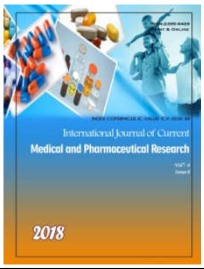
INTERNATIONAL JOURNAL OF CURRENT MEDICAL AND PHARMACEUTICAL RESEARCH
ISSN: 2395-6429, Impact Factor: 4.656
Available Online at www.journalcmpr.com
Volume 4; Issue 8(A); August 2018; Page No. 3562-3568
DOI: http://dx.doi.org/10.24327/23956429.ijcmpr20180511



Research Article

EVALUATION OF TEMPERATURE RISE ON EXTERNAL SURFACE OF ROOT DURING ULTRASONIC RETRIEVAL OF FRACTURED NiTi FILE FROM THE CANAL

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ARTICLE INFO

Article History:
Received 22nd May, 2018
Received in revised form 5th June, 2018
Accepted 16th July, 2018
Published online 28th August, 2018

Key words:
Broken instrument, temperature, Ultrasonics

ABSTRACT

The objective of this in vitro study was to evaluate the amount of heat generated on the external root surface during retrieval of NiTi instrument using ultrasonics. This study checked the temperature rise at higher and lower power settings in presence and absence of coolants at the junction of separated NiTi instrument & the ultrasonic tip, and near the apex of root. Method: 60 permanent human maxillary first molars were decoronated from the cemento-enamel junction using diamond disc such that 8-10mm of mesiobuccal roots of maxillary first molars were obtained. Cleaning & shaping of canals was done using 2.5% sodium hypochlorite & 17% EDTA. The canals were enlarged upto size F1 Protaper. 4mm of Pro-Taper F1 file was fractured & left in the mesiobuccal canal, 4-5 mm from the coronal access. K type thermocouples connected to digital thermometer were attached to external root surface to measure temperature rise. These teeth were divided in 4 equal groups (n=15) : Group 1-With water as coolant/lower power setting ,Group 2 Without coolant/lower power setting ,Group 3 With water as coolant/higher power setting, Group 4 Without coolant/higher power setting. Ultrasonic tip ET 20 was activated for 30 sec, and temperature rise was recorded. The highest temperature rise was seen in the group without coolant at higher power setting whereas lowest temperature rise was seen in the group with coolant at lower power setting.

INTRODUCTION

The goals of endodontic instrumentation include thorough debridement and disinfection of root canal system to achieve a complete three dimensional obturation. Intra-canal separation of endodontic files may occur during cleaning and shaping of root canals which is a common procedural accident. This incident may prevent efficient cleaning and shaping of root canals that leads to failure of endodontic therapy [1]. Fracture of the instrument most commonly occurs due to overuse or incorrect use of the instrument & most commonly it is seen in the apical third of the curved root canal. However in curved canals endodontic files made from Nickel titanium alloy are found to have superior bending and torsional properties when compared with stainless steel. In curved canals, if straight line access is not achieved there is an increased chance of instrument binding to the dentinal walls eventually leading to fracture of the Niti file. NiTi files are prone to fracture which can be due to, 1. Torsional fatigue or 2. Cyclic fatigue Torsional failure occurs when the instrument tip binds and remaining file continues to rotate. It occurs most commonly due to application of increased apical force during instrumentation [2]. Cyclic fatigue is the most common cause for separation of instrument. It is caused due to compressive & tensile stresses on rotating file in a curved canal. The repeated application of these stresses can lead to weakening & fracture of instrument usually at maximum point of flexure. Nickel titanium (NiTi) alloy was developed in 1960, at the U. S. Navy Ordinance Lab in Silver Spring, Maryland by William Buehler [2]. Removal of separated files is often time consuming & difficult. An attempt is recommended either by removal of separated fragment or bypassing it, so that a good coronal & apical seal is obtained after obturation [1]. There are various conservative methods for management of separated instruments in the root canal space which includes [3] (1) an attempt to remove the fragment or (2) an attempt to bypass the fragment or (3) clean and shape the root canal system to the level of the fragment The best practice to treat such cases is removal of the fragment without complications followed by efficient cleaning and shaping of the root canal system without compromising the root dentine. Intentionally leaving a fragment in the root canal might be considered when nonsurgical removal has been attempted without success [4]. Various studies [5] have been advocated which suggests the use of different devices, techniques & methods for conservative removal of fractured fragment, one of them is use of ultrasonics. The use of ultrasonic energy is highly efficient method of removing separated instrument. This method has

