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ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA

Fracture Resistance of Roots Obturated by Different Techniques After the Removal of Broken Instruments

Kırık kanal eğelerinin kök kanalından çıkarılması sırasında kullanılan yöntemler sonrasında değişik kök kanal dolguları ile doldurulmuş dişlerin kırılma dirençlerinin incelenmesi

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Abstract

Aim: The aim of this study was to evaluate the effect of different obturation techniques on vertical root fracture resistance after the removal of broken instruments using ultrasonic tips and the Masserann kit.

Material and Method: Three-hundred-forty-two extracted single and straight roots were used. All canals were prepared to a size using ProTaper F1 instruments and divided into three experimental and two control groups. 4 mm.of F2 instruments were fractured in coronal, middle or apical third of the canal. The fractured instruments were removed using ultrasonic tips or Masserann kits. The groups were divided into 3 sub-groups based on the obturation methods including lateral condensation,the warmed gutta-percha technique (SystemB+Obtura) and Resilon&Epiphany sealer.

Findings: The samples were subjected to a continous vertical loading, using Instron for vertical fracture. Data were analysed using a one-way Anova and Post Hoc Tukey tests.

The roots from which the broken instruments had been removed using ultrasonic tips required significantly more force for fracture than the roots in the Masserann group in the middle and apical sections ($p<0.05$), but not the coronal section ($p>0.05$). The groups which were obturated with the Resilon system required significantly more force for fracture than the lateral condensation group ($p<0.05$). Lateral condensation showed the least resistance at the middle section in the Masserann group ($p<0.05$).

Results: Removal of a fractured instrument from the middle and apical third of the canal decreased the force required to fracture the root vertically, regardless of the technique used for instrument removal.

Keywords: Fractured instrument; Instrument removal; Masserann Kit;Ultrasonics, Resilon

Öz

Amaç: Bu çalışmada, dişlerin kök kanalında farklı bölgelerinde kırılan Ni-Ti eğeler iki farklı yöntem ile çıkarılmış ve değişik kanal dolgu yöntemleri ile doldurularak kırılma dirençleri incelenmiştir.

Gereç ve Yöntem: Bu çalışmada 342 adet tek köklü çekilmiş diş kullanılmıştır. Kuron kısmı kesildikten sonra 13mm boyuna getirilen kanallar ProTaper F1 eğesi ile genişletilmiş ve üç deney grubu ile iki adet kontrol(pozitif ve negatif) grubuna ayrılmışlardır. Pozitif kontrol grubu hariç, diğer gruptaki köklerin kuronal orta veya apikal bölgelerinde 4mm.lik Protaper F2 kanal aleti köklerin kırılmış ve kırılan aletler ultrasonik yöntem veya Masserann Kit kullanılarak çıkartılmıştır. Bunu takiben kök kanaları, lateral kondensasyon, SistemB+Obtura veya Epiphany+Resilon ile doldurulmuşlardır. Daha sonra, dişlerin kırılma dirençleri İnstron cihazı kullanılarak ölçülmüş ve veriler Tek yönlü varyans analizi ve Tukey testi kullanılarak istatiksel olarak değerlendirilmiştir.

Bulgular: Alet kırılmayan pozitif kontrol grubu kırık alet çıkarılan bütün deney gruplarından anlamlı derecede daha dirençli bulunmuştur($p<0.05$).Kırık aletin çıkarılıp doldurulmayan negatif kontrol grubu, doldurulan diş gruplarından daha az dirençli oldukları görülmüştür. Kökün orta ve apikal 1/3 kısımda ultrasonik yöntem uygulanan dişler Masserann uygulananlardan istatistiksel olarak daha dirençli bulunmuşlardır ($p<0.05$).ancak kuronalde bu fark istatistiksel olarak anlamlı bulunmamıştır($p>0.05$).Resilon sistem ile doldurulan dişler, lateral kondensasyonla doldurulan dişlerden daha dirençli görülürken, ısıtılmış güta-perka tekniği ile arada istatistksel olarak bir fark görülmemiştir ($p>0.05$).Orta kısımda Masserann uygulanıp lateral kondensasyon ile doldurulan dişler diğer dolgu tekniklerinden daha az dirençgöstermişlerdir. ($p<0.05$).

Sonuçlar: Kırık alet çıkarma işlemi kılllanılan yöntemede bağlı olarak kökün orta ve apikal kısmında doku kaybına bağlı olarak dişin direncini azaltmaktadır. Resilon dolgu yöntemi kırık alet çıkarma sonrası uygulanabilecek bir dolgu metodudur.

