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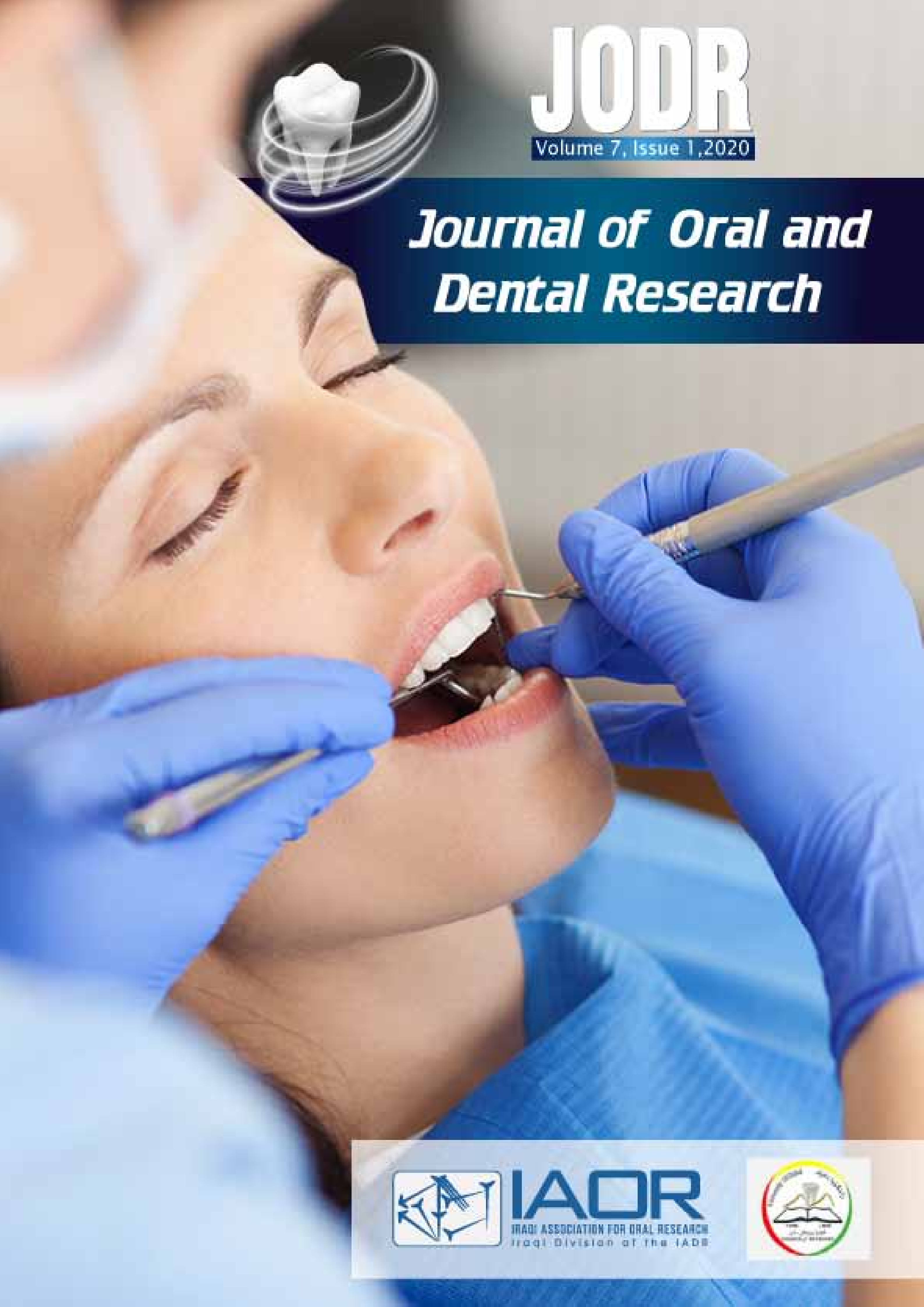

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The Amount of Extruded Debris: (An In-vitro Comparative Study)

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Abstract

Background Debris including dentin chips, residual pulp tissue, microorganisms and irrigants can be forced towards the periapical area. This extrusion may cause discomfort, pain, persistent inflammation and inter appointment flare up. **Objectives** To measure and compare the amount of apically extruded debris by using five irrigation techniques. **Materials and Methods** Seventy-five palatal root of extracted maxillary first molars were used. Each root was mounted in the pre-weighed collecting glass vial. The samples were randomly divided into five groups of 15 samples for each group according to the used irrigation technique: (Needle irrigation, Passive Ultrasonic Irrigation by NSK Varios, sonic irrigation by EndoActivatr, CanalBrush and EndoVac irrigation system). Canals were prepared using ProTaper NEXT rotary NiTi files to size X4, the irrigation technique of each group was conducted according to manufacturer instructions. The difference between pre and post-instrumentation weights presented as the weight of extruded debris. **Results** Showed that all irrigation techniques caused apical extrusion of debris with different values.
Conclusion EndoVac was found to be the safest irrigation system among all groups with respect to apical extrusion of debris.

Keywords: Apically extruded debris; CanalBrush; EndoVac; EndoActivator; Irrigation

Introduction

Chemomechanical debridement of root canals is an essential part of endodontic therapy. The aims of this phase of treatment are elimination of organic and inorganic debris by using instruments and endodontic irrigants (Leonardi et al, 2007). Irrigation is an important cornerstone of a successful endodontic treatment because it allows for cleaning beyond what instrumentation can achieve alone (Gu et al, 2009). It has been demonstrated that during root canal instrumentation and irrigation, debris including dentin chips, residual pulp tissue, microorganisms and irrigants can be forced towards the periapical area (Pranav and Van, 2009). This extrusion may cause discomfort, pain, persistent inflammation and interappointment flare up (Tanalp and Gungo, 2014). Irrigants are often delivered with a 30 or 27-gague endodontic needle placed into the canal until just short of the binding point (Mitchell et al, 2010). Passive ultrasonic irrigation (PUI) of root canals has been suggested to improve canal debridement and disinfection, PUI operates at frequencies range (25-40 kHz) (Van der Sluis et al, 2007). EndoActivator (Dentsply, Switzerland) is a sonic irrigants agitation system that operates at frequencies range (1-10 KHz) was developed to effectively remove debris from lateral canals and eliminate the smear layer (David et al, 2010). While CanalBrush (Coltene, Germany) is highly flexible polypropylene endodontic microbrush, which designed to remove canal debris effectively (Gu et al, 2009; Yildiz et al, 2010). The EndoVac (Kerr, USA) irrigation system with apical negative pressure was developed to address the procedural difficulty of delivering irrigants safely to the working length with less extrusion (Nielsen et al, 2007). The type of irrigation system, needle tip design as well as needle placement depth influences the flow pattern and apical wall pressure, which are important factors affecting irrigation effectiveness and safety. Accordingly, it would highly benefit for the patient to choose an irrigation system that minimizes the risk of extrusion into the periapical tissues (Pranav and Van, 2009; Shaimaa and Heba, 2016). Hence, this study was designed for evaluating the amount of apically extruded debris using five irrigation techniques (Needle irrigation, Passive Ultrasonic Irrigation, EndoActivator, CanalBrush and EndoVac).

Materials and Methods

Samples collection and preparation

Seventy-five freshly extracted maxillary first molars with straight and mature palatal root had been used in the present study. The external surface of teeth was cleaned using periodontal cumine, then the presence of any visible cracks or fracture was verified with the use of magnifying eye lens and light cure device. The palatal root of each tooth was sectioned to a uniform length of 12 mm. The pulpal tissue was removed using barbed broach #10. Apical patency of canals was ensured by insertion a #10 hand K-file into the canal and advancing until it was visualized at the apical foramen. Working length was obtained by subtracting 1mm from the actual length of the root. Single canal and apical foramen, this was determined by taking digital radiographs in buccolingually and mesiodistal directions. The samples then had been randomly divided into five groups (15 samples for each group) according to the type of irrigation technique that was used to irrigate the root canals.

Sample fixation and debris collection

The procedure for collection the extruded debris was carried out similar to that described by Myers and Montgomery in 1991 (Myers and Montgomery, 1991) in which seventy-five collecting glass vial with the rubber stopper were used for collecting the extruded debris. All vials were coded numerically according to the irrigation system used for each group, then each vial was weighed without the rubber stopper using the sensitive electrical balance (0.00001) (Kern-ABT 100-5M, Germany). This recorded weight represented the pre-instrumentation weight. A glass container (Beaker) was placed in the central hole of a specially designed squared wood base to provide fixation to the glass container, and each vials were then positioned inside the glass container, to facilitate holding the vial and to prevent any debris from environment to accumulate during working. Each root was forced into a hole made in the center of rubber stopper except for the coronal portion. And then the stopper/root complex were fixed to the pre-weighed vial, in which the middle and apical part of the root inside the vial. A rubber dam sheet had been used to coat the outer surface of the glass container. A bent needle (gauge-23) was introduced through the rubber dam and stopper beside the root to equalize the pressure between the inner and outer sides of the vial (Figure 1).

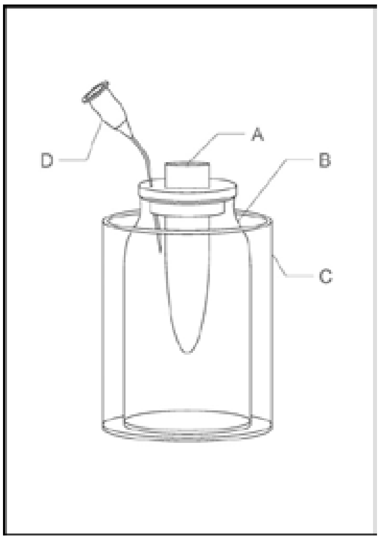

Figure (1): Drawing illustration of the collecting apparatus: (A) Root, (B) collecting glass vial, (C) Glass container, (D) Ventilating needle.