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gained rapid, widespread acceptance within a short period of time as the ultimate goal in recovery of the root canal space after removal of separated instrument which ensures that the remaining dentin is sound and able to support the subsequent restoration structurally, as well as provide a restorative complex that is functionally healthy. The concept of using ultrasonics in endodontics was first introduced by Richman [6] in 1957. Ultrasound is sound energy with a frequency above the range of human hearing, which is 20 kHz. Subsequently the low-frequency ultrasonic handpieces operating from 1 to 8 kHz were developed, which produces lower shear stresses, thus causing less alteration to the tooth surface [7]. Ultrasonic energy is derived from one of the two sources: 1.Magnetic resonance and 2.Piezoelectric energy 1. The Magnetic resonance method is based on the principle of magnetostriction which converts electromagnetic energy into mechanical energy. The amount of heat generated is too high which can damage the surrounding periodontal ligament and cause bone necrosis [7]. 2. The Piezoelectric energy method is based on the piezoelectric principle. The tips of these units work in a linear, back-and-forth, "piston-like" motion, at a frequency of 25-40 KHz throughout the root canal length [8]. Piezoelectric energy devices operate in energy ranges that are higher than those of magnetorestrictive devices & most of the units used for instrument removal are within the higher energy ranges of operation [7]. Ruddle [9] described a modified technique to be used with ultrasonic tips. He has given the technique in which a "staging platform" is prepared around the most coronal aspect of the fragment using modified Gates Glidden drills. This provides sufficient space around the segment to allow the use of ultrasonic tips. This allows better visualization of the fragment and facilitates using ultrasonic tips within the root canal system. Studies [4,9] have reported relatively high success rates (88–95%) using Ruddle's modified technique. This procedure can lead to temperature rise on external surface of root.

Various studies [3,8,11] have concluded that tremendous amount of heat is generated within the root canal system, as a result of friction of the vibrated ultrasonic tip and the dentine of the root canal walls. When the ultrasonic tip is activated, friction between walls of root canal & oscillating files may lead to increased heat being generated that can be transmitted to the external root surface leading to injuries caused to the periodontal ligament and the alveolar bone causing ankylosis, root resorption, necrosis of adjacent bone and soft tissue [12]. Therefore, efforts should be made to minimize heat generated during activation of ultrasonic tips against fractured fragments. So it is important to use coolants, for reducing the temperature rise while using ultrasonic tips [11]. Most commonly water is used as a coolant. The coolant spray flows through or around the device preventing the working tip from overheating. This reduces the amount of heat produced by the device inside the root canal. An ideal coolant should have high thermal capacity, low viscosity, & biocompatibility. Due to its high heat absorbing capacity it acts as an electrical insulator, protecting the surrounding periodontal ligament from damage caused due to temperature rise within the root canal [13]. The purpose of this in vitro study was to evaluate the temperature rise on external root surface caused due to ultrasonic retrieval of fractured instrument from the mesiobuccal canal of the maxillary first molar.

MATERIAL & METHODS

60 human maxillary first molars extracted for periodontal reasons, were used in this study. The teeth were cleaned of soft tissue, blood, calculus & stored in saline solution. Then immersed in 2.5% Sodium hypochlorite for two hours and stored in 10% formalin solution. Teeth were then decoronated from the cemento-enamel junction using Diamond disc mounted on mandrel with air motor & straight handpiece (NSK), leaving 8-10 mm roots. Only mesiobuccal roots of maxillary first molars were used in this study. Thorough debridement and disinfection of root canal was done by biomechanical preparation and use of 2.5% sodium hypochlorite as an irrigant & 17% EDTA as a chelator. Cleaning & shaping of canals was done using universal protaper system. The initial file system used was stainless steel K files upto size 20 followed by use of protapers, until the apical preparation with size F1 Protaper. Four millimeters of Pro-Taper F1 file (Dentsply Maillefer, Ballaigues, Switzerland) was measured & markings were made on the file using a permanent maker. Then this F1 protaper was purposely fractured partially using a Diamond disc mounted on mandrel with air motor & straight handpiece (NSK). The fractured NiTi instrument fragment was left in the mesiobuccal canal, 4-5 mm from the coronal access.