Anahtar Kelimeler: NiTi kırık alet, Masserann, ultrasonik, monoblok, SistemB+Obtura

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INTRODUCTION

As new instruments and techniques are being developed, the use of NiTi rotary instruments has become popular over

the years. However, aside from their favourable qualities, they fracture. Intra-canal breakage hinders cleaning and shaping of the root canal system, resulting in a high chance of failure, especially in infected canals (1,2).

The clinician must evaluate the treatment choices with consideration for a root canal infection, the anatomy of the root canal, the position and type of fractured instrument, and the potential amount of damage to the remaining tooth structure (3-5). Removing the instrument, bypassing and sealing the broken instrument within the root canal space, or true blockage are chosen approaches. Removing a broken instrument is a difficult and time-consuming procedure, especially from the middle and apical third of the canal. Fors & Berg (6) also, stated that the potential to remove a broken instrument depends mainly on its location within the root canal system.

There are reports in the literature regarding using special instruments, such as the Masserann kit, EndoExtractor, Canal Finder System, or ultrasonic tips for the removal of broken instruments. The Masserann kit (Micromega, Besançon, France) has been used successfully for a long time (7). However, it removes a gross amount of dentin, which weakens the tooth structure especially in the middle or apical third of the canal (8-10). Weakened root canal walls lead to a fracture of the vertical root during condensation or after completion of the root canal treatment (11-13). To improve the potential of safety and success of the removal procedures special ultrasonics tips have been used by a technique described as staging platform and and this technique has been used successfully for this purpose, as described in literature (14). It is suggested that ultrasonic vibration transmitted to the broken instrument loosens it making it easier to remove. However, in both techniques the root canal must be sufficiently enlarged for visualization and handling of the broken instrument. Excessive removal of the root structure may weaken the tooth structure and result in perforation or a vertical root fracture (7,15,16). After procedure of removal, the canal should be obturated by proper material which can strenghten the root and be durable.

The effect of different obturation techniques on a weakened root canal wall after removing the broken instruments has not been properly investigated. Lateral condensation or vertical condensation might create stress on the root canal wall if it was shaped too thin after instrumentation and removal procedure. However, resin-based Resilon is a polycaprolactone polymer that contains bioactive glass and fillers and is a good alternative to gutta-percha. Resilon can bond to the adhesive sealer and dentin, thereby creating a monoblock. Studies have shown improved fracture resistance in Resilon-obturated teeth (17,18). Thus, monoblock obturation with Resilon may streng then a root that has been weakened after the removal of fractured instruments. The aims of the present study were to investigate tooth strength after removing broken instruments from coronal, middle or apical thirds of the canals using the Masserann technique or ultrasonic tips and to investigate the effect of different obturation techniques (lateral condensation, warmed gutta-percha condensation techniques, or resin-based Resilon and Epiphany sealer) on tooth strength by using a universal testing device.

MATERIALS AND METHODS

A total of 342 mandibular premolars with a single canal with fully formed apices were collected. All teeth were free of restoration, root resorption, root cracks or root canal therapy.The roots were examined by eye-loops (Carl-Zeiss,Oberkochen, Germany) under 4.5 X magnification. Teeth that had caries, resorption or cracks were discarded. A range of 12 mm to 16 mm was defined as an appropriate root length. Roots that were longer or shorter were discarded. The crowns were sectioned at the cementoenamel junction and an access cavity was prepared. Pulp tissue was removed by using K-files (Mani Inc., Japan). All teeth were instrumented by using Protaper instruments (Protaper Universal-Dentsply, Tulsa OK, USA) and the crown-down technique. Canals were copiously irrigated with 5.25% sodium hypochlorite during instrumentation. A separated instrument was created by using a diamond bur to notch F2 instruments 3 mm from the tip. Three-hundred-eighteen notched instruments were used in the canal at 250 rpm until the instruments separated in the coronal, middle, or apical thirds of the canals. Radiographs were taken from all the experimental teeth and categorized into three groups based on the position of the broken instrument (coronal, middle, and apical thirds of the root). The remainder of the teeth were used as positive controls with no broken instruments (Table1). The removal procedure was performed with a Masserann kit or ultrasonic tips with eye loops under 4.5 × magnification.

Ultrasonic groups. Following straight-line access, Gates-Glidden burs (Lexicon GG Burs, Tulsa Dental, OK, USA) were shaped with a diamond bur to create an end-cutting

drill as described by Ruddle (14). This standardized the amount of dentine removed from the roots for the removal groups. This was taken down to the level of the obstruction in order to create the "staging platform." VDW Ultra Unit with ultrasonic tips (VDW Redo 1,2,3 VDW GmbH, Munich, Germany) were used to circumferentially trephine around the broken instrument in a counter-clockwise direction.

