.01).

Conclusions: According to findings of this study although all filling techniques were found to be effective in obturation of oval shaped canals, lateral condensation technique resulted more gutta-percha & sealer content than Soft-Core technique.

Keywords: Cone-Beam Computed Tomography, Lateral Condensation, Oval Canal, Reciproc System, Soft-Core


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OVAL ŞEKİLLİ KANALLARIN FARKLI ŞEKİLLENDİRME VE DOLGU TEKNİKLERİ İLE DOLDURULMA ETKİNLİĞİNİN İNCELENMESİ

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ÖZ

Amaç: Bu çalışmanın amacı, oval şekilli kanallarda farklı şekillendirme ve dolgu teknikleri kullanılarak bu tekniklerin etkinliklerinin karşılaştırılmasıdır.

Gereç ve Yöntem: Çalışmada oval kanal varlığı tespit edilmiş 150 adet çekilmiş tek köklü premolar diş kullanılmıştır. Step back tekniği ve Reciproc döner alet sistemi kullanılarak şekillendirilen dişler sonrasında; lateral kondansasyon, Microseal, System B, Obtura ve Soft-Core teknikleri ile beraber kerr kanal patı kullanılarak doldurulup 5 alt guruba ayrılmıştır. Konik ışını bilgisayarlı tomografiyle axialden elde edilen görüntülerde her numununun apikal, orta ve koronalden kesitler alınıp bu kesitlerde kanal dolgusu (güta-perka + pat) ve boşluk alanların yüzdeleri hesaplanıp istatistiksel olarak karşılaştırılmıştır.

Bulgular: Şekillendirme teknikleri karşılaştırıldığında, step-back tekniği ile şekillendirilmiş dişlerdeki kanal dolgu oranı reciproc tekniğine göre istatistiksel olarak anlamlı derecede yüksek bulunmuştur. Dolgu teknikleri karşılaştırıldığında, lateral kondansasyon tekniği ile doldurulan dişlerde kanal dolgu oranı soft-core ile doldurulan dişlere göre orta ve koronal bölgede istatistiksel olarak anlamlı derecede yüksek bulunmuştur. Diğer dolgu teknikleri arasında istatistiksel olarak anlamlı fark bulunmamıştır (p<0.01).

Sonuç: Bu çalışmanın bulgularına göre oval şekilli kanalların doldurulmasında tüm dolgu teknikleri başarılı olmasına karşın, lateral kondansasyon tekniği Soft-Core tekniğinden daha yüksek oranda güta-perka ve pat içeriği sahiptir.

Anahtar Kelimeler: Konik ışını bilgisayarlı tomografi, Lateral kondansasyon, Oval Kanal, Reciproc Sistem, Soft-Core


Orijinal Araştırma
INTRODUCTION

An effective mechanical shaping in root canal treatment is the most important component of success preceding the canal filling process. Circular cross section tapering from coronal to apical; in other words conic root form is ideal; however, cross section of the canal such as oval, ellipsoid or sunglass may be encountered in the ideal circular shape.1 Wu et al.2 reported a high percentage of oval shaped canals in the apical 5 mm in human teeth (250%) with their diameter decreased apically. These canal shapes may make it difficult to clean and shape before canal filling. Studies have shown that the recesses in 40% of oval canals were neither instrumented nor completely filled. Inadequate shaping and filling of irregular canals may negatively influence the root canal treatment.1,2