The samples obtained were randomly divided in four groups (total- 60).

Group 1- With water as coolant/lower power setting
Group 2- Without coolant/lower power setting
Group 3- With water as coolant/higher power setting
Group 4- Without coolant/higher power setting

Modified Gates Glidden drill #3, #4, were used to create a straight line access for the ultrasonic tip in each sample, at the level of most coronal part of the fractured segment using magnifying loupes. The ultrasonic tip ET 20 (Satelec/Acteon, Merignac, France) as recommended by manufacturer for removal of separated instruments, was activated against the peripheral surface of the coronal part of the fragment (1 mm) for 30 s. In groups 1 & 3, the ultrasonic tips were activated by an ultrasonic unit (Supprason Neutron P6, Satelec/Acteon, Merignac, France) with water as a coolant at low and high power setting. In groups 2 & 4 the ultrasonic tips were activated by an ultrasonic unit, without coolant at low and high power setting. Water was used as a coolant which was delivered drop by drop at the canal orifice using a syringe & a needle. The roots were isolated using a rubber dam in such a way that no water would get leaked towards the external root suface where the thermocouple tips were attached for recording the temperature rise. Activating the ultrasonic tips in all groups was performed by one operator. Using a thick layer of sticky wax, the end of a K-type thermocouple (RS Components Ltd, Corby, UK) was fixed on the two selected sites on the external root surface as follows

1. One end was attached to the external root surface approximately at the junction of ultrasonic tip and broken instrument fragment (T1) and
2. The other end was attached near the apex of the root (T2).

Statistical Analysis

Descriptive and inferential statistical analysis were carried out in the present study. Results on continuous measurements were presented on Mean ± SD. Level of significance was fixed at p

= 0.05 and any value less than or equal to 0.05 was considered to be statistically significant. Student t tests (two tailed unpaired) were used to find the significance of study parameters on continuous scale between two groups. Analysis of variance (ANOVA) was used to find the significance of study parameters between the groups followed by post hoc analysis. The Statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analysis of the data and Microsoft word and Excel were used

RESULTS

Table 1 Intergroup comparison of temperature rise at T1 using ANOVA test

Group	N	Mean	Std. Deviation	P value
Group 1 With coolant/Lower power setting	15	32.67	1.757	<0.001
Group 2 Without coolant/Lower power setting	15	44.94	3.863	
Group 3 With coolant/High power setting	15	39.84	6.14	
Group 4 Without coolant/High power setting	15	45.38	7.648	
Total	60	40.71	7.336	

p < 0.001 – Significant

Table 2 Intergroup comparison of temperature rise at T2 using ANOVA test

Group	N	Mean	Std. Deviation	P value
Group 1 With coolant/Lower power setting	15	35.13	1.879	<0.001
Group 2 Without coolant/Lower power setting	15	48.98	6.038	
Group 3 With coolant/High power setting	15	43.02	5.537	
Group 4 Without coolant/High power setting	15	50.42	10.440	

p < 0.001 – Significant

Temperature rise seen at T1 & T2, group 1 was found to be the least amongst all the groups. The highest temperature rise was seen in the group 4 where the ultrasonic was used at higher power setting in absence of coolant with a statistically significant p < 0.001.

Using Tukey's post hoc analysis the intergroup comparison was done.

Table 3 Intergroup Comparison of temperature rise at T1 using Tukey's post hoc analysis

Group	With coolant/Lower power setting	Without coolant/Lower power setting	With coolant/High power setting	Without coolant/High power setting
Group 1 With coolant/Lower power setting	-	<0.001	0.003	<0.001
Group 2 Without coolant/Lower power setting	<0.001	-	0.05	0.996
Group 3 With coolant/High power setting	0.003	0.05	-	0.031
Group 4 Without coolant/High power setting	<0.001	0.996	0.031	-

Table 4 Intergroup Comparison of temperature rise at T2 using Tukey's post hoc analysis

Group	With coolant/Lower power setting	Without coolant/Lower power setting	With coolant/High power setting	Without coolant/High power setting
Group 1 With coolant/Lower power setting	-	<0.001	0.011	<0.001
Group 2 Without coolant/Lower power setting	<0.001	-	0.082	0.936
Group 3 With coolant/High power setting	0.011	0.082	-	0.019
Group 4 Without coolant/High power setting	<0.001	0.936	0.019	-