Root canal instrumentation: Root canals preparation was done with ProTaper NEXT rotary NiTi files (Dentsply Maillefer, Switzerland) in a crown-down technique with brushing motion until reaching X4 (40/06) according to the instructions of the manufacturer at constant speed (300 rpm) and torque (4.0 Ncm). Root canals irrigation: In order to control the amount of pressure during delivering the irrigants, Auto Syringe (Vista.USA) set at medium speed (flow rate 2.5 mL/min) had been used for canal irrigation with a (30-gauge) closed end side-vented irrigation needle, each time the needle tip was placed into the root canal until just short of the binding point, but no closer than 2mm to the working length. For each sample, 1 mL of distilled water (D.W) was used for irrigation after each file and following the use of the last file, 2 mL of D.W was used to complete the irrigation process. The total amount of irrigating solution was 6 mL of distilled water. Group I: (Needle irrigation using side-vented needle): After completion of canal instrumentation, the samples of this group received 2 mL of distilled water using Auto Syringe with (30-gauge) side-vented endodontic irrigation needle without any agitation of irrigants. Group II: Passive Ultrasonic Irrigation by the NSK Varios: After completion of canal instrumentation, a Piezoelectric Ultrasonic unit (NSK Varios 570 iPiezo Engine, Japan) was used to subject the root canals of this group to PUI with the aid of a stainless steel ultrasonic file corresponding to 25 ISO size. PUI was done by dividing 1 mL of distilled water into 3 equal parts. After delivering each part, it was activated by passively moving the oscillating ultrasonic file for 20 seconds at 1 mm shorter than the working length (the total period was 60 seconds). The canal then received 1 mL of distilled water as a final rinse. Group III: Sonic Irrigation by the EndoActivator: After irrigating the canal with 1.0 mL D.W, the EndoActivator (Dentsply Maillefer, Switzerland) with a medium-size polymer tip (corresponding to number 25 ISO size) was inserted passively inside the root canal, placed 2mm shorter than the working length, and then activated at 10,000 cpm. The activation of irrigant was done using pumping action in short 2-3mm vertical strokes for a period of 60 seconds. The canal then received 1 mL of distilled water as a final rinse. Group IV (Canal Brush): The instrumented canals had received 1.0 mL D.W, then a medium-size Canal Brush (Coltene, Germany) corresponding to number 30 ISO size was placed in Endo-Mate TC2 motor (at speed of 600 rpm) and used to activate the irrigant at 1 mm shorter than the working length. The canal was brushed in a circumferential motion with a gentle 2-3 mm up and down movement for a period of 60 seconds. The canal then received 1 mL of distilled water as a final rinse. Group V (EndoVac irrigation system): After each used file, the canal was irrigated with 1 mL of distilled water using the Master Delivery Tip (MDT) installed onto Auto Syringe that hold the irrigants solution, as follows: First, the MDT was used to deliver 0.5 mL of irrigants. At the same time, the MDT was placed at the access, the Macro Cannula was placed inside the canal to 4 mm from WL and worked up and down rapidly to help flush evacuate the irrigant from the coronal and middle thirds of the canal. Finally, the MDT was returned to continue irrigating the canal with the second 0.5 mL of irrigants while placing the Micro Cannula inside the canal at 2 mm from the WL for 6 seconds. Then, it was moved down to WL and held in position for other 6 seconds, to help flush evacuate the irrigants from the apical third of the canal. Then, each sample received 2 mL of D.W. as a final rinse using the same protocol. Collection and weighing of extruded debris: Once canals irrigation had been completed, the rubber-stopper/root assembly was separated from the vials. Then, the apex of the root was flushed with 1.0 mL of distilled water to wash and collect any adherent debris into the vial. Subsequently, the vials were placed in a dry heat oven at 100°C until the distilled water was completely evaporated. The vials were then kept in closed desiccator containing calcium chloride for 24 hours to absorb any remaining moisture. After that, each vial was re-weighed by using an electronic balance to obtain the final weight of the vial containing the extruded debris; this value represented the post-instrumentation weight (Figure 2). The weight of extruded debris was then calculated by subtracting the pre-instrumentation weight from the post-instrumentation weight of each collecting vial. The amount of extruded debris was analyzed statistically using the One-way analysis of variance test (ANOVA) and Tukey's post hoc test for multiple comparisons at a significance level of p 0<0.05.

Figure (2): Weighing of the vials using sensitive electronic balance.

Results

The results of this study revealed that all groups induced extrusion of debris from the apical foramen but with different values. Table (1) showed the mean, minimum, maximum values and the standard deviation of each experimental group. EndoVac group (V) showed the lowest mean value of apically extruded debris in comparison with other groups, followed by Needle irrigation (I), EndoActivator (III) and Canal-

JODR
VOLUME 7, Issue 1, 2020

Brush (IV) groups respectively. While passive ultrasonic irrigation group (III) has showed the highest mean value. Tukey's post hoc test results showed that group I (Needle irrigation) had no significant difference with group III (EndoActivator) (P 0>0.05).

Table (1): Descriptive statistics of apically extruded debris for all groups.

Group	Min.	Max.	Mean	SD
I	0.12	0.58	0.3100	0.14233
II	0.59	1.11	0.8227	0.17090
III	0.24	0.61	0.3847	0.10260
IV	0.39	0.74	0.5447	0.12212
V	0.03	0.16	0.0753	0.04155
Total	0.03	1.11	0.4275	0.27793

Table (2): Analysis of Variance (ANOVA) test for mean of AED for all groups.

	Sum of Squares (ss)	df	Mean Square	F	P-value	Sig.
Between Groups	4.643	4	1.161	75.741	0.000	S
Within Groups	1.073	70	0.015			
Total	5.716	74				

Discussion

When performing an endodontic treatment, irritants might be introduced into the periapical area. Extrusion of these infected debris and irrigants apically are associated with postoperative complications such as inflammation, delay of healing of periapical tissue and pain (Fatih et al, 2016), and considered to have a large influence on the failure of the treatment procedure (Dragana et al, 2018). Therefore, a reduction of extruded debris is desirable to reduce postoperative flare-ups. The present study revealed that all of the irrigation techniques caused apical extrusion of debris with different values. The results were consistent with previous studies, which demonstrated that no method could completely inhibit debris extrusion. (Varsha et al, 2013; Psimma et al, 2013; Emre et al, 2015). The present study showed that EndoVac irrigation system extruded apically the lowest mean value of debris when compared to other four groups, and this result is in agreement with (Varsha et al, 2013; Jatin et al, 2014; Karatas et al, 2015). The reason could be related to that EndoVac is based on negative apical pressure. According to the design of EndoVac system, it uses a couple of macro and micro cannula to deliver the irrigants all the way down to the working length of the canal and then evacuate it by the negative pressure of the suction unit, makes it possible to irrigate root canal up to the working length safely without extrusion of irrigants beyond the apical foramen of the canal (Benjamin and Craig, 2007; Varsha et al, 2013). According to this study, the results showed that Group II (PUI) had the highest mean value of apically extruded debris when compared to other four groups, and this result is in agreement with previous studies (Varsha et al, 2013, Jatin et al, 2014). This might be related to that the PUI creates cavitation and acoustic microstreaming of the irrigants. Active streaming enhances the irrigants to contact a greater surface area of the canal wall. Thus, improve the potential of debris removal from canal that may cause more extrusion. Additionally, tip of ultrasonically activated file was placed 1 mm shorter than the working length that create a turbulence of irrigants in the apical third, causing more extrusion in the present study. Group III (EndoActivator) in the present study extruded significantly less than passive ultrasonic irrigation, and this result is consistent with previous studies (Pranav and Van, 2009; Jatin et al, 2014). This might be related to two reasons. First, sonic irrigation works at a lower frequency, the frequencies for sonic application ranges from 1 to 10 KHz, while the frequencies for ultrasonic application ranges from 25 to 40 kHz. Second reason, the oscillating patterns of the sonic instrument is different; it produces purely acoustic microstreaming without cavitation (Ricardo et al, 2014) leading to reduce the debris removal from the canal walls and which in turn may cause a reduced amount of apical extrusion (Nair et al, 2011). The present study showed that Group I (needle without activation of irrigants) extruded less debris than PUI and Canal brush. This result is in agreement with earlier study (Shaimaa and Heba, 2013). While the mean value of apically extruded debris for Group I and Group III (EndoActivator) were almost equal (p 0> 0.05) (statically not significant difference), and this may be due to that in Group I, the absence of irrigants agitation inside root canal using mechanically driven instruments resulted in deficiency of turbulence of fluid in the apical third that may cause to force debris from the apical foramen. The current study showed that the mean values of AED for CanalBrush was significantly less than PUA and significantly more than EndoVac group and this finding is in accordance with the results of a previous study (Jatin et al, 2014). This may be explained by the action of CanalBrush which is based on centrifugal force and rotated clockwise at high speed and only 1mm shorter than the working length. Different factors may affect the amount of extruded debris such as: the technique of instrumentation and irrigation, type of instrument used for canal shaping, type and amount of irrigating solution, size of apical stop, preparation endpoint and the presence of more than one canal. (Varsha et al, 2013; Burklein et al, 2013). For this reason, the samples for this study were carefully selected, all teeth had mature apex, patent apical foramen, and had a standard initial size file which was #20 K file. Also, canal instrumentation was accomplished in the same manner in all groups; the W.L was kept 1 mm short of the apical foramen. Studies revealed that when instrumentation was performed 1 mm shorter than the canal length, it would result in a significantly less extrusion of debris than when it was performed the apical foramen (Fukumoto et al, 2006; Varsha et al, 2013). The irrigants solution that had been used in the present study was distilled water for two reasons. First, the type of the irrigation material affects the amount of extruded debris, and 5.25% NaOCl had the greatest amount of debris followed by 2.5% NaOCl then CHX (Parirokh et al, 2012). Second reason, when sodium hypochlorite irrigants get dehydrated, it would result in the formation of salt crystals that cannot be isolated from cutting debris which would increase the weight of extruded debris (Burklein et al, 2013). In addition, safe-tip (closed-end) needles had been used during irrigation, since the open-end needles produced more extrusion (Gu et al, 2009). The depth of placement of the needle tip in this study was 2 mm short of the full W.L since extrusion is decrease when the needle moved away from apical foramen (Psimma et al, 2013). To achieve standardization and to minimize the variables during the course of the present study steps, all works had been completed by the same operator (the researcher). It must be highlighted that the results of in vitro study cannot be directly generalized to the clinical situation, because of the absence of periapical tissues and bone that work as a natural barrier against extrusion of debris and irrigants. But the used methodology of the present study had been received the utmost attention and implemented by several studies associated with apically extruded debris.

Conclusion According to the proposed methodology and results of this in vitro study it was concluded that all irrigation techniques extruded debris beyond the apical foramen. The EndoVac irrigation system showed the lowest mean value of AED. While the PUI showed the highest value of apically extruded debris.

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JODR
VOLUME 7, Issue 1, 2020

Effect of Surface Treatments on Fracture Strength of Zirconia Core

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Abstract
Background The increasing of demand for all-ceramic restorations has led to the development of ceramic materials with optimized mechanical properties, such as densely sintered aluminum oxide and zirconium oxide (zirconia) ceramics. **Objectives** The purpose of this in vitro study was to evaluate the effect of etching with hydrofluoric acid or phosphoric acid and the effect of packable P60 composite veneer material on fracture strength of zirconia cores. **Materials and Methods** Twenty-four zirconium cores (Vita, Germany) with 0.7mm thickness were fabricated by CAD-CAM technology and sintered at 1450 ^{o}C for 60min according to the manufacturer's instructions. All zirconium cores were subjected to air abrasion with 50µm of Al2O3. These were randomly divided into three groups, (n=8). Group A: control group, veneered with IPS E-max Ceram porcelain; group B: etching with 37% of phosphoric acid and veneered with packable composite resin; and group C: etching with 9.5% of hydrofluoric acid and veneered with packable composite resin. All specimens were subjected to fracture strength test in an universal testing machine, a load was applied with 6mm diameter steel ball indenter at a crosshead speed of 0.5mm/min. **Results** One-way ANOVA test showed that there were statistically highly significant differences among all studiedgroups. LSD testwas performed to show thesource of significancy it showed a highly significant difference among all testedgroups. **Conclusion** A combination of surface treatment of 50µm Al2O3 and 37% concentration of phosphoric acid and adhesive agent could enhance the fracture strength of composite veneered crowns.

Keywords: Composite resin, fracture strength, surface treatment, sandblast, zirconia core.

JODR
VOLUME 7, Issue 1, 2020

Introduction

Prosthodontic treatments aim to replace lost function speech, chewing, swallowing and aesthetic (Agustin et al, 2014). The use of metal-ceramic restorations in the fabrication of fixed partial dentures was for more than 40 years (Casson et al, 200; Tarib et al, 2016).

Because of the esthetic demand for dental restorations, metal systems were replaced by the all-ceramic system (Chintapalli et al., 2013). Hence zirconia ceramic has ideal properties, it has been recently introduced to restorative dentistry as a metal-free alternative (Kitayama et al, 2010; Korkmaz et al, 2015). With the development of CAD-CAM technology, the design and production of zirconia frameworks could be achieved using the digital process (Phark et al, 2009). Therefore, the all-ceramic restorations by the use of a zirconia core become more practical applications (Aboushelib et al, 2007; Ural et al, 2011). Such restorations have ceramic core replaced metal alloy and was veneered with ceramic (Guazzato et al, 2004). Zirconia core has the highest opacity; it requires veneering materials like feldspathic porcelain and these veneering materials mask its opacity and give it aesthetically appearance (Chen et al, 2008).

Fractured of veneering porcelain is the most common complication in Y-TZP based restorations (Rinke et al, 2011). It occurs during mastication as the fragments of porcelain mass was chipped (Fischer et al, 2008; Stawarczyk et al, 2011), ceramics under tensile strain are fragile (Borges et al, 2003).