Table1.All groups were summerized.

Locating of Broken Instrument	Removing Procedure	Obturation Technique
Group A	Group A1	Negative Control (n=8)
Coronal Third	Ultrasonic	Monoblock (n=15)
n=106	n=53	System B+Obtura (n=15)
		Lateral Condensation (n=15)
	Group A2	Negative Control (n=8)
	Masserann	Monoblock (n=15)
	n=53	System B+Obtura (n=15)
		Lateral Condensation (n=15)
Group B	Group B1	Negative Control (n=8)
Middile Third	Ultrasonic	Monoblock (n=15)
n=106	n=53	System B+Obtura (n=15)
		Lateral Condensation (n=15)
	Group B2	Negative Control (n=8)
	Masserann	Monoblock (n=15)
	n=53	System B+Obtura (n=15)
		Lateral Condensation (n=15)
Group C	Group C1	Negative Control (n=8)
Apical Third	Ultrasonic	Monoblock (n=15)
n=106	n=53	System B+Obtura (n=15)
		Lateral Condensation (n=15)
	Group C2	Negative Control (n=8)
	Masserann	Monoblock (n=15)
	n=53	System B+Obtura (n=15)
		Lateral Condensation (n=15)
Group D		Monoblock (n=15)
Positive Control		
(no broken instrument)		System B+Obtura (n=15)
n=24		Lateral Condensation (n=15)

Masserann groups. A Masserann kit was used according to the manufacturer's instructions.

After the removal procedure, all canals were shaped to a size F5 file. For irrigation, 10 mL of 5.25% NaOCl was used and after all canals were prepared, they were flushed with 10 ml. of 17% EDTA, rinsed with 10 mL of saline solution, and then dried with paper points. Subsequently, canals were obturated by the following three different obturation methods: lateral condensation, warmed gutta-percha technique (System B & Obtura), or using the Resilon & Epiphany sealer.

Lateral Condensation technique. Canals were filled with gutta-percha points (Dentsply Maillefer, Ballaiguse, Switzerland) and AH Plus sealer (Dentsply DeTrey GmbH, Costanz, Switzerland) using lateral condensation.

Warmed gutta-percha technique.

Canals were obturated using the Elements Obturation Unit (Analytic, Sorbon Dental Specialties, CA, USA). A matched taper master cone was placed to obturate the canal below the level of the staging platform and seared off at that level with a System B heat source. The remaining portion of the canal was back-filled with warm thermoplasticized gutta-percha using Obtura II to a level that was 1 mm below the canal orifice.

Resilion and Epiphany.

Canals were filled with Resilon points (No. 40 with .06 point) with Epiphany sealer (Pentron, Clinical Technologies, Wallingford, CT, USA) using lateral condensation technique. After filling the canal, the coronal part of the filling was subject to supplementary light curing of the sealer for 40 s, as indicated by the manufacturer's instructions.

Positive control group.

Forty-five teeth were obturated with one of three obturation methods (15 for each) with no broken instruments.

The access cavity was sealed with Coltosol (Coltene/ Whalesdent, Switzerland) temporary filling. Subsequently, the teeth were stored at 37°C and 100 % humidity for 7 days to allow the sealer to set. After a 1-week incubation, the roots were covered with a 0.2 mm-thick layer of polyether material (Impregum Garant L Duosoft, 3M ESPE, Seefeld, Germany) to stimulate human periodontium. The apical part of the root (5 mm) was vertically embedded in an acrylic resin block and stored for 24 hours to allow the resin to set completely.

A universal testing machine (Shimadzu, Tokyo, Japan) was used to evaluate the force required to fracture the roots (Fig1a,b). The force was recorded in Newtons. All data were recorded and analysed using the NCSS 2007 statistical software program (Kaysville, Utah, USA) One-way analysis of variance (ANOVA) and Tukey honest significant difference tests ($p<0.05$).

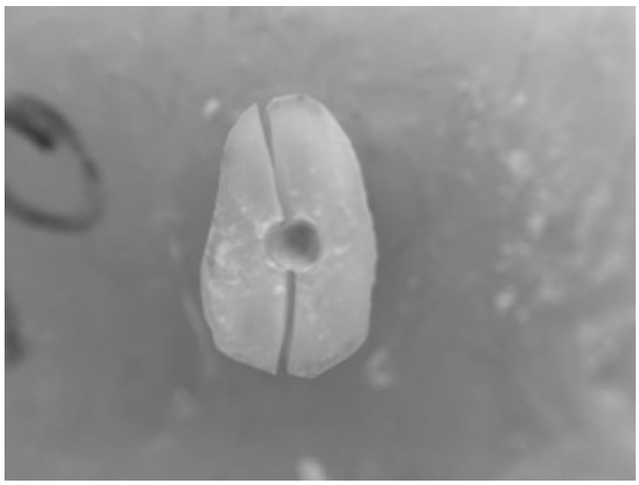

Fig1a.Instron testing machine and a fractured specimen.