Many preparation techniques and instruments have been used to facilitate the instrumentation of oval canals as conventional techniques, Ni-Ti systems, techniques involving sonics and ultrasonics, and systems operating with reciprocating movement.3,4,5,6 However, it has been reported that none of these techniques could form strictly oval canals and that un-instrumented recesses may remain.1,2 Different anatomic variations like oval-shaped canals, are hard to instrument and fill in.1 It has been determined that it may be difficult to instrument the entire wall of a tooth with oval-shaped canals and that un-instrumented recesses may remain.1 Therefore, the effectiveness of various techniques has been explored using different filling techniques in the studies of oval-shaped canals.2,12,13 Lateral condensation of the gutta-percha is one of the most accepted root canal obturation methods. However, it was reported that at no time does a homogeneous mass of gutta-percha develop when lateral condensation technique is used. For this reason, the thermoplasticized gutta-percha technique was developed to overcome the disadvantages of lateral condensation technique. Although each technique has specific benefits and handicaps, success rate in using different type of root canals is variable.1,11 Different anatomic variations like oval-shaped canals, are hard to instrument and fill in.1 It has been determined that it may be difficult to instrument the entire wall of a tooth with oval-shaped canals and that un-instrumented recesses may remain.1 Therefore, the effectiveness of various techniques has been explored using different filling techniques in the studies of oval-shaped canals.2,12,13

Up to the present, different methods (radiography, leak testing, radioisotopes, microscopic analysis, SEM analysis, computed tomography, micro-CT, cone-beam computed tomography) have been used in the determination of the quality of the root canal filling.1,4,13,15,16,17 Cone-beam computed tomography (CBCT) has been used in recent years in the practice of endodontics. It has been used in many areas to identify root resorption and root perforation, as well as for the evaluation of root canal morphology, diagnosis of periapical lesions and monitoring of prognosis, diagnosis of root fracture, evaluation of preoperative surrounding tissue and in determining the results of endodontic treatment. CBCT device is also used to detect the cavities between gutta-percha and the canal walls in the determination of the canal filling quality, allowing a 3-dimensional evaluation.18,19

The aim of this study is to assess and compare the effectiveness of Reciproc system and step-back technique, as well as obturation techniques (lateral condensation, Miroseal, System B, Obtura and Soft-Core) in oval shaped canals using cone-beam tomography.

MATERIAL AND METHODS

This in-vitro study was conducted with 150 oval-canal teeth selected from 215 single-rooted maxillary and mandibular premolars (This study was approved by the Research Ethics Committee of Marmara University). Radiographs of bucco-lingual and mesio-distal of each tooth were taken and short diameter of ≥1,5 at a level 5 mm. from the apex was accepted as an oval canal in the study. The crowns were removed at the level of the CE using a cylindrical diamond burr (Medin, Vlachovicka, Czech). Access cavity was prepared and working length was established by detecting 1 mm from the actual canal length using a 15 K-file (Mani Inc. Japan).

150 teeth were divided into two groups (75 each) and instrumented by Step-back technique or using Reciproc rotary system (VDW GmbH, Munich, Germany).

Group 1: Seventy five canals were shaped by step-back technique. Firstly, apical thirds were prepared using K and H type file from size 15-40 file, and irrigation was performed by 2ml of 5.25% NaOCl in each file. Following apical preparation, the canals were flared with # 45, 50, 55, 60, 70, 80 K files in step-back fashion with 2, 3, 4, 5, 6 and 7 mm short of the working length, respectively. The recapitulation was accomplished by # 40K-file. Further coronal enlargement was accomplished with # 3 and 4 Gates-Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland). The smear layer was removed by using 2 ml of 17% EDTA solution followed by 2ml 5.25% NaOCl. Final rinse was accomplished with 2ml of saline solution. Following irrigation, canals were dried with paper points (Diadent-Absorbent Paper Points, Seoul, South Korea).

Group 2: Seventy-five canals were shaped using Reciproc rotary Ni-Ti system (VDW GmbH, Munich, Germany). Each tooth was prepared at the working length from coronal to...
apical using 0.6 taper R40 Ni-Ti file of Reciproc system. Glide gel (Dentsply Maillefer, Ballaigues, Switzerland) was applied with 1.5 K-type file for lubrication. Canal irrigation was performed using 2ml of 5.25% NaOCl during and after instrumentation. After irrigation with 2 ml of 1.7% EDTA and 2ml of 5.25% NaOCl, each canal was rinsed with 2 ml saline solution and dried with paper points.

The teeth were then subdivided into 5 groups (15 of each) and obturated via five different techniques (lateral condensation, Microseal, System B, Obtura, Soft-Core).