Several factors could influence fractures of veneering ceramic-like overload at the premature contacts, ceramic strength and the adhesive bonding abilities; inappropriate framework design (Estevam et al, 2010; Fushiki et al, 2012); miss-match coefficient of thermal expansion; and excessive wear of the opposing teeth (Guazzato et al., 2005; Park et al, 2014).

When the zirconia core was veneered with a high strength composite resin material, it has been proposed as an alternative veneering method (Dhawan et al, 2003). Composite resins are widely used for direct restorations because they exhibited excellent, physical, optical, mechanical properties, and ease of handling (Hervas-Garciaet al, 2006). They exhibit viscoelastic effects, as well as susceptibility to creep and recovery (Komine et al, 2012). These features can provide advantages, especially in the areas of high occlusal stress, like implant-supported fixed restorations (Çiftci and Canay, 2000). The procedure of treating ceramic surfaces is required to ensure a long-term bond between composite and ceramic material like sandblasting, etching with different acids (Nagayassu et al, 2006; Bajraktarova-Valjakova et al, 2018).

Air abrasion with Al_2O_3 particle was recommended to provide the required micro roughening on the bonding surface (Kern, 2015). In addition, the adhesive bonding was used to improve the bonding of resin to zirconia. Such bonding is dependent on the surface energy and wettability of the adherent by the adhesive (Pisani-Proenca et al, 2006; Kobes and Vandewalle, 2013).

Material and Methods

A total of twenty-four zirconia cores were prepared from pre-sintered zirconia blank. They were designed and cut by the CAD-CAM system. Based on the surface treatment and veneering materials zirconium cores were divided after standard surface sandblasting procedure into three groups (n=8) as shown in figure (1).

An ideal pre-prepared plastic right maxillary first molar (Nissin Dental Products, Kyoto Japan) with deep chamfer finishing line (0.8mm), (2mm) reduction occlusally was utilized for the construction of a master metal die as shown in figure (2).

The plastic die was sprayed with dental scan spray to inhibit reflection of light during the scanning process and the plastic die was placed inside the dental scanner unit (DOF, full HD, 5M pixel; Korea) and fixed on scan stage by special clay as shown in figure (3).
A three-dimensional image was taken so that all surfaces and finishing lines of the plastic die appeared clearly. The metal die was fabricated by using the CAD-CAM system to simulate the shape of ideal pre-prepared plastic die to receive all crowns (Hamza and Sherif, 2017).
The digital model of the die transferred to the CAM software to start the dry milling process of the metal die by using the milling unit which was loaded with the cobalt-chromium disc (10mm) [Interdent, Travagliato (BS) Italy]. The base for the metal die was constructed from dental stone type IV (Azarbal et al, 2018), this base allows the proper position of the metal die during scanning. Then the dental stone was mixed according to manufacturer instruction, vibrated, and poured to 4mm below the cementoenamel junction (Abdulkareem and Ibraheem, 2016) as shown in figure (4).
The metal die was surface scanned and by the same procedure used previously in the scanning of the plastic die. A zirconia core with (0.7mm) thickness was designed to fit on the digital die using CAD-CAM technology (Alsadon et al, 2017).
The cores were designed through the software, Yttria-stabilized zirconia blank was positioned in the blank holder into the milling machine and fixed with the screwdriver, at that point, milling procedure began. When the milling procedure was finished, the sintering procedure was established for all cores at a high temperature according to the manufacturer's guidelines. Following sintering, the surface of each zirconium core was subjected to an air abrasion procedure with (50µm) Al203 particles using a sandblasting machine at a pressure of 1.5 bar for 10 seconds, and at a fixed distance of 10mm between the nozzle head and the core surface. The study groups were prepared as follows:
Group (A) the control group, specimens veneered with IPS E.max Ceram porcelain.
Group B, specimens surface treated with Phosphoric acid 37% and bonding agent, veneered with 3M ESPE Filtek (Packable P60 Composite resin).
Group C, specimens treated with Hydrofluoric acid of 9.5% and the application of bonding agent, then veneered with 3M ESPE Filtek (Packable P60 Composite Resin). In group (A) a silicon index was fabricated, a putty condensation silicone impression material (Zhermack, Italy) was used to fabricate a silicon index, an impression was taken to the previously veneered composite crown to control the thickness of veneering ceramic as shown in figure (5). While for the application of veneering ceramic on zirconium core, the layering technique was used by mixing ceramic powder (50 mg) of IPS Ceram, dentin A3 powder with a special liquid to produce the desired creamy consistency of ceramic, then the ceramic was applied to the prepared core surface by a brush, then sintering process was achieved in the ceramic furnace according to the manufacturer instructions.
The procedure was repeated for the 2nd layer of dentin and enamel porcelain were condensed and fired also according to the manufacturer's instructions. After complete firing, the dimensions of veneering ceramic were checked byindex and Vernier. In group (B) a phosphoric acid gel (37% concentration) was applied to the sandblasted core surface for 60sec and then rinsed with water spray for 30sec to remove all residual acid. Single Bond Universal Adhesive (3M ESPE, USA) was used before the application of composite resin. A drop of bond applied to the etched surface and rubbed using a disposable

brush and lightly air-dried for 2sec, then the bond was light-cured for 20sec, and all the five surfaces of each crown were light-cured. For the application of composite resin (veneering material) and to obtain the desired and uniform composite veneering thickness to all composites groups, a disposable celluloid crown was used as a mold for veneering material. The Packable Filtek P60 composite resin was applied inside the celluloid crown using the Ash instrument (no. 6) to add the composite increment and the material adapted and compacted to ensure a procedure free of bubbles or gap between the material and celluloid crown. Also to obtain a full contouring crown, then the celluloid crown containing the veneering material was placed over the zirconium core and applied a slight pressure for adjusting it. All excess material from the margin was removed using a lacron carver instrument. Then light-activated using a light-cure unit with a power intensity of 600mw/cm2 for 20sec for each occluded, buccal, palatal, mesial and distal surfaces according to manufacturer's instructions. After the curing procedure was completed, the celluloid crown was removed from the restoration. The glaze-on technique was established for the group (C), the surface of zirconium cores was coated with a very thin layer of glazing porcelain and sintered with glaze firing protocol according to manufacturer's instructions, this to obtain a glazed surface for zirconium cores (Peampring et al, 2017). For etching, a glazed surface was etched with 9.5% of hydrofluoric acid for 30sec, then rinsed with water spray for 60sec to remove all residual acid, and dried with oil-free compressed air.
The single bond universal adhesive material (3M ESPE, USA) was used before the application of composite resin. The bonding procedure was accomplished in the same manner as in the group (B). Then the veneering material applied as in group (B) using Filtek P60 composite resin III. Fracture resistance testing procedure takes place using a universal Instron testing machine of 6mm diameter steel ball indenter (Lloyd LRX-Plus, Lloyd Instruments Ltd. Fareham Hants, UK), and a crosshead speed of 0.5mm/min at the center of each crown. The fracture at maximum load was then recorded (Peampring et al, 2017). One-way analysis of variance (ANOVA) and Least Significant Difference test (LSD) tests were applied at a confidence level of 95% and significant P-value of ($p \leq 0.05$).

Results

Table (1) showed the highest mean of fracture resistance value was in the group (B), while the lowest mean of fracture resistance value was in the group (C). In table (2), One-way ANOVA revealed that there was a statistically highly significant difference in fracture resistance between both group A and C, and B and C. While there was statistically non-significant difference effect between both group A
and B. LSD test also in table (3) determined the source of variance among all tested groups.

Figure 1: Zirconium cores.

JODR
VOLUME 7, Issue 1, 2020

Figure 2: An ideal pre-prepared plastic right maxillary first molar.

Figure 3: The plastic die was placed on the stable scan stage.

Figure 4: The final metal die with stone base.

Figure 5: Silicone index.

Table (1): Descriptive statistics of fracture resistance in Newton for the study groups A, B, and C.

	N	Minimum	Maximum	Mean	Std. Error	SD
Group A	8	1721.65	1978.92	1826.4575	38.59839	109.17273
Group B	8	1819.76	2133.67	1935.6350	39.77285	112.49461
Group C	8	1331.95	1716.75	1582.4713	41.56172	117.55428

Table (2): One-way ANOVA test for the study groups A, B, and C.

Groups	F	*P-value*	Sig
Groups (A,B,C)	20.439	.000	*** HS

*P≤0.05 Significant
**P>0.05 Non-significant
*** P≤0.001 Highly significant

Table (3): Least Significant Difference test (LSD) for the study groups A, B, and C.

Groups			Mean Difference	Std. Error	P-value
LSD	Group A	Group B	109.17750	56.56319	.155
		Group C	243.98625	56.56319	.001
	Group B	Group C	353.16375	56.56319	.000

Discussion

To control some of the ceramic veneered zirconia lowering properties regarding fracture resistance, veneering zirconia-based crown with composite was suggested. Such crowns are fabricated with a light-activated composite. The advantages could incorporate strength, less abrasive and biocompatibility of zirconia frameworks permit simplicity of treating and repair intraorally (Guazzato et al, 2004; Agustin et al, 2014). In the present study, the load to failure test is the method to examine the structural safety of such structures, which takes into account different component layers of the crown and anatomy complexity (Casson et al, 2001), also the crosshead speed of 0.5mm/min with the load that applied at the crown occluded center using a 6mm stainless steel ball diameter (Peampring et al, 2017). The selection of (Al2O3) air-brone of 50µm particle size was highly recommended for achieving strong adhesion of veneering ceramic due to increasing surface roughness and providing undercuts (Guazzato et al, 2005). Also, sandblasting the zirconia surface before porcelain veneer or resin bonding appears to be the most popular method to promote mechanical interlocking when moderate pressure applied with small particle size (Kern, 2015). In term of sandblasting effect, the results of the present study showed a high fracture strength value was in group B, while the lowest was in group C. This could be explained by that the sandblasting which may not only bring about morphological changes of the material surface but also increase adhesion efficiency. Also, one possible factor that could be referred to is the loss of primary stability of zirconia by its transformation from the tetragonal into the monoclinic crystallographic phase as a result of elevated temperature and the presence of moisture (Korkmaz et al, 2015). The abrasion with air-brone particles probably enhances the formation of ceramic-resin micromechanical interlocking by expanding the bonding region, resulting in an activated micro-roughened zirconia surface, modifying surface energy and wettability of the ceramic surface (Chintapalli et al, 2013). The result of the present study comes in agreement with Phark et al., 2009 which concluded that abrasion with Al2O3 abrasive particle has been distinguished as an effective factor in obtaining a durable and stable bond for aluminum and zirconia-based ceramics. Also, the result of the present study comes in agreement with Su et al, 2015 who state that sandblasting procedure is an important surface treatment method that could enhance the bonding strength between veneer material and zirconia, this fine powder particle was more abrasive and significantly more zirconia was removed when using 50µm of powder particles.