When the group with coolant at lower power setting was compared with the groups without coolant at lower power setting & without coolant at high power setting the results were statistically significant with p value p < 0.001. Whereas it was found to be non significant when compared with the group with coolant at high power setting

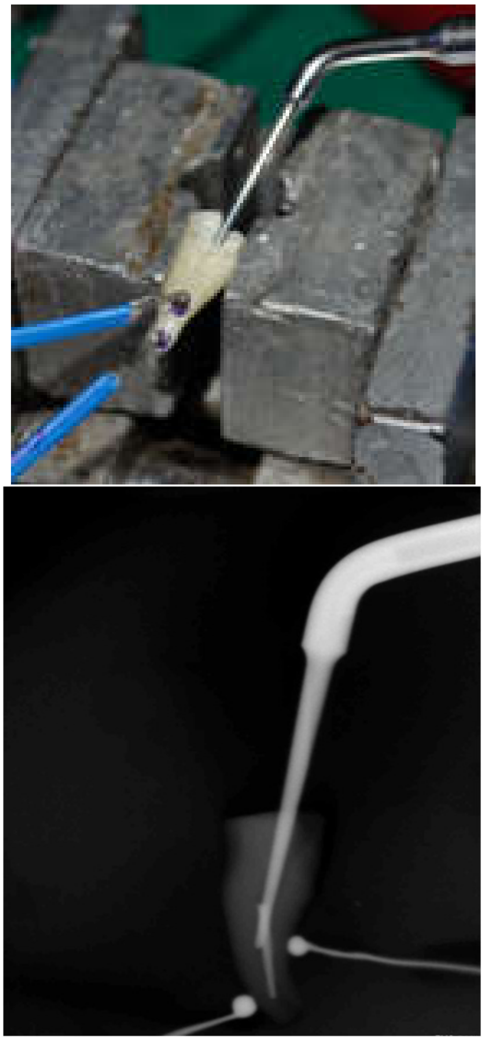
Table 5 Intragroup Comparison of temperature rise at T1 and T2 using unpaired t test

	Group	N	Mean	Std. Deviation	t value	P value
With coolant/Lower power setting	T1	15	32.673	1.7572	3.703	<0.001
	T2	15	35.133	1.8798		
Without coolant/Lower power setting	T1	15	44.940	3.8635	2.186	0.037
	T2	15	48.987	6.0387		
With coolant/High power setting	T1	15	39.840	6.1408	1.493	0.147
	T2	15	43.027	5.5373		
Without coolant/High power setting	T1	15	45.387	7.6482	1.506	0.143
	T2	15	50.420	10.4400		

The result obtained from the above observations was as follows

Using ANOVA test, the highest temperature rise was seen in the group without coolant at higher power setting whereas lowest temperature rise was seen in the group with coolant at lower power setting. Using Post hoc Tukeys test, the intergroup comparison of temperature rise at T1 & T2 was statistically significant with a p value p < 0.001 in the groups: a) With coolant & Without coolant at lower power setting b)

Without coolant at higher power setting & With coolant at lower power setting. Using Unpaired t test, the intragroup comparison of temperature rise at T1 & T2 was statistically significant in group with coolant at lower power setting with a p value $p < 0.001$



[Diagram showing: Placement of thermocouples on the external surface of root and radiographically confirming the points T1 & T2]

DISCUSSION

A successful endodontic treatment needs thorough debridement, & obturation of root canal system. Any mechanical obstruction like a seperated instrument may be detrimental & lead to endodontic failure. As it may be an obstacle to mechanical and chemical treatment leading to bacteria and pulp tissue remanants in the root canal which may have a negative impact on treatment outcome [10]. Fracture of root canal instruments is one of the most troublesome incidents in endodontic therapy. Removal of separated endodontic files is a challenging procedure in most cases [7]. Over years, many techniques have been used, but ultrasonics has been the most popular with good success rates in dental practice. There are some disadvantages with use of ultrasonics that is the temperature rise on the external root surface which has an adverse effect on the surrounding periodontal tissues [14]. In the current study, the temperature rise on the external root surface during retrieval of fractured NiTi fragment using ultrasonic tips at high & low power settings in presence & absence of coolants in the mesiobuccal roots of maxillary first molar was investigated. According to Yuan Gao [15] there are increased chances of file separation in the mesiobuccal root of maxillary first molar due to the apical curvature in lower third of the root along with different wall thickness around the canal. The incidence of lingual root curvature towards buccal direction is high in maxillary first molars upto 54.6%. Separation of instrument can occur, as most of the times dentists are not aware of such situations [16].