**Obturation of the Root Canals**

**Lateral condensation technique** #40 gutta-percha master cone (Diadent, Choongchong Buk Do, Korea) was fitted within 0.5 mm of working length. Control radiograph was taken, and freshly mixed pulp canal sealer was applied (EWT, Kerr, Sorbon, Romulus, MI, A.B.D.) using a K file in a counter clockwise rotation. The master cone was lightly coated with sealer and placed into the canal. For condensation, standardized finger spreaders (Dentsply Maillefer, Ballaigues, Switzerland) were used. When the points prevented the spreaders from penetrating beyond the coronal third of the canal, the canal was considered to be adequately filled. Radiograph was taken and excess gutta-percha was cut with a hot instrument.

**Microseal technique** (Analytic, Sybron Dental Specialties, CA, USA): No. 40 MicroFlow master cone (Analytic, CA., USA) was used to achieve tug back. An appropriate spreader and mechanical condenser were selected. Then, Kerr sealer was applied to the canal wall using a file, and the master gutta-percha cone coated in sealer was positioned. The spreader was inserted alongside the master cone at the appropriate length for compaction. An appropriate compactor was inserted in the heated gutta-percha cartridge and was coated with a uniform layer of gutta-percha. Gutta-percha coated compactor was then placed as close to the working length as possible, avoiding rotation while being inserted. The compactor was applied for 2 s. at a speed of 6000 rpm to the root canal, after which it was removed slowly while rotation was continuing. More gutta-percha was placed on the compactor in order to fill spaces in the canal. This procedure was continued until the canal was filled completely. After control radiograph was taken, the excess gutta-percha and sealer were removed from the access cavity.

**System B technique** (Analytic, Sybron Dental Specialties, CA, USA): A medium-large master cone which bounds in the canal 3 mm from working length was used. Sealer was applied to the canal walls and master cone was inserted. The System B unit was preset at 200°C during the apical condensation of master cone. Then the unit was set to 100°C to condense secondary gutta-percha cones. Finally, the rest of the secondary cones were condensed using the system at 250°C.

**Obtura System** (Analytic, Sybron Dental Specialties, CA, USA): The sealer was applied to the canal walls. Obtura device was set to 200°C and # 25 gauge needle (Analytic, Sybron Dental Specialties, CA, USA) was selected and inserted into the canal 3-5 mm short of working length. The trigger was pressed allowing the molten gutta-percha, and the tip was withdrawn slowly from the canal. Then, an appropriate plug was used to condense apical segment. Backfilling was done by application of thermoplasticized gutta-percha in 4-5 increments. Finally, plugger was used to condense coronal section.

**Soft-Core System** (Kerr, Bioggio, Switzerland): After checking the root canals with 40 size verifier, # 40 Soft-Core obturator was selected. The sealer was applied to the canal walls using a file, and warmed Soft-Core obturator was inserted in the apical stop. After completion of the obturation, the handle and insertion pin were removed with a small round burr. After canal obturation, temporary filling (Citodur, Septodont, Switzerland) was placed to access cavities and all teeth were stored in 100% humidity at 37°C for a week. Then, obturated canals were analyzed using cone-beam computed tomography.

**Analysis of filled root canals by cone-beam computed tomography**

All specimens were embedded in a foam mold for stabilization. Cranex 3D-endo device (Soredex, Tuusula, Finland) with parameters 6mA, 89kVp was used to scan the specimens from coronal to apical section with 0.1 mm sequential slices. Images were obtained from coronal, axial and sagittal oblique planes in DICOM format after scanning. Images of coronal, middle and apical thirds of each tooth were selected using OnDemand3D-App program (version 1.0). Also, obturated area (gutta-percha & sealer) and voids of each image were measured through this program (Figure 1).