On the other hand, some findings may disagree with Inokoshi et al, 2014, a study suggested that air-borne particles abrasion with alumina could produce micro-cracks and damage the surface integrity which influences the properties of zirconia. This difference in results may be due to the differences in some study variables such as applied pressure. In terms of phosphoric acid and bonding agent effect, the highest mean value of the fracture strength test was noticed when the zirconium core was abraded and chemically managed with phosphoric acid treatment. This could be explained by the interference of efficient and functional monomers within the zirconium surface (Kobes and Vandewalle, 2013). The phosphate monomer that found in the primer may have bonded to the zirconia ceramic and form chemical bonds at the zirconia resin interface through either covalent bonds, hydrogen bonds or van der Waals forces. The bond adhesive primer contains silane monomers and this silane may increase the bond strength by producing a chemical bond between res-

in composite and silica-based surfaces. This increase in wettability could improve the flow of resin into the ceramic surface, causing a strong micromechanical bond (Kobes and Vandewalle, 2013). These results probably in agreement with Komine et al, 2009 who conducted that obtaining a durable bond strength could be obtained by utilizing an acidic functional monomer containing phosphate monomer, carboxylic anhydride, or phosphoric acid. Also, Derand and Derand, 2000, reported that the phosphoric-acid groups of 10-methacryloxydecyl dihydrogen phosphate (MDP) can react with the oxide layer on the surface of the ceramic material. This leads to sufficient adhesion between these two materials. Ural et al, 2011, also found that Methyl methacrylate in the primer can be polymerized with the monomers of a resin composite systemso that bonding between the resin and the ceramic
surface might have been increased. To fuse a glaze material to the zirconia substructure and then apply composite material with the specific bonding with silanization protocols may be advice favorably for the durable bonds of the composite to zirconia ceramics (Kitayama et al, 2010). HF acid is broadly utilized in dental laboratories in traditional fixed prosthodontics and adhesive all-ceramic applications (Guazzato et al, 2004). The hydrofluoric acid is used when the matrix contains silica or silicates. At first, silicon tetrafluoride is formed. This combines with hydrofluoric acid to form soluble complex ion (hexafluorosilicate) which in turn reacts with hydrogen protons to form tetrafluorosilisic acid, a product that can be selectively removed with water, and the crystalline structure is uncovered, the outcome surface of the ceramic becomes rough (Tarib et al, 2016). Thus, the HF acid treatment is widely used on silica-based ceramic to react with, and exclude the glassy matrix that contains silica. This leaves the crystalline phase exposed, generating surface roughness as a result of the formation of numerous porosities and grooves due to the acid action on the matrix and the crystal structure; initiating the extreme bonding (Bajraktarova-valjakova et al, 2018). Also this study findings come in agreement with a study by Guazzato et al, 2004 who reported that the adhesion of all-ceramic restorations, surface morphological changes, just like pores and grooves, are considered important. Both chemical bonding and micromechanical interlocking to the surface of ceramic could increase the fracture resistance of the restored tooth restoration. Also, provide high retention; improve marginal adaptation; and prevente microleakage. Moreover, Borges et al, 2003 and Pisani-Proenca et al, 2006 stated that chemically a hydrofluoric acid may dissolve glass by reacting with silicon oxide which is the main ingredient in glass ceramic. Furthermore, the glaze coating of zirconia framework is an effective method to obtain a clinically acceptable bond strength of composite material to a zirconia substructure (Fushiki et al, 2012). Nagayassu et al, 2006 claimed that etching of dental porcelain with hydrofluoric acid was reported to give higher bond strength of resin composite to porcelain. The differences in such results may be explained by using silane coupling agents following etching with hydrofluoric acid.

Conclusion This study concluded that the use of different surface treatment for zirconia cores was generally more effective in increasing fracture strength. The use of a bonding agent of 37% phosphoric acid and composite resin material had a significant increase in fracture strength and bonding strength between zirconia and the composite resin.

Conflict of interest We are the author's (Yusra A. Ibraheem, and Dr. Zahraa N. Alwahab) state that the manuscript for this paper is original, it has not been published previously; it is part of my MSc. Dissertation; is not under consideration for publication elsewhere and that the final version has been seen and approved by all authors.

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Effects of Recycling-PEEK Waste from CAD-CAM on Surface Hardness and Roughness of PMMA

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Abstract

Background Being health care professionals, technicians should be aware of regarding safe disposal of biomedical waste and the recycling of dental materials to minimize biohazards to the environment. **Objectives** The aim of the present study was to assess the PMMA mechanical properties after recycling and reuse of waste Polyetheretherketone (PEEK) material from the CAD-CAM production method as effective filler.
Materials and Methods The PEEK fiber was collected from the CAM machine after the milling procedure. Then, standard sieves of ISO standardization no. 40, 60 and 100 were used respectively to achieve a fine particle grit size of 150µm. The PEEK of 1% wt. was added to the PMMA resin base of 99% wt., and PEEK of 2% wt. was added to the PMMA resin base of 98% wt. to achieve a PMMA/PEEK composite of two different filler percentage to compare with the PMMA with no additives. The conventional heat-curing method was applied using a water bath to polymerize the disc specimens for both surface roughness and hardness tests. Study data were analyzed via One-way ANOVA (post-hoc/Tukey test) performed at a significant P-value of ($p \leq 0.05$) and confidence level of 95%. **Results** After comparing the results, a significant difference in the surface hardness and roughness of PMMA/2%PEEK composites was noticed comparing to other tested groups ($p \leq 0.05$). **Conclusion** The recycling of PEEK waste from CAD-CAM production method and reuse it as dental filler at 1% and 2% wt. incorporating PMMA reduced the surface roughness and enhanced the surface hardness of PMMA denture base material.

Keywords: CAD-CAM; recycle; surface hardness; surface Roughness; PEEK.

Introduction

Biomedical waste management has become a concern in the dental world as different materials start to increase in use. In dentistry, few studies have suggested to recycle and reuse some of the dental materials (Bhat, 1983; Baghele et al, 2013; Ranjan et al, 2016). The majority of such study population was completely clueless regarding knowledge pertaining to the recycling process. They were unaware of the proper disposal of some non-degradable dental materials (Elgayar and Aboushelib, 2014; Singh et al, 2014; Mattoo et al, 2014; Tippat and Pachkhade, 2015). Polyetheretherketone (PEEK) is a newly inovative polymer with outstanding thermal and mechanical properties. It is light in weight, non-toxic, highly resistant to corrosion with a low moduli close to that of natural bone (Chen et al, 2019). The crystalline PEEK polymer shows a harder hardness compared to other polymers (Stuart and Briscoe, 1996). PEEK has been recently widely used for dental application as prosthodontics fixed restorations (Zoidis and Papathanasiou, 2016; Najeeb et al, 2016) and removable restorations (Muhsin et al, 2019; Peng et al, 2019). Computer-aided design and manufacturing technology (CAD-CAM) had become widely applicable in dental office and laboratory. It is possible to produce partial or complete restorations using PEEK material through use of CAD-CAM (Schwitalla et al, 2015; Chen et al, 2018; Harb et al, 2019). One of the most important challenges in using PEEK in the clinic is high cost due to the large unused volume of PEEK block after milling by CAD-CAM. Although newer devices have higher accuracy in cutting, but in the process of cutting the block, there are still large parts in the form of fibers and unused patches that have imposed a high cost on the patient. It also has problems in its decomposition and recycling in the environment, and there are no specific guidelines in some countries on recycling highly crystalline PEEK remnants. Dental appliances may be constructed using PMMA resins and subsequently be repaired or relined. Although Polymethlemethacrylate (PMMA) remains the most popular choice for polymeric prosthodontics restorations as it may relatively easy to be used in both clinical and laboratory fabrication process alongside its approperate cost (Alla et al, 2013; Alla et al, 2015), several studies reported different techniques for reinforcing PMMA through inclusion of other materials (John et al, 2001; Narva et al, 2005; Akinci et al, 2014; Gad et al, 2017). Also, many studies have shown that some modification in the inorganic fillers could remarkably improve the PMMA mechanical properties such as surface hardness (Vuorinen et al, 2008; Syngouna and Chrysikopoulos, 2011; Vojdani et al, 2012; Ahmed and Ebrahim, 2014). On the other hand, additional studies were examined the surface roughness of the non-polished PMMA denture base (Zissis et al, 2000, Berger et al, 2006, Abuzar et al, 2010, Mekkawy et al, 2015). However, few studies reported the effect of surface roughness on bacterial accumulation and plaque formation (Quirynen et al, 1990; Bollenl et al, 1997; Radford et al, 1999). They state that the bacterial colonization may occur with a higher incidence when the surface roughness value in some denture base materials was greater than 2.0μm. Since "composite" refers to reinforcing constituent either of long or continuous fibers (Kurtz, 2011). Hence, this study has been aimed to find out a simple scientific technique to recycle PEEK waste fibers from CAD-CAM and reuse it to assess its effectiveness as a filler agent on some PMMA mechanical properties.

Materials and Methods

1. PEEK-Waste Fiber Collection

In the present study, a decomposed PEEK blank was used. The PEEK fiber was collected after using the CAD-CAM production method (PEEK-JUVORA™, UK). The result fiber was brushed-off from the CAM machine after dry milling procedure (Roland-DWX-50, USA). Then a magnet is used during vibrating sieving procedure to remove any trace of metal particles may incorporated from the cutting bur. The standard stainless steel sieves of ISO standardization (Italy) no. 40 (420μm), 60 (250μm), and 100 (150μm) respectively was used to achieve fine particle grit sizes (Shin and Hryciw, 2004; Syngouna and Chrysikopoulos, 2011).

2. Preparing the PMMA/PEEK Composite

The proposed PMMA/PEEK study composite material was prepared according to the following measurements using sensitive balance as shown in table (1). To achieve an even PEEK fiber distribution within the PMMA powder, each prepared quantity was dispensed using a dispenser unit at 40 rpm/min for 5 h (12000 rpm).

3. Study Sample Grouping

A sample of 60 disc specimens was prepared for this study, and divided into two main groups. The subdivided group tested for surface hardness and roughness mechanical tests, (n=10). The X-ray diffraction (XRD) was used to analyses the effect of the PEEK filler on the PMMA crystallinity behavior. The XRD technique indicates the normal order of crystalline structure in the polymeric chains. XRD pattern was obtained in the 2θ range between 0 and 90 degree (LabX6000-Shimadzu, Japan).

4. Sample Preparation

Silicon mould for the wax disc specimens was prepared for the surface hardness and roughness tests. The dimensions were of 12(±0.1)mm in diameter and 2(±0.1) mm in thickness. PMMA and PMMA/PEEK composites cured followed the conventional compresion method using water-bath curing system. The PMMA powder/liquid mixing ratio was according to the manufacturer's instructions of (3/1) by volume (Veracril, Spain). Short-cycle heat polymerization processing method was timed for 3½ h. After curing, the flasks were kept on bench to cool overnight, deflasked, specimens' flashes removed, cleaned from the gypsum product using the ultrasonic unit for 15 minutes.

5. Testing Procedure

Figure (1) shows the surface hardness that measured using Shore D durometer hardness tester unit (China) and the surface roughness which measured using the profilometer surface roughness tester device (China).

Statistical Methods

The study data analyzed via One-way ANOVA (post-hoc, Tukey test) at a confidence level of 95% and a significant P-value of ($p \leq .05$).

Results

Table (2) and (3), Figure (2) and (3) show the result of surface hardness and roughness of PMMA/PEEK composites, while Figure (4) shows the XRD patterns of the experimental prepared composites. After comparing the results for surface hardness, a significant difference was noticed in the surface hardness between the PMMA as a control group and that of both the PMMA/1% PEEK and PMMA/2%PEEK composites ($p \leq 0.05$). For surface roughness, a statistically non-significant differences was reported in surface roughness between the PMMA and PMMA/1%PEEK composite, also between PMMA/1%PEEK and PMMA/2%PEEK composites ($p > 0.05$). However, there was a significant difference in the surface roughness between the PMMA and PMMA/2%PEEK composite ($p \leq 0.05$).

Table (1): The composition of Polymethylmethacrylate/Polyetheretherketone (PMMA/PEEK) composite for the experimental group study.

Groups	PMMA Composite Resin	
	Resin Base (98–100 wt. %)	PEEK Filler (0–2 wt. %)
	PMMA (g)	PEEK (g)
Control (I)	100%	0%
Group (II)	99%	1%
Group (III)	98%	2%

Table (2): ANOVA-test showing the surface hardness of the tested group specim.

Groups		Mean Difference	p-value	Sig.
PMMA	PMMA + 1% PEEK	-5.3000*	.000	S
	PMMA + 2% PEEK	-9.4000*	.000	S
PMMA + 1% PEEK	PMMA + 2% PEEK	-4.1000*	.003	S

Table (3): ANOVA-test showing the surface roughness of the tested group specimens.