RESULTS

The mean and standard deviation of of forces required to vertical fracture for experimental groups are presented in Table 2 and Fig 2.

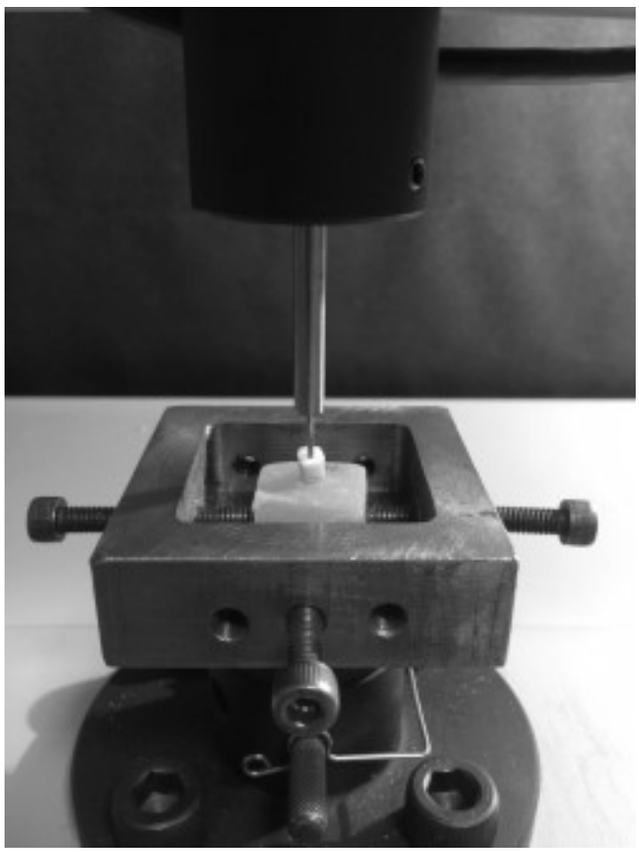

Fig2. Mean values for the force required for vertical fracture

Table 2. The Mean Force Required for Vertical Root Fracture for Experimental Groups Tested (Newtons) (*P<0.05)

Location	Obturation method	Ultrasonic	Messerann	P
		Mean S.D.	Mean S.D.	
Coronal 1/3	negative control (empty)	143,13±35,21	147,46±33,29	0,731
	Resilon+Epiphany	311,1±30,53	245,84±89,56	0,012*
	System B + Obtura	290,67±48,99	255,38±48,52	0,057
	lateral condensation	240,02±88,91	246,38±19,52	0,789
Middle 1/3	negative control (empty)	94,42±16,41	79,58±18,09	0,026*
	Resilon+Epiphany	238,56±14,25	217,73±83,45	0,349
	System B+Obtura	210,27±118	210,68±58,9	0,99
	lateral condensation	208,81±74,86	139,52±23,4	0,002*
Apical 1/3	negative control (empty)	51,51±12,1	42,14±9,26	0,024*
	Resilon+Epiphany	177,52±56,27	130,48±35,4	0,047*
	System B+ Obtura	152,18±29,06	113,14±18,69	0,046*
	lateral condensation	136,89±25,04	105,08±18,32	0,083

Control groups: Negative control groups (instrument removed and not obturated) showed significantly less strength than the experimental groups in all sections ($p<0.05$). The group that used ultrasonic tips showed more strength than the Masserann group, but a significant difference was only found in the middle and apical thirds ($p<0.05$), but not in the coronal third of the canal ($p>0.05$). Positive control groups (obturated without a broken instrument) showed significantly more strength than all the experimental groups ($p<0.05$).When obturated techniques were compared, the Resilon system had a significantly better result than the lateral condensed teeth in the positive control groups ($p>0.05$). No other significant differences was found among the obturation methods ($p>0.05$).

Experimental groups:In the coronal section, Resilon-obturated teeth had a significantly better result with ultrasonic instruments than with the Masserann technique ($p<0.05$). No other significant differences were found among the groups ($p>0.05$).

In middle the section, laterally condensed teeth had better results with ultrasonic tips that with the Masserann technique ($p<0.05$). No other significant differences were found among the groups ($p<0.05$).

In the apical section, Resilon-obturated teeth were stronger in the ultrasonic tips group than in the Masserann technique group ($p<0.05$).