**Statistical Analysis**

Statistical analysis was performed using the SPSS (Statistical Package for Social Sciences) Windows 15.0
Different Shaping and Filling Techniques in Oval Canals

Two-way analysis of variance (ANOVA) was conducted to determine the effects of instrumentation and filling techniques respectively in the apical, middle, and coronal section; and to observe the interaction of these two factors on the filling quality. All pairwise multiple comparison procedures were performed using Tukey HSD test (p<0.05).

RESULTS

When comparing percentages of filling materials (gutta-percha and sealer) according to the instrumentation and filling techniques, no statistical difference was found in the apical section (p>0.05), but joint effects of these were found statistically significant (Table 1, p<0.05). There were significant differences among percentages of filling material with regard to the instrumentation techniques in the middle section (Table 1, p<0.05). There were no significant differences among percentages of filling material according to the instrumentation techniques in the coronal section (p>0.05), but there were significant differences among percentages of filling material with regard to the filling techniques (p<0.01). On the other hand, the joint effects of instrumentation and filling techniques were found statistically significant (Table 1, p<0.05).

When comparing the filling techniques independently from the root thirds, a statistically difference was only found between lateral condensation and Soft-Core techniques (p<0.01). According to this, lateral condensation technique showed statistically higher percentage of filling material than Soft-Core technique (p<0.01) and no statistically significant difference was detected among the other groups (p>0.05).

All volume percentage values of five obturation techniques at different levels of oval canals are summarized in Table 2 (Fig. 1). When we were compared according to levels of the instrumented teeth by step-back, lateral condensation all technique showed statistically better result in the coronal (p<0.01) and middle sections (p<0.05) than Soft-Core system. Microseal technique showed statistically more gutta-percha & sealer content in apical section than System B and Obtura system when instrumented with step-back (p<0.05). System B technique showed statistically more gutta-percha & sealer content in coronal section than Microseal technique when instrumented with Reciproc system (Table 2, p<0.01).

When the two instrumentation techniques were compared, the teeth instrumented using step-back technique showed statistically more gutta-percha and sealer content than with Reciproc instrument (p<0.05).

DISCUSSION

Although many instruments and techniques were used for oval canal preparation, it is indicated that none of the instrumentation techniques completely prepared oval canals. In the literature, most of the study results related to efficiency of instrumentation techniques in oval canals, hand instrumentation provided better cleaning efficiency than rotary instrumentation. Gökyay compared H-file, ProTaper system and Hero-Shaper in oval canals and found that Hero-Shaper system files touched canal outlines the least. Barbizam et al. also found that hand instrumentation of oval canals provided better results than rotary instrumentation. Wu et al. compared two hand instrumentation techniques (balanced force and circumferential filing) in shaping oval canals and found that even circumferential files removed more dentin than balanced force. However, they indicated that both techniques left large portions of the canal wall uninstrumented. Despite the development of canal instruments and shaping systems in endodontics, root canal systems, especially in oval canals, have not been sufficiently shaped. The main reason for this has been the thought that canal tools were geometrically incompatible with root canals. Most rotary systems are in a circular canal form regardless of the canal type and form, but hand tools used for rotational and linear movement can move around the oval canal. Although better results were obtained using hand instruments, none of the studies indicated that oval

Figure 1. Percentage of canal filling and void areas at section taking from apical 1/3 in Soft-Core technique with OnDemand3D-App program
### Table 1. Evaluation with Two-way ANOVA test of the effect on the filling quality (gutta-percha and sealer) of instrumentation and filling techniques in the root thirds