Groups		Mean Difference	p-value	Sig.
PMMA	PMMA + 1% PEEK	.4370	.299	NS
	PMMA + 1% PEEK	.8857*	.004	S
PMMA + 1% PEEK	PMMA + 1% PEEK	.4487	.183	NS

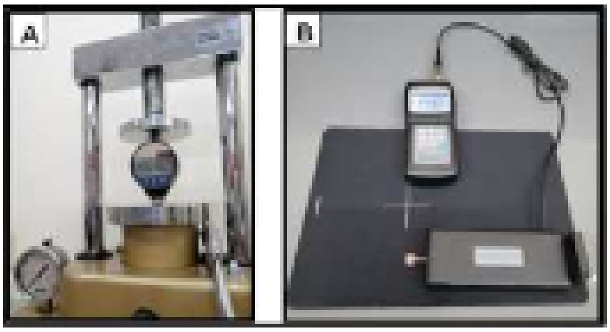

Figure 1: A, Shore D durometer surface hardness unit; and B, Surface roughness profilometer tester device.

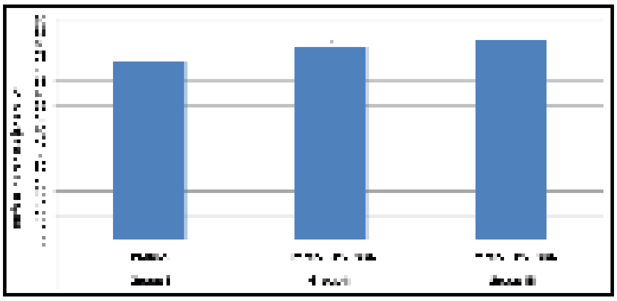

Figure 2: Mean distribution of the surface hardness of the tested groups.

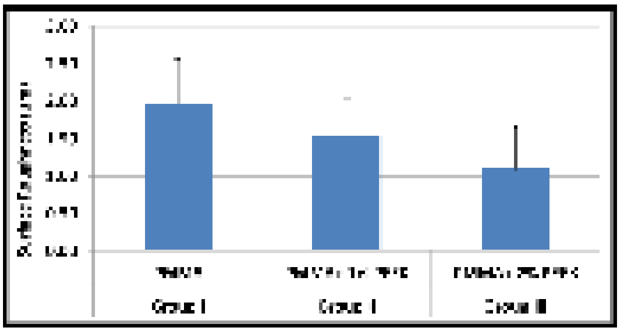

Figure 3: Mean distribution of the surface roughness of the tested groups.

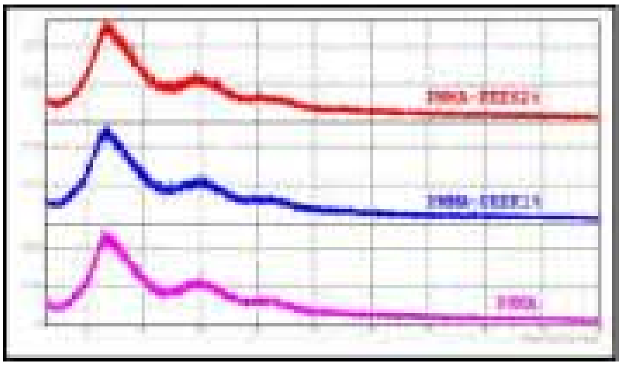

Figure 4: Diagram shows the XRD pattern of PMMA base resin, PMMA/1%PEEK, and PMMA/2%PEEK prepared study material.

Discussion

The initial mechanical properties of any dental material may predict the primary mode of clinical failure and provide a determination for a specific application. Recently, the development of new materials for load-bearing areas were suggested to improve the mechanical properties. PMMA was one of the most commonly used denture bases with inferior mechanical properties. In the present study, the surface hardness and roughness of PMMA base resin are evaluated after the addition of 1% and 2% of PEEK fiber. The present data results showed that the value of surface harness may affect greatly by the measurements of PEEK fiber that added to the PMMA. The additions of 1% or 2% of PEEK fibers to the PMMA base resin have shown higher surface hardness than that of non-additives. According to (Kurtz, 2011), the annealing process for Juvora™ material provided a high crystallinity behaviour for CAM purposes. The increase in the PEEK fibers filler percentages could affect positively the surface hardness. This result may agree with (Stuart and Briscoe, 1996) who state that the material hardness may increase by the presence of polymer of high crystallinity polymer. On the other hand, the surface roughness of the non-polished PMMA/PEEK composite was evaluated as a mean to predict the colonization of diferent microorganisms. The additions of 1% of PEEK fibers to the PMMA base resin have shown statistically the same surface roughness of that of PMMA and that of 2% PEEK filler. The lowest mean value in the surface roughness was of 1.09(±0.6)μm, which was recorded within the PMMA/2%PEEK composite. The addition of 2% of PEEK fibers statistically reduced the surface roughness of the PMMA composite. Yet, the present results could agree with (Quirynen et al, 1990; Bollenl et al, 1997; Radford et al, 1999) as the surface roughness less than 2μm. Hence, PMMA/2%PEEK composite may offer promises as a new modified denture material with less opportunities for future microbial accumulation. XRD indicates similar non-sharp diffraction peaks of crystalline nature for all the tested composites. The behavior of the PMMA/PEEK composite shows no phase differences in the chemical composition due to the addition of the PEEK fibers.

Conclusion

PMMA-based composites prepared with 1% and 2% wt. of PEEK fibers were submitted to evaluate the surface hardness and roughness mechanical properties. These results indicated that the addition of PEEK filler to PMMA

Conflict of interest

We are the author's (Aseel Hayder Salim, and Assist. Prof. Dr. Saja Ali Muhsin) state that the submitted manuscript for this paper is original. It has not been published previously, and it's part of MSc. dissertation and is not under consideration for publication elsewhere, and that the final version has been seen and approved by all authors.

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Chlorhexidine Effect on Color of Treated White Spot Lesion with Remineralization Materials (Fluoride Varnish, Tooth Mousse)

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ABSTRACT
Background the white spot lesions represent subsurface enamel demineralization, manifested as white opacities which considered as esthetic problem. **Objectives** to evaluate the color improvement of white spot lesions and stability against discoloration following, fluoride varnish, tooth mousse treatments with immersion in chlorhexidine. **Materials and Methods** artificial white spot lesions created on the gingival third of buccal surface of premolar tooth (N=90) using demineralization solution; PH (4-4.5) at room temperature for 4 weeks, specimens were treated with fluoride varnish, tooth mousse and untreated group (control). Groups were immersed in chlorhexidine for 1 hour. Color change was measured with vita easy shade device at baseline, after white spot lesions formation, after treatment and after immersion in chlorhexidine. **Results** the mean of color change in deionized distilled water and chlorhexidine increased after formation of white spot lesions then decreased with the application of fluoride varnish and tooth mousse, there was a significant difference between the white spot lesions, fluoride and Mousse group in deionized distilled water and chlorhexidine, there was non-significant effect of chlorhexidine on color of white spot lesions treated with fluoride varnish. **Conclusion** the fluoride varnish and tooth mousse could return mineral to subsurface enamel of white spot lesions and might improve esthetics and color stability when the use of chlorhexidine with tooth mousse.

Key words: Chlorhexidine; fluoride varnish; tooth mousse; white spot lesions.

Introduction

Most orthodontic patients concern about maximize dental aesthetics during and after orthodontic treatment to improve the psychological state. One of the aesthetic aspects that concerned by the patient after removal of fixed orthodontic appliance is the integrity and color of the enamel that might affected due to larger accumulation of bacterial plaque with fixed orthodontic appliance and, hence, predisposes patients to enamel demineralization resulting from dissolution of the enamel, that appear within only a few weeks after appliance placement (Derks et al, 2004; Bergstrand and Twetman, 2011) and the favored sites for such demineralization area are around the cervical margins of the teeth (Featherstone, 2000). These subsurface enamel demineralization areas can vary from microscopic alterations to visible "white spot lesions" (WSL) that may represent the early phase of caries formation (Gorelick et al 1982; Bergstrand and Twetman, 2011).

The presence of these lesions affect enamel translucency that mainly attributed to the degree of the mineralization of the enamel structure and its mineral content, the translucency of enamel and underlying dentin determine the color of the tooth which varies from yellowish white to grayish white, WSL manifest themselves as white opacities visually which considered as esthetic problem (Bergstrand and Twetman, 2011).

The treatment protcols used to prevent WSL in orthodontic patient included oral hygiene instruction, application of fluoride and use of antimicrobial moth rinses which require patient compliance and was found effective in reducing the demineralization during orthodontic treatment and significant reduction in the enamel white spot lesions could be achieved during orthodontic therapy using l0 ml of neutral sodium fluoride rinse (Geigar et al, 1992). Other treatment modalities that not require patient compliance was remineralization by topical fluoride, casein phosphopeptide amorphous calcium (CAPP-ACP) and Resin infiltration or use invasive modality such as micro abrasion or adding antimicrobial agent to orthodontics material. (Andersson, 2007; Paris et al, 2013). Fluoride varnishes were developed to prolong the contact time between fluoride and enamel, so current concept of caries preventive mechanism of fluoride varnish is based on the formation of calcium fluoride on enamel surface permits significantly more incorporation of fluoride than with other fluoride applications, e.g. Acid phosphate fluoride gel, monofluoride phosphate dentifrices, home fluoride rinses (Demito et al, 2004; Vivaldi et al, 2006).

For instance, a three-monthly application of fluoride varnish resulted in a reduction in WSL incidence and the application of a fluoride varnish can be easily adapted to current orthodontic bonding; this reduction was about 35% in demineralized lesion depth by (Todd et al, 1999; Petersson et al, 2000). Other techniques proposed to mask the appearance of white spot lesions and some authors demonstrated that treatment for white spot lesions by improvement of remineralization using a complex of casein phosphopeptides and amorphous calcium phosphate (CCP-ACP), In vivo study investigated the effect of a dental cream containing CPP–ACP and compared with fluoride mouth rinses on remineralizing white spot lesions using laser fluorescence, where the regression of white spot lesions was seen following the application of CPP–ACP cream. (Anderson, 2007). Another in vivo study used sugar free chewing gum containing CPP–ACP also showed increase acid resistance and promotes remineralization of enamel (Ijima et al, 2004). The twice daily application of 10-fold diluted CPP–ACP paste resulted in preventing dentin demineralization (Oshiro et al, 2007).

The results of studies concerning the color properties of dental materials with increasing awareness of white spot lesions treatment and subsequent screening their color stability or the staining potential of different agents like chlorhexidine are meaningless unless they are based on reliable methods of color assessment, so studies frequently use colorimeters, digital cameras, spectrophotometers or portable digital

spectrophotometer for example Vita Easy Shade Compact to assess color alterations. (Leonard et al, 2001; Eliades et al, 2004; Alline et al, 2011; Enver et al, 2014).
Chlorhexidine is the most effective antimicrobial cationic agent for the control of periodontal pathologies in the orthodontic patient (Sari and Birinci, 2007). However, the evidence regarding the effectiveness of chlorhexidine in controlling WSL is inconclusive (James et al, 2010). It is well known that chlorhexidine inhibits acid production in biofilm and thus reduces the fall in pH during sucrose challenges (Rolla and Melsen, 1975). Some authors concluded that one of the ways to prevent initial lesions in enamel is to protect the body of the lesion from microorganisms, by the application of antimicrobial agents (Yazio˘glu and Ulukapi, 2014). Color of enamel in areas of the teeth that are less accessible to brushing tend to stain and is often promoted using certain cationic agents such as chlorhexidine or metal salts (Joiner, 2004; Yuana et al, 2014). Few in vitro studies have evaluated the effects of cationic agents such as chlorhexidine on the color of remineralization dental materials of WSL; therefore, the aim of the present in vitro study was to evaluate the color stability of WSL, remineralization treatment materials in distilled water and Chlorhexidine.