Universal protaper system consists of endodontic files made of NiTi alloy. The thermodynamic property of this alloy produces a shape memory effect when the metal is subjected to stress [3]. When an external force on the metal exceeds a given amount, mechanical slip is induced within the file that causes permanent deformation. The super elasticity of NiTi is most pronounced at the beginning, when a first deformation of as much as 8% strain can be overcome. After 100 deformations, the tolerance is about 6% and after 100,000 deformations, it is about 4% [4]. The fracture of NiTi files may occur without warning unlike stainless steel files which show instrument distortion as a warning of impending fracture therefore care has to be taken while using NiTi files [17]. Unwanted procedural accidents can occur during any stage of endodontic treatment which can arise as intracanal instrument fracture inspite of proper care being taken [18]. Cyclic fatigue is the most common cause for separation of instrument. When the compressive & tensile stresses on rotating file in a curved canal are increased, the repeated application of these stresses lead to weakening & fracture of instrument usually at maximum point of flexure. Fracture of the instrument most commonly occurs due to overuse or incorrect use of the instrument & most commonly it is seen in the apical third of the root canal. Such an incident may prevent efficient cleaning & shaping of root canals leading to endodontic failure [4]. Various authors [8,12,18] have described different techniques for management of such fractured instruments. Though there is higher demand for removal of fractured instruments there is no standardized procedure for successful fragment removal from the canal [7]. Removal of separated instruments is a time consuming, complex & challenging procedure. Many techniques have been used but the use of ultrasonics is the most popular with good success rates in dental practice [19].

In the current study Ruddles technique of 'staging platform' has been used along with the ultrasonics & the similar technique has been used in other studies [3,12]. Ultrasonics in endodontics was introduced by Richman [5] in 1957. The Ultrasonic energy used in endodontics is based on the piezoelectric principle [6]. These ultrasonic tips work in a linear, back-and-forth motion, at a frequency of 25-40 KHz throughout the root canal length. The use of ultrasonic energy is widely accepted & highly efficient method of removing separated instrument with the ultimate goal in recovery of the root canal space is to ensure that the remaining dentin is sound and able to support the subsequent restoration structurally, as well as provide a restorative complex that is functionally healthy [7]. Manufacturers recommended ultrasonic handpiece to be used with the tip ET 20 which is indicated for removal of separated instruments [20]. These tips are made from Titanium-Niobium alloy with a smooth surface design to penetrate into the narrow canals for removal of separated instruments. They can cut only at their ends with a chipping action [21]. The working end of the tip is 3μ in diameter which is 3-4 times smaller than that of standard steel. This grain of the metal transmits the ultrasonic vibrations, at high power maintaining the efficiency and resistance needed for removal of fractured instrument.

In the current study sixty permanent human maxillary first molars extracted for periodontal & orthodontic reasons with single patent canals were included in this study. Teeth were then decoronated from the cemento-enamel junction using diamond disc mounted on mandrel with air motor & straight handpiece, leaving 8-10 mm roots. Only mesiobuccal roots of maxillary first molars were used in this study. According to Ingle [22] *et al* 78% of mesiobuccal canals of maxillary first molars are curved apically in distal direction, if straight line access is not achieved there is an increased chance of instrument binding to the root canal wall eventually fracturing the NiTi file. It is important to know the direction of curvature of root especially curvature towards lingual or buccal because it is not radiographically visible. In this study the biomechanical preparation of these mesiobuccal roots was done using 17% EDTA & 5.25% sodium hypochlorite along with universal manual protaper system up to F1. These endodontic files are made of Nickel-Titanium alloys. Nickel titanium alloys have superior bending and flexural properties when compared with stainless steel files due to greater taper, higher elasticity, and resistance to torsional fracture [4]. The apical preparation of the root was prepared using these NiTi files upto size 20, 0.06% taper. To simulate the clinical scenario of instrument separation in the root, these F1 Protaper files were purposely fractured partially using a diamond disc mounted on mandrel with air motor & straight handpiece. These fractured NiTi fragments were left in the mesiobuccal canal, 4-5 mm from the coronal access in the apical third of the root. Fracture of the NiTi file is most commonly seen in curved canals, if straight line access is not achieved, there can be binding of instrument to the dentinal walls eventually leading to instrument separation [3]. NiTi files are prone to fracture either due to torsional fatigue or cyclic fatigue. During instrumentation when increased apical force is applied to the endodontic file the instrument tip binds to the dentinal walls leading to separation of instrument. This is called as torsional fatigue of the instrument [17].