<table>
<thead>
<tr>
<th>Section</th>
<th>Source of variation</th>
<th>(Sum of Squares) SS</th>
<th>(Degrees of freedom) df</th>
<th>(Mean Square) MS</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Instrumentation technique</td>
<td>14.516</td>
<td>1</td>
<td>14.516</td>
<td>0.450</td>
<td>0.504</td>
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<tr>
<td>Apical</td>
<td>Filling technique</td>
<td>255.363</td>
<td>4</td>
<td>63.841</td>
<td>1.978</td>
<td>0.101</td>
</tr>
<tr>
<td></td>
<td>interaction</td>
<td>372.859</td>
<td>4</td>
<td>93.215</td>
<td>2.888</td>
<td>0.025*</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>4356.719</td>
<td>135</td>
<td>32.272</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1178678.951</td>
<td>145</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrumentation technique</td>
<td>166.279</td>
<td>1</td>
<td>166.279</td>
<td>5.422</td>
<td>0.021*</td>
</tr>
<tr>
<td>Middle</td>
<td>Filling technique</td>
<td>327.599</td>
<td>4</td>
<td>81.900</td>
<td>2.671</td>
<td>0.035*</td>
</tr>
<tr>
<td></td>
<td>interaction</td>
<td>119.699</td>
<td>4</td>
<td>29.925</td>
<td>0.976</td>
<td>0.423</td>
</tr>
<tr>
<td></td>
<td>Error</td>
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<td>140</td>
<td>30.667</td>
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</tr>
<tr>
<td></td>
<td>Total</td>
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<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrumentation technique</td>
<td>81.551</td>
<td>1</td>
<td>81.551</td>
<td>2.782</td>
<td>0.098</td>
</tr>
<tr>
<td>Coronal</td>
<td>Filling technique</td>
<td>411.229</td>
<td>4</td>
<td>102.807</td>
<td>3.507</td>
<td>0.009**</td>
</tr>
<tr>
<td></td>
<td>interaction</td>
<td>355.757</td>
<td>4</td>
<td>88.939</td>
<td>3.034</td>
<td>0.020*</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>4045.833</td>
<td>138</td>
<td>29.318</td>
<td></td>
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<tr>
<td></td>
<td>Total</td>
<td>1139184.765</td>
<td>148</td>
<td></td>
<td></td>
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</tr>
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</table>

* p<0.05   ** p<0.01

### Table 2. Percentages of canal area filled with gutta-percha & sealer of root thirds by obturation techniques (%)

<table>
<thead>
<tr>
<th>Obturation T.</th>
<th>Instrumentation T.</th>
<th>Apical Mean±SD</th>
<th>Middle Mean±SD</th>
<th>Coronal Mean±SD</th>
<th>TOTAL Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral condensation</td>
<td>step-back(n:15)</td>
<td>92.41±5.49</td>
<td>93.15±3.68</td>
<td>92.03±5.85</td>
<td>92.54±4.98</td>
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<tr>
<td></td>
<td>Reciproc (n:15)</td>
<td>89.15±6.98</td>
<td>90.94±4.30</td>
<td>87.73±5.70</td>
<td>89.27±5.79</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.166</td>
<td>0.141</td>
<td>0.049*</td>
<td></td>
</tr>
<tr>
<td>Microseal</td>
<td>step-back(n:15)</td>
<td>93.41±4.19</td>
<td>91.59±3.87</td>
<td>89.07±4.28</td>
<td>91.36±4.41</td>
</tr>
<tr>
<td></td>
<td>Reciproc (n:15)</td>
<td>89.75±6.46</td>
<td>87.45±5.69</td>
<td>83.47±5.49</td>
<td>86.89±6.33</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.076</td>
<td>0.027*</td>
<td>0.004**</td>
<td></td>
</tr>
<tr>
<td>System B</td>
<td>step-back(n:15)</td>
<td>88.18±4.50</td>
<td>89.46±5.51</td>
<td>87.52±5.21</td>
<td>88.41±5.04</td>
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<tr>
<td></td>
<td>Reciproc (n:15)</td>
<td>93.18±4.37</td>
<td>88.86±5.61</td>
<td>90.49±4.25</td>
<td>90.79±5.01</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.006**</td>
<td>0.773</td>
<td>0.103</td>
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<tr>
<td>Obtura</td>
<td>step-back(n:15)</td>
<td>87.90±5.21</td>
<td>91.37±5.79</td>
<td>87.20±6.78</td>
<td>88.82±6.11</td>
</tr>
<tr>
<td></td>
<td>Reciproc (n:15)</td>
<td>88.75±6.06</td>
<td>91.74±6.46</td>
<td>87.50±6.56</td>
<td>89.36±6.49</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.694</td>
<td>0.871</td>
<td>0.902</td>
<td></td>
</tr>
<tr>
<td>Soft-Core</td>
<td>step-back(n:15)</td>
<td>89.47±5.21</td>
<td>90.13±5.75</td>
<td>85.77±3.63</td>
<td>88.43±5.21</td>
</tr>
<tr>
<td></td>
<td>Reciproc (n:15)</td>
<td>87.39±7.27</td>
<td>86.18±7.56</td>
<td>84.97±5.56</td>
<td>86.18±6.77</td>
</tr>
</tbody>
</table>