Materials and methods

Sample Preparation

Ninety human permanent premolars were selected as sample according to the selection criteria from 115 premolar teeth extracted from 67 male and 48 females for orthodontic treatment who attend oral surgery department at the Baghdad College of dentistry and some private clinics in Baghdad city. The sample was evaluated within two weeks from extraction time by means of a reflecting spectrophotometer (VITA Easy shade, Zahnfabrik, Switzerland) to equalize the shade, exclusion selection criteria were: presence of stain, demineralization (white spot lesion), caries, Fluorosis, Enamel cracks, restorations in teeth (Enver et al, 2014).
After extraction, the teeth cleaned in tap water for 1 minute each and stored in 0.05% of thymol solution at room temperature in closed container within two weeks until their use to minimize brittleness of enamel and microbial growth. Each sample tooth was fixed on a glass slide in a vertical position with carving wax block, then each tooth was polished with non–fluoridated pumice slurry and rubber cup bur attached to a low speed hand piece for 10 sec (Ostby et al, 2007), The white spot lesions (WSL) was created at the gingival third of buccal surface of sample tooth about 6 mm×6 mm dimension window by using adhesive tape, The other surfaces of tooth coated by acid resistance nail varnish around the gingival window(Issa et al, 2003). The sample teeth were immersed in the demineralization solution with PH (4 - 4.5) at room temperature in closed container to prevent dehydration for 4 weeks where the solution changed every two days (48 hours) to keep the pH constant. After demineralization, specimens were washed thoroughly with distilled deionized water (DDW), and the nail varnish was removed by using acetone then the teeth washed in DDW again. After this procedure each tooth displayed an artificial WSL of 6 mm× 6 mm (Issa et al, 2003).

WSL and Treatment Group

After WSLs formation; 90 teeth were randomly divided into three groups each group was 30 teeth as following:

WSL Group

Specimens with untreated white spot lesion, stored in DDW.

Fluoride Treatment Group

The tooth surface was treated with fluoride varnish (5% sodium fluoride varnish contained CAPP-ACP), (GC Corporation, Tokyo, Japan) according to manufacture instruction, teeth cleaned and dried first before application of fluoride varnish then varnish applied on the tooth surface by using disposable brush.

Tooth Mousse Treatment Group
Tooth mousse (GC Corporation, Tokyo, Japan) applied according to manufacture, in brief as following:
1. Enough tooth mousse applied to the tooth surface using a disposable artistic brush for minimum 3 mins.

2. Tooth mousse leaved if possible an additional three minute undisturbed and kept on tooth for thirty minutes following application.

Immersion in chlorhexidine Procedure
Chlorhexidine(Corsodyl®Chlorhexidine digluconate 0.2% W\V,(GlaxoSmithKline, UK) was used as an immersion media in the study and was started after formation of WSL and treatment procedure;remineralization; finished. The samples immersed in chlorhexidine in closed container for one hour in at 37°c in the incubator (Ostby et al, 2007).

Sample Screening and Evaluation
The artificial WSL of each tooth was evaluated by means of a reflecting spectrophotometer (VITA Easy shade, Zahnfabrik, Switzerland). Baseline comparisons performed by measuring the color change (ΔE) of the WSL compared to the adjacent sound enamel. The device was calibrated before each session on the white table supplied with it, the treated artificial WSL (fluoride varnish, tooth mousse) of each tooth evaluated again by means of a reflecting spectrophotometer. Then after immersion in chlorhexidine, again the artificial WSL and treated WSL of each tooth were evaluated by means of a reflecting spectrophotometer.

Statistical Analysis
Statistical analyses were carried out with the statistical package IBM SPSS® System for Windows version 21 (IBM Institute Inc, Armonk, NC, USA) which include Mean, standard error and standard deviation, inferential statistics including: One way analysis of variance (ANOVA) to test any statistically significant difference among groups and Least significant difference (LSD) to test any statistically significant differences between each two subgroups when ANOVA showed a statistical significant difference within the same group, T- test was used to determine whether there was a significant difference in mean of change in color (ΔE) after immersion in chlorhexidine.

Results
The mean values of Colour change (ΔE) for WSL group in DDW increased after formation of artificial WSL; while with the application of fluoride varnish and tooth mousse values of Colour change (ΔE) decreased. The color change (ΔE) mean of WSL immersed in chlorhexidine was increased then decreased after treatment in the tooth mousse and fluoride varnish group (Table 1).
WSL and treated WSL groups in DDW and in chlorhexidine revealed a significant effect for the type of treatment on the color change (ΔE) in one-way ANOVA, there was a statistically significant difference in LSD test between the WSL, fluoride and tooth mousse groups in DDW and in chlorhexidine (Table 2).
The effect of chlorhexidine revealed a significant difference for the effect in the WSL group and the WSL that treated with tooth mousse in T-test while a non-significant difference of the effect of chlorhexidine in the WSL group that treated with fluoride varnish (Table 3).

JODR
VOLUME 7, Issue 1, 2020

Table (1): Descriptive statistics of the effect of different treatment on degree of color change of white spot lesions.

		N	Mean	Std. Deviation	Std. Error
White spot lesion groups in DDW	WSL	15	26.33	1.06	0.34
	Fluoride	15	13.06	2.27	0.72
	Tooth mousse	15	14.74	2.67	0.84
White spot lesion groups in CHX	WSL	15	37.84	1.02	0.32
	Fluoride	15	13.09	2.41	0.76
	Tooth mousse	15	23.10	3.38	1.07

Table (2): Inferential analyses of the effect of different treatment modalities on color change of white spot lesions.

Study groups	ANOVA		Treatment	Treatment	LSD	
	F	Sig.			Mean Difference	Sig.
White spot lesion group in DDW	125.35	.000	WSL	Fluoride	12.27	.000
				Tooth mousse	9.59	.000
			Fluoride varnish	Tooth mousse	-2.68	.003
White spot lesion group	188.72	.000	WSL	Fluoride	25.75	.000
				Tooth mousse	14.74	.000

The mean difference is significant at the 0.05 level.

Table (3): Inferential analysis the effect of Chlorhexidine in study groups.

Study groups	T Test			
	Bavarage		T test	Sig.
WSL group	DDW	CHX	13.51	.000
Fluoride varnish group	DDW	CHX	.03	.978
Tooth mousse group	DDW	CHX	8.36	.000

The mean difference is significant at the 0.05 level.

Discussion

In this study, evaluation of color stability by reflecting spectrophotometer (VITA Easy shade) was preferred because it is a sensitive and objective instrument for investigating color change. This method achieves a reproducible means for determining when change in color occurs below visual perception levels.

WSL and treated WSL groups in DDW

The increased mean of color change (ΔE) after formation of artificial WSL was because the air or water in the micro-porosities of WSL which effect the light refraction through the enamel that produce the white opacity and the air or water in the micro-porosities of WSL was replaced with fluoride varnish and tooth mousse treatment material, leading to less light scattering within the enamel and significant decrease of ΔE mean values with a statistically significant difference between the two groups ;WSL and fluoride group, WSL and tooth mousse group.

WSLs and Treated WSLs Groups in Chlorhexidine

The immersion of WSL in chlorhexidine increased the color change (ΔE) mean that might be due to the erosive effect of alcohol of chlorhexidine that increase of WSL porosity and staining effect of chlorhexidine on WSL. The treatment of WSL with tooth mousse or fluoride varnish decreased the ΔE mean value with a significant difference between WSL and tooth mousse group because of the deposition of calcium ions of tooth mousse that enhanced subsurface remineralization, while the non-significant effect of chlorhexidine on WSL treated with fluoride group might due to fluoroapatite crystals that formed by fluoride ions of varnish that prevent the staining effect of chlorhexidine.

Conclusion

• Formation of WSL during Fixed orthodontic treatment is associated with significant tooth color changes. The use of remineralization material (fluoride varnish, tooth mousse) could return mineral to subsurface enamel of WSL and improve esthetics with good color stability.

• Chlorhexidine with tooth mousse can improve the esthetic characteristics of WSL; however, the long-term effect of resin infiltration on WSL in clinical practice should be studied further.

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JODR
VOLUME 7, Issue 1, 2020

Intentional Replantation The survival Treatment: Case Report

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ABSTRACT
Background intentional replantation is not a new procedure. It has been used for many years as a treatment option in case of a tooth has been non-surgical retreated and disease persists. **Objectives** it is to evaluate the tooth replantation and to preserve the tooth loss. **Materials and Methods** 23 year's old patient attended the Conservative Department complaining from slight mobility and pain of the lower left first molar. **Results** apical surgery may be contraindicated because of anatomic factors such as mental foramen, mandibular canal, thick bone and periodontal attachment loss or because of medical conditions. **Conclusion** the intentional replantation procedure should be considered as an alternative to the tooth extraction.

Keywords: Endodontic manipulation; periodontal ligament; periodontal attachment; splints; tooth replantation.

Introduction

The teeth replantation or re-implantation means reinsertion of a tooth in its socket after complete avulsion due to trauma or other defective etiologies. While the intentional re-implantation (IR) refers to the tooth extraction for extraoral root canal therapy, curettage of the apical lesion, then its replacement to its socket (Ward, 2004). Historically, this method was used by many practioners according to Rouhani et al, (2011). It's first used in the 11th century AD by Abulcasis who designated the first account of replantation and the use of ligatures to splint a replanted tooth (Weinberger, 1948). Fauchard in 1712 reported that intentional replantation after 15 mins of tooth extraction (Fauchard, 1746) and according to Dryden and Arens, (1994). Thomas Berdmore studied this option of treatment for mature and immature teeth (Berdmore, 1768). The intentional replantation of diseased teeth by Woofendale, (1783), stated that an extracted tooth was boiled to remove tooth disease before replantation by John hunter (Hunter, 1778). Several studies focus on the periodontal ligament (PDL) essential role to enhance intentional replantation. In 1890, Scheff referred to the PDL effect in the prognosis of replanted teeth. The importance of intact PDL on intentional replantation success by Hammer, 1955. He believed that healthy tooth PDL is essential for the reattachment and retention of replanted teeth. In addition, 10 years of replantation lifespan could be expected as a consequence of technically ideal manner. In 1961, Loe and Waerhans tried to replant teeth immediately, to keep the PDL vital (Loe and Waerhans, 1961). Sherman revealed that the normal PDL could be reestablished following IR (Sherman, 1968). Grossman, (1982) stated that it is essential to remove and reinsert the tooth immediately into the socket. This may correct the clinical appearance or to avoid radiographic endodontic failure. These might relate to examination, diagnosis, endodontic manipulation, and repair returning. Moffat et al considered intentional replantation as one-stage treatment that would maintain successful and natural tooth aesthetics (Moffat et al, 2002). Since intentional replantation is less common than the implant and endodontic treatment, the modern dentistry has been shown arising interest in IR with advances in bio-materials in several dental aspects including root end biomaterials and periodontal regenerators (Khalid et al, 2004).

Case report

A twenty-three years old male patient attended the Conservative Department at Karbala Specialized Dental Center, Iraq complaining from slight mobility and pain of the lower left first molar. Intraoral examination showed a defective composite filling. Intra-oral radiograph was taken to the accused tooth, which revealed root canal treatment with a large periapical lesion and bifurcation involvement. Treatment options were discussed. Tooth re-implantation was recommended as a clinical procedure. The IR procedure armamentarium as shown in figure (1). After administration of local anaesthesia, the tooth was extracted in atraumatic way and it has been held in a forceps for the entire work. The wound was packed with sterile gauze and the patient asked to close his teeth together to immobilize the pack. Resection of both the mesial and distal roots were performed by beveling the root tip with a bur in a straight handpiece. Retro-preparation of the mesial and distal roots was accomplished using a round bur in a contra-angle handpiece with copious irrigation. An MTA retrograde filling was placed in the root canals. After completion of the extra-oral procedure, the socket was irrigated gently with a normal saline solution to remove the clot and the tooth was replanted again in its socket in an out of occlusion relation with its antagonist tooth and splinted with a non resorbable suture for one week and then for another two weeks with an orthodontic wire. The clinical steps showed in figures (2a, 2b, 2c, 2d, 2e). After three months, the replanted tooth was firm in its socket and the patient was asymptomatic. Radiographic examination revealed a decrease in radiolucency around the roots which indicate healing and bone formation (Figure 3). After eight months, the healing process was uneventful and the tooth was asymptomatic, and with no evidence of resorption was noticed on the periapical radiograph (Figure 4). The patient was examined 13 months after the procedure.The tooth was functional, asymptomatic with no evidence of bone resorption or apical pathology in the radiographs (Figure 5).