The warmed gutta-percha technique had teeth that were stronger when they were manipulated using ultrasonic tips teeth than those manipulated by the Masserann technique ($p<0.05$).

DISCUSSION

Instrument breakage leads to endodontic failures due to incomplete root canal instrumentation and obturation (19-21). Therefore, removal of the broken instrument is an important issue, especially in infected canals. During the removal procedure a great amount of dentin can be removed due to location of the instrument or anatomy of the canal. This may lead to weakening and fracture the root structure (8,22-25). Thus, the instrument removal process must be exceptionally delicate without compromising the strength and the clinician must prefer a method that induces less tissue damage in the least amount of time during the removal procedure.

Although removal of the broken instrument was considered a success in some published studies, in most studies bypassing the instrument was also accepted (3,5,26). In the present study, a broken instrument was removed to investigate the damage caused to the root structure by the removal procedure. We also investigated the effect of the obturation technique on a weakened tooth structure.

Although different methods were used to remove broken instruments, the use of ultrasonic instruments was found to be successful in most studies (5,26-28). Ward et al.(27,28) and Gencoglu et al.(9) used ultrasonic instruments to successfully remove the fractured instrument in their respective studies. Gettleman et al. (29) and Madarati et al.(30) investigated the effects of ultrasonic usage on the removal of fractured files and found that the greatest change in the canal volume occurred when the fractured files were removed from the apical third, followed by middle and coronal thirds. In the present study, although both techniques were found to be effective for the removal of instruments, it seemed any instrument that used for the removal procedure decreased the tooth strength. However, the ultrasonic tips removed less dentin than the Masserann technique in almost all teeth (obturated or not obturated groups). This was only significantly different in the middle and coronal sections of the negative control groups. In addition, tooth strength decreased in the coronal to apical sections due to the removal technique and the volume of the hard tissue as expected.

The Masserann kit has been used for over 30 years to remove broken instruments (3,9,31-34). However, Yoldaş et al.(31) suggested that Masserann kits increase the risk of perforation in the curved canals. Most studies results showed that ultrasonic devices were superior to the Masserann kit (5). In our previous study, we also found that ultrasonic tips were more effective than Masserann, especially in curved canals.

This study also showed that the Masserann device produced more tissue damage to the middle and apical third of the canal than the ultrasonic instruments. This contributes to the tooth strength. However, the difference was not significant in the coronal section and both techniques were effective for removal of the broken instrument in this section. Besides the instrument type used for the removal process, many other factors such as the size, type of broken instrument, anatomy of the root, or location of the instrument all affect the removal procedure (3,5,35). In the present study, the middle and apical sections of the tooth were found to be weaker, most likely due to the loss of more hard tissue. So clinicians must consider whether more tissue damage will be created by attempting to remove the instrument or leaving it in. Fors &Berg (6) suggested that objects in the apical third should be left in situ; otherwise, removal can result in root perforation, which reduces the prognosis of the root canal treatment.

After the removal of the fractured instruments, one of the aims of long-term success of these treatments should the selection of a material that has the potential to reinforce the root structure and protect it against fracture. In the present study, all obturated groups showed significantly more resistance to fracture than the non-obturated negative control group. However, the resin-based Resilon sealer showed better strength than the other groups. This was only significantly different for lateral condensation. In the positive control group (with no broken instrument), the same results were obtained for the Resilon sealer. It seems that resin coating of gutta-percha facilitates a chemical bond with the Epiphany sealer and adheres better to the root canal than the lateral condensation technique with the AH Plus sealer. Although warmed gutta-percha showed better result than the lateral condensation technique, the difference was not significant.

It seems logical to remove as little dentin as possible during the removal procedure without jeopardizing long-term success. If wedging forces of the spreader are added during lateral condensation or excessive dentine is removed to facilitate plugger placement for vertical condensation, the likelihood for root fracture increases (13). According to the result of this study, lateral condensation technique seems to not be a good choice, especially after removal of broken instruments from the middle or apical sections. In addition, the resin-based based material, Resilon, may compensate for this weakening effect, making it more useful than the lateral condensation technique. It seems that the Resilon system has the potential to reinforce the root structure against fractures. Hammad et al.(36) compared vertical forces on the fracture of teeth obturated with different materials and found that resin-based materials (Resilon and EndoRez) increased the resistance of the root canal to fracture using vertical forces. In the present study, Resilon increased the tooth's resistance to fracture as a result of a chemical bond to dentine and formed a monoblock system after removal of the broken instrument. More research to find alternatives that may better seal and mechanically reinforce compromised roots is needed.

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