Same superscripts indicate statistically significant differences among all pair-wise comparisons. P values with asterisks indicate the difference between instrumentation techniques in each row (Tukey HSD test, *p<0.05, **p<0.01).
canals were fully shaped. The results of present study were consistent with previous studies. In the present study, obturated area after instrumentation was measured and hand instrumentation by step-back technique showed more gutta-percha & sealer than rotary reciproc instrumentation in oval shaped canals. However, none of the specimen was free of voids.

Oval canal obturation was investigated in some studies in the literature. Oval canal obturation was investigated in some studies in the literature. However, a few studies were performed to evaluate the effect of instrumentation on obturation techniques in oval canals. Lateral condensation technique was used in some studies in obturation of the oval canals; however, the success of this technique is still controversial. Wu et al. instrumented oval canals using balanced force technique by Flexofile, obturated by warm gutta-percha or lateral condensation technique. They found warm gutta-percha technique was superior to lateral condensation at 4 mm. from the apex. Keleș et al. used Revo-S Ni-Ti instruments for shaping of oval canals obturated by cold or warm vertical condensation technique and found warm vertical condensation technique was superior to lateral condensation. In the present study, no statistical difference was found among warm gutta-percha techniques and lateral condensation except with Soft-Core technique. Soft-Core technique was found to provide lower content of filling than lateral condensation in the middle and coronal sections. Ozawa et al. also found that lateral condensation technique was superior to Thermafil technique after shaping with ProTaper instruments in the middle third of oval canals. This was because round shape core material with surrounding gutta-percha was not sufficient to fill oval shape root canal. However, laterally or vertically condensed gutta-percha is more effective in filling oval shaped canals in the middle and coronal sections. In this study, we also observed that statistical difference was not found in apical section among obturation techniques where the canal shape was predominantly round, and the filling material was generally well adapted to the canal wall in all techniques. However, oval shape is predominant in middle and coronal sections, and the study found that only lateral condensation technique showed better results than Soft-Core technique in the middle and coronal thirds of the canal. It seemed that laterally or vertically condensed gutta-percha techniques were more effective than core technique in the middle and coronal sections in oval canals.

Cone-beam computed tomography (CBCT) can be used for determination of canal filling quality, allowing a 3-dimensional assessment and detection the gaps between gutta-percha and canal walls. In the present study, cone beam computed tomography (Cranex 3D-endo) was used to investigate obturation techniques. However, the sealer which was used in this study, cannot be distinguished from gutta-percha when taking images with this device. Not many studies have been published about the usage of CBCT to investigate root canal filling quality. Kamburoğlu et al. used four different CBCT devices to determine the quality of canal filling. They found that Veraviewepocs 3D was the best and Iluma device was the worst in terms of the quality of images. In the present study, Cranex 3D-endo device (Soredex, Tuusula, Finland) was used to determine the canal filling quality. Further research is necessary for determination of canal filling quality and comparison of the efficiency of filling techniques with CBCT devices.

CONCLUSIONS

According to the results of this study, hand instrumentation by step-back technique offered better results than Reciproc Ni-Ti rotary system after being obturated by different gutta-percha techniques. Although all filling techniques resulted in some voids in oval canals, lateral condensation technique or vertical condensation techniques are preferable rather than Soft-Core technique.

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REFERENCES

CLINICAL DENTISTRY AND RESEARCH