JODR
VOLUME 7, Issue 1, 2020

Figure 1: Armamentarium for the treatment case study.

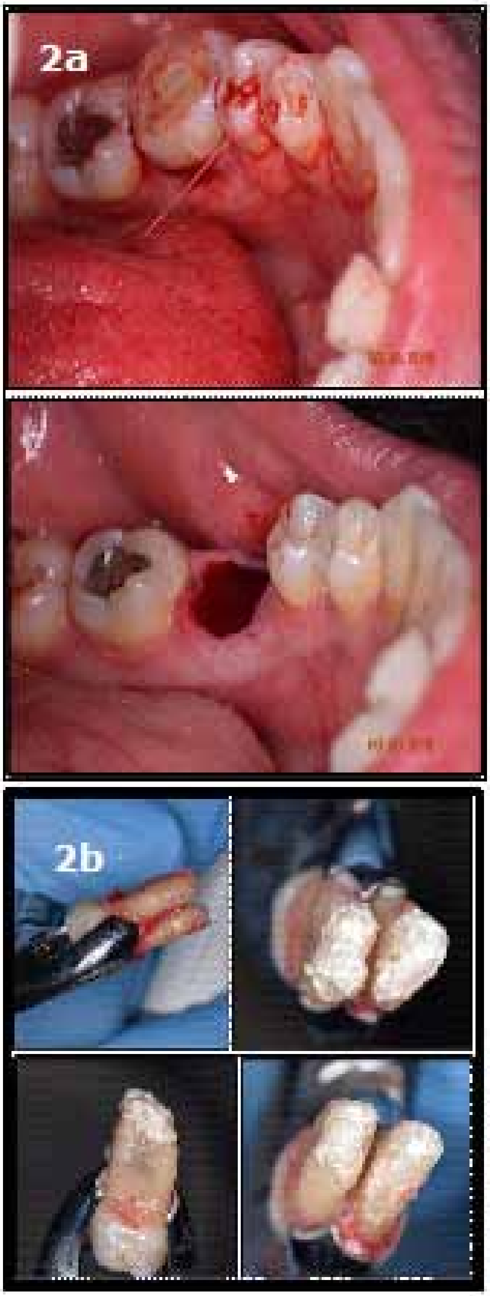

Figure 2: The clinical steps showed (2a, 2b).

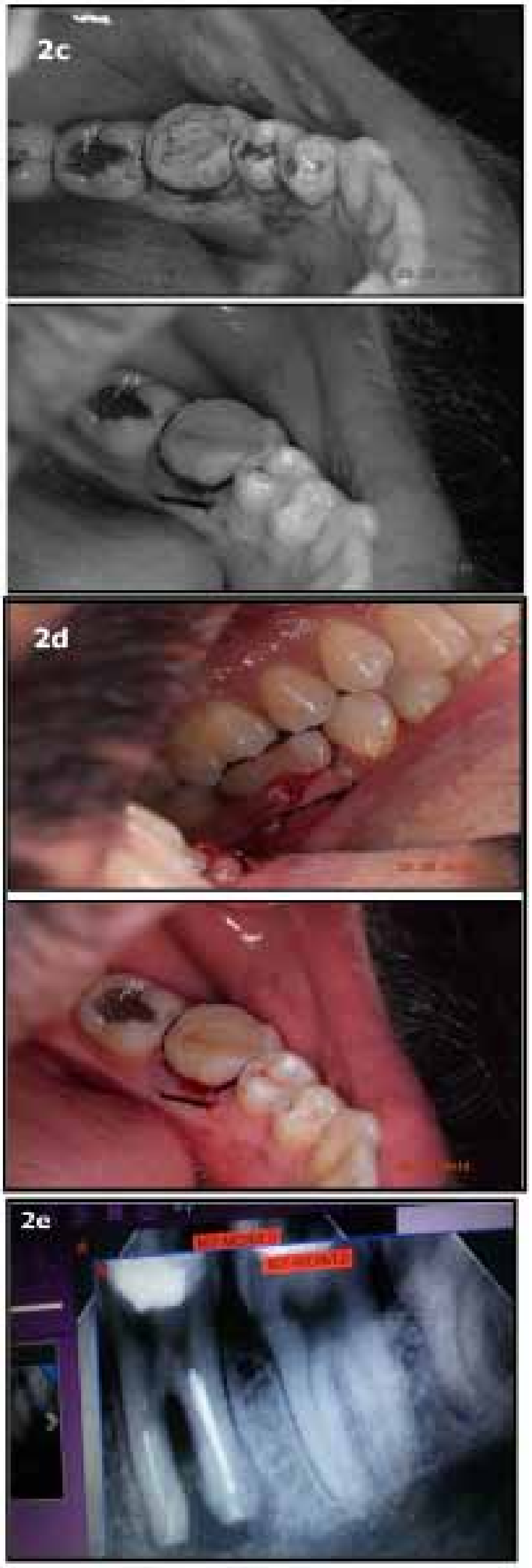

Figure 2: The clinical steps showed (2c, 2d, 2e).

Figure 3: The radiograph revealed a decrease in radiolucency around the roots.

Figure 4: periapical radiograph showed no evidence of resorption.

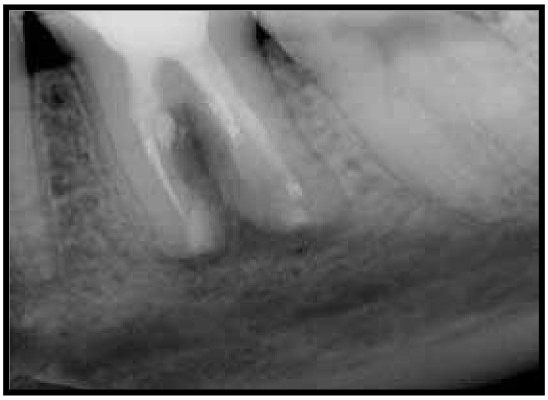

Figure 5: periapical radiograph showed no evidence of bone resorption or apical.

Discussion

The IR is considered as an alternative treatment choice in cases when root canal treatment is failure and apical resection might be difficult to perform. Thus, apicoectomy and retro-filling process were performed extraorally, then the tooth replanted into its alveolar socket (Allen, 2015). The successful intentional replantation procedure depends on two main factors, an atraumatic extraction and the short extraoral time which recommended being less than 10 mins. When the clinician following the proper selection of such cases alongside recommended steps, a highly and successful rate could be expected. An intentional replantation for the molar tooth is a costly-effective alternative procedure for a failing nonsurgical root canal treatment (NSRCT) than many other treatment options. It has an initial cost equivalent to that for apical surgery. IR is not a commonly performed procedure because of its unfamiliar and not a routine procedure as not easy to convenience the patient to re insert what it was already removed from the dental arch because of it was a diseased non treated tooth and somehow the technique sensitivity as its need well skilled dentist starting from case selection, the procedure itself till reinsertion of the tooth back again to its socket. Dental clinicians may unfamiliar with such a procedure to be considered as one of their treatment planning. Grossman, (1966) stated that intentional replantation should be the procedure of the last resort. Within our work in this case it must be mentioned that this procedure can be re considered as treatment plan to be used for treating hopeless teeth when persistent infection after nonsurgical retreatment of the root canal systems and in case that the patient cannot afford payment for bridgework or dental implant and within the advancement of biomaterials such as Mineral Trioxide Aggregate (MTA) availability in the dental practice and with a little more effort from the dentist , this procedure of re-implantation should be consider to afford a good dental service for some selected cases. A study by Bender and Rossman, (1993) were reported a failure of intentional replantation case after 3 weeks of replantation. This could be related to missing preoperative antibiotics according to the author's opinion. However, the patient was then given preoperative antibiotics with a chlorhexidine rinse, and the tooth was replanted for a second time. Then, after 46 months, the researchers indicate that the tooth had healed without any complication. They reported 31 cases of intentional replantation with an overall success rate of 80.6%. The survival time for IR teeth ranged from one day to 22 years. Rouhani et al, (2011) reported 95% success rate on reimplanted cases with the retention average between 3 to 5 years. A study by Aqrabawi, (1999) evaluated two cases of intentional replantation and retrograde filling of mandibular second molars. Up to 5 years recall visit, radiographs showed no evidence of any pathologic changes. On the other hand, Nuzzolese et al, (2004) alongside many researchers stated that the literature confirmed the successful rate of intentional replantation at 5 years ranges from 70%-91%. An unconventional intentional replantation of a mandibular second molar by Chandra and Mahalinga, (2006) revealed that the tooth was still functional. Besides, the patient was asymptomatic and the recall intraoral periapical radiographs showed an intact periodontal ligament space and laminadura with no evidence of gross root resorption or ankylosis. Furthermore, a study by Muhamad Abu-Hussein et al, (2013) indicated a case of mandibular second molars that treated with intentional replantation and retrograde fillings after 8 year recall visit, the radiographs revealed no evidence of pathological changes.

Conclusion

Within the limitation of the present case report, the followings were concluded:

• The primary goal of any conservative is to preserve natural dentition.

• The intentional replantation for proper case selection could provide long-term results as good as those of apical surgery.

• The intentional replantation might be suggested as an alternative treatment plan for certain cases when routine treatments not applicable, have failed, or periapical surgery unlikely to succeed, impracticable or less acceptable by the patients.

• Although intentional replantation is considered as the procedure of the last resort, however, dental practitioners may still unfamiliar with the application of such a technique.

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JODR
VOLUME 7, Issue 1, 2020

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JODR
VOLUME 7, Issue 1, 2020

Comparison of Post Endodontic Pain Using Different NaOCL Consistencies (In Vivo Study)

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ABSTRACT
Background the main objective of endodontic treatment is to clean and fill the root canal system without post-operative discomfort. **Objectives** the effects of 5.25% of NaOCl solution and gel on post endodontic pain. **Materials and Methods** Sixty six patients were diagnosed with necrotic pulp and chronic apical periodontitis. They divided into two groups randomly, group (I) as a control group to be treated with 5.25% of NaOCl solution (NS), while group (II) was an experimental group which treated with 5.25% of NaOCl gel (NG). The root canal was prepared using rotary files then irrigated with 5 ml of 5.25% Naocl solution for (NS) group while, 5 ml of normal saline with the 5.25% Naocl gel coat each rotary file before insertion into canal for (NG) group. A questionnaire was given for all patients to be filled out at 24, 48 hours and 7 days for pain assessment. A chi-square assessment was performed to find out the significant differences. **Results** for (NS) group, 36.4 % of patients have moderate pain during the first 24 hours, while only 27.3% of (NG) group shows moderate pain during the same suggested time. The moderate pain was gradually decreased to become 27.3% for (NS) group and 18.2% for (NG) group during the first 48 hours. After 7 days only a 9.1% in (NS) group show mild pain and no pain reported with (NG) group. **Conclusion** NaOCl gel can reduce the incidence of post endodontic pain, however, it was non-significant when compared to NaOCl solution.

Keywords: Chronic apical periodontitis; necrotic pulp; sodium hypochlorite gel; sodium hypochlorite solution; post endodontic pain.

Introduction

The main aim of root canal therapy (RCT) is to clean, shape and fill the whole root canal system without postoperative pain (POP) (Udoye and Aguwa, 2010). Despite the precautions taken during endodontic treatment, some patients may suffer from pain or flare-up after RCT. Such a condition is an undesirable situation for both endodontists and patients.

Furthermore, it is considered a poor indicator of the long term success of RCT (Thomas, 2015). Therefore, prevention of post endodontic pain is considered an important part of endodontic treatment (Siqueira et al, 2000; Thomas, 2015). Sodium hypochlorite solution reported that it has strong antimicrobial and histolytic properties (Okino et al, 2004), which made it considered a standard endodontic irrigation solution for root canal cleaning and disinfection (Zehnder, 2006). However, NaOCl at high concentration can be cytotoxic to periapical tissue (Dunavant et al, 2006; Tanomaru et al, 2002) and this may cause POP if NaOCl extravagated into these tissues (Jeansonne and White, 1994). To avoid this problem, many modalities have considered during RCT procedure, such as straight-line access opening with coronal flaring; preoperative diagnostic radiograph; using of laterally orifices needle; accurate working length; needle tip freely move in the canal; and avoid excessive digital pressure (Mathew, 2015). NaOCl in gel form was introduced to provide improved control and reduce the possibility of apical extrusion to periapical tissue (Zand et al, 2016; AlSudani and Alomar, 2011). Therefore, this study designed to evaluate the effect of NaOCl in the form of solution and gel on post endodontic pain.

Material and Methods

Patient selection

The population sample of this prospective clinical study was from patients who seek dental treatment in a private clinic over one year. The sample involved in this study needed RCT after diagnosis of necrotic pulp with chronic apical periodontitis, in permanent single-rooted teeth (anterior and premolar). All participants were over eighteen years old; pulp necrosis was confirmed by the negative response to cold and electrical test and no bleeding when entering the pulp chamber. The patients qualified for this study participation if they had not used antibiotics, anti-inflammatories or analgesics for no less than a week before the study treatment, and with no preoperative pain. However, they disqualified if they had incomplete root formation, persistent exudate, deep periodontal pockets, calcified teeth, or if apical patency was not realized. Besides, patients with immunosuppression or immune-compromised were similarly disqualified (Almeida et al, 2012). All volunteers were informed about the purpose of the study and provided a written declaration form to sign it to be approved. Sixty-six patients (male = 33, female = 33) had been participating in this research, the patients were randomly divided into 2 equal treatment groups according to NaOCl forms using a simple cone flip method. Group I as a control group with a 5.25 % of sodium hypochlorite in solution form (chloraxd 5.25% solution, cerkmed, Poland), and group II as an experimental group with a 5.25% of sodium hypochlorite in gel form (chloraxd 5.25% gel, cerkmed, Poland). Gender distribution for each group as follow: Group I (male = 16, female = 18), Group II (male 17, female = 15).

Endodontic procedure

The RCT for all participated patients was accomplished by the same endodontist. The patients were anesthetized by one cartridge of 2% lidocaine with 1:80000 epinephrine (3M Xylestesin), followed by the placement of a rubber dam to isolate the infected tooth, then access opening was performed. The working length was determined using electronic apex locator (Morita Root ZX II Mini Apex Locator) with k-file size 15 (stainless steel, Dentsply M-access K-File), the file inserted into the canal until the screen of apex locator indicate the apex, then withdrew the file till the flashing bar on display reach area between 0.0 and 1, the rubber stopper was adjusted to reach the reference point then the working length determined and confirmed by a radiograph. The root canal preparation was carried using the rotary endodontic file system (Protaper universal, Dentsply Maillefer, Switzerland) the instrumentation used according to the manufacturer instructions. Between each instrument changing step, the canal was irrigated as follows: in group (I) control group, the root canal irrigated with 5 ml of 5.25% sodium hypochlorite solution, while in the group (II), a 5 ml of normal saline with the 5.25% of sodium hypochlorite gel-coated each rotary file before its insertion into the canal. A 30-gauge irrigation needle was used for both treated groups and it was inserted into root canal about 2 mm shorter than the working length. Also, irrigation solutions had been delivered to the root canal slowly and passively. Furthermore, a size 10 k file was employed for maintaining apical patency throughout the instrumentation process. In both groups and when the preparation of the canal completed, root canals were irrigated with a 10 ml sterile saline solution. Next, the canals were dried with sterile paper points (Dentsply Maillefer, Switzerland) analogous to the master apical file. Then, a sterilized dry cotton-wool had been placed in the pulp chamber and the cavity had been filled with temporary cement (Cavit. ESPE Dental AG, Seefeld, Germany).

Pain assessment

A questionnaire with a self-explanatory scale was given for all participant patients to be filled out after 24, 48 hours and 7 days. This is to assess the pain rate. According to many reported researches, the severity of pain was categorized into four-point scale, 0= no pain, 1= mild pain (no need for analgesia), 2= moderate pain (comforted by analgesia) and 3= severe pain (not comforted by analgesia) (Direnzo et al, 2002; Glennon et al, 2004; Yoldas et al, 2004; Oginni and Udoye, 2004). The analgesic described for all patients was paracetamol tab of 500mg three times a day (on need). Furthermore, each participant in research received a recall from a researcher assistant to remind them to score the pain experience and to help them to fill the form properly.

Statistical Analysis

Chi-square test was used in this study for pain-intensity comparison between the two groups at 24, 48 hours and after 7 days following the procedure. Levels of significance had been set at the P-value of ($P=0.05$).

Results

Sixty-six patients (male = 33, female = 33) were enrolled in this research, with the age ranging between 18 to 61 years old. All the participants completed the study questioning sheet form and return to hand it. Generally and at each period, results revealed non-significant differences between assessed groups. The patients in each group showed no suffering from severe pain at any stage, and significant differences were almost lacking ($p > 0.05$) as shown in Table (1). The pain level was reduced as time goes forward after the procedure. It was shown that 24 hours after the treatment procedure was the hardest time. 36.4 % of NaOCl solution group patients of 12 out of 33 have a moderate pain during the first 24 hours, while only 27.3% in the NaOCl gel group with 9 patients out of 33 shows moderate pain during the same period. However, during the first 28h, the differences were still statistically non-significant. The moderate pain was gradually decreased to become 27.3% (9/33) for the patients with NaOCl solution and 18.2% (6/33) for the patients treated with gel. After 7 days only 9.1%

(3/33) patients in the solution group show mild pain and no patient assessed with any type of pain in the NaOCl gel group.

Table (1): Results of the 4-point scale questionnaire.

Pain intensity	24 hour		48 hour		7 days	
	Frequency N=33	Percentage	Frequency N=33	Percentage	Frequency N=33	Percentage
NaOCl solution						
0	6	18.2	15	45.5	30	90.9
1	15	45.5	9	27.3	3	9.1
2	12	36.4	9	27.3	0	0
3	0	0	0	0	0	0
NaOCl gel						
0	12	36.4	21	63.6	33	100
1	12	36.4	6	18.2	0	0
2	9	27.3	6	18.2	0	0
3	0	0	0	0	0	0

Pain intensity: 0= no pain, 1=mild (no need for analgesia), 2= moderate (comforted by analgesia) and 3= severe (not comforted by analgesia).

Discussion Pain after RCT is usually caused by periapical tissue response to one or more factors, which can include mechanical, chemical, or microbial. Over-instrumentation can be considered as a mechanical factor, whereas, the extrusion of irrigation solution, intracanal medicament or filling material through apical foramen can be considered as a chemical factor. The microbial factor due to poor cleaning and shaping procedures may leave infected debris inside the canal (Siqueira and Barnett, 2004) (Figini et al, 2008). Among these factors, microbial is considered as the utmost mutual reason for POP, then further causes which may comprise mechanical or chemical injury to pulpal or periapical tissues. There have been strong interaction indicators among periapical tissues and microorganisms. Since flare-ups are further probable to happen in necrotic cases than in vital cases (Thomas, 2015), it is why only patients with necrotic pulp and chronic apical periodontitis were selected to be included in this study (Siqueira et al, 2000). Additionally, patients with preoperative pain were excluded from this study sample because it considers as one of the strongest predictors for POP (Glennon et al, 2004). The only instrumentation phase (without obturation) was applied, and the measurement of post endodontic pain was evaluated to avoid any risk of root canal filling materials that may be extruded and cause the POP which may affect the results of the present study. Several studies reported that extrusion of filling material leads to POP (Harrison et al, 1983; Seltzer, 2004; Gondim et al, 2010). Furthermore, Alonso- Ezpeleta et al, in 2012 a researcher concluded that POP was suggestively connected to the obturation method employed throughout RCT (Alonso-Ezpeleta, 2012). The patient's subjective evaluation considers one of the major difficulties in studying and measuring pain, this is why questionnaire design is crucial and should be entirely understood by patients and easily explained by investigators. (Arias et al, 2009). Herein, POP was measured using a questionnaire and 4-point pain intensity, similar to methods used in several previous studies (Direnzo et al, 2002; Glennon et al, 2004; Yoldas et al, 2004; Oginni and Udoye, 2004). NaOCl is presently the irrigant of choice due to its chemical properties that make it an active cleanser and disinfectant of the root canal system and an outstanding solvent for organic tissues (Zehnder, 2006). A concentration of 5.25% was selected to guarantee the powerful antimicrobial action (than that of a lower concentration NaOCl) and stability of histolytic activity (Jeansonne and White, 1994). Since high concentration solutions might have a superior potential for dissolution of debris in areas that cannot be reached by endodontic instrumentation (Okino et al, 2004). Nonetheless, high concentrations substantially rise irrigant cytotoxicity and, in cases of extravasation result in acute injuries to periapical tissue which include ulceration, hemolysis and damage to fibroblast and endothelial cells that cause swelling, trismus and sensory-motor destruction, which lead to POP (Dunavant et al, 2006) (Guivarc'h et al, 2017). In contrast; NaOCl gel 5.25% has a minor risk of extrusion through the apex (Vahid et al, 2016) that might decrease post endodontic pain. Although many studies were compared the antibacterial effects of different concentrations of NaOCl solution versus gel and evaluated their effect in eliminating microorganisms from infected root canals (Vahid et al, 2016; Nejad et al, 2017; Claudio et al, 2010). Yet, no paper shows the effect of different NaOCL forms on POP. Therefore, in the present study, two forms of 5.25% NaOCl in solution and gel form were used to evaluate their effect on the POP. The present study findings clearly showed that no significant differences were observed relating to POP at any period of suggested time and between the 5.25% of NaOCl treatment of both the solution and gel form that used for irrigation during endodontic therapy. The major reasons for POP were mechanical, chemical, or microbial injuries to the periapical tissues which result in serious inflammation. It is challenging to regulate if a single or multiple factors elicit pain in a clinical examination. If a root canal system was not washed appropriately, the enduring infection can result in exacerbation by imbalances in the host-bacteria relationship, synergistic or additive microbial interactions, or the existence of conclusively pathogenic bacteria before treatment began (Clark and Eldeeb, 1993). The review of literature lacked an evaluation of the outcome of diverse NaOCl forms on post endodontic pain. However, Vahid et al, 2016 showed that 2.5% of NaOCl gel was effective in reducing E. faecalis count. Furthermore, Nejad et al, 2017 were found NaOCl 5.25% solution and gel showed the same antimicrobial effectiveness. Therefore, NaOCl 5.25% in the form of a gel can be recommended as a safe and controllable intracanal irrigant. The equivalent antibacterial activity of 5.25% NaOCl solution and gel, and these facts can explain the results of the present study. According to the previous literature review, the preoperative pain had a significant impact on POP (Gondim et al, 2010; Ali et al, 2012; Applebaum et al, 2015; Law et al, 2015). Therefore, in this study, to prevent bias due to the presence of preoperative pain, only patients with lacking preoperative pain were included and this can be another interpretation for the results of such study.

Conclusion

Within the study limitations, both NaOCl forms that used in this research were associated with low pain incidence, No patients within each group suffer from severe pain. A 5.25% NaOCl gel usage can reduce the incidence of post endodontic pain; however, it was non-significant when compared to 5.25% NaOCl solution.

Conflict of interest

We are the author's (Eanas I. Jellil, Mustafa N. Abdulghani, and Baidaa M. Zaidan) state that the manuscript for this paper is original, and it has not been published previously (or part of MSc. dissertation or Ph.D. thesis) and is not under consideration for publication elsewhere, and that the final version has been seen and approved by all authors.

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