These samples were then randomly divided in four groups depending upon the power settings i.e. high power setting (power setting 9) & low power setting (power setting 6) in presence & absence of water as a coolant for duration of 30s. Many studies [3, 7] recommend that for removal of fractured instruments, the ultrasonic tips should be activated at the lowest power-setting to avoid heat build-up & it should not be used for more than 120 seconds. Hence, using a higher power-setting would provide an insight regarding temperature rise resulting from different procedures which use the same technique for removal of fractured fragment in the root canal. Lower activation time of 30s was considered in the current study as heat generation is dependent on the activation time. Also Hashem *et al* [12] concluded that temperature rise was very high when the ultrasonic tips were activated against root dentine up to 60 and 120 s. Ruddles [12] technique of making staging platform for removal of fractured fragments from the root canal was used in the current study. He suggested the use of Gates Glidden burs to create a staging platform, around the head of the broken instrument such that a trough is formed around the coronal part of the broken instrument. The coronal part of the broken instrument is free & when the vibratory effect of ultrasonics is applied to it that will cause dislodgement of the broken instrument. Ruddles method has been used by various authors [1,3,5,6] in their investigations regarding removal of seperated fragments. The ultrasonic tip ET 20 was used with the ultrasonic unit as recommended by manufacturer for removal of separated instruments. This tip was activated against the peripheral surface of the coronal part of the fragment (1 mm) for 30 s in a counter clockwise motion. These ultrasonic tips allow remarkable transmission of ultrasonic energy at the operating site. The tip is very thin, & flexible with high level of resistance which is suitable for retrieval of broken instruments [20]. Thinner ultrasonic tips are more effective in removal of separated instrument as compared to larger tips because they are able to transmit the ultrasonic energy, oscillation, more efficiently to dentin generating a greater displacement amplitude [21]. The temperature rise on the external surface of root was measured using a K type Thermocouple device. Using a thick layer of sticky wax, the ends of K-type thermocouple was fixed on the two selected sites on the external root surface as follows, 1) One end was attached to the external root surface approximately at the junction of ultrasonic tip and broken instrument fragment (T1) and 2) The other end was attached near the apex of the root (T2). The k-type thermocouple tips were connected to a temperature recording device that records the temperature rise. The experimental set up of this study is similar to that described by Hashem *et al* [12] & Madarati *et al* [3]. In groups 1 & 3, the ultrasonic tips were activated by an ultrasonic unit with water as a coolant at low and high power setting respectively. Water was used as a coolant which was delivered drop by drop at the canal orifice using a syringe & a needle.

The roots were isolated in such a way that no water would get leaked towards the external root surface where the thermocouple tips were attached for recording the temperature. Whereas in the groups 2 & 4 the ultrasonic tips were activated by an ultrasonic unit, without coolant at low and high power setting respectively. The temperature rise was recorded & calculated for each group at T1 & T2 each. The current study in table (1,2) highest temperature rise was seen in group without coolant at high power setting for T1 (45˚C) & T2 (50˚C). At higher power-settings, the output dose of the ultrasonic unit increases, hence the tip oscillation, & displacement amplitude increases leading to temperature rise. At T1 heat can be generated as a result of friction of two solid objects coming in contact with each other [21] when an ultrasonic tip contacts the separated NiTi file [23]. At T2 the temperature rise is dependent upon the thermal diffusivity and conductivity of dentin [24]. Dentin is a poor thermal conductor, & thus protects the periodontal ligament from high temperatures inside the root canal [9]. This function depends on thickness of dentin, which varies as the dentin thickness is higher at the middle part of the root as compared to the apical part of root as mentioned by Brown *et al* [25]. When ultrasonic tips are used without coolant for removal of separated endodontic files, the temperature rise generated on the external root surface was dependent upon the dentin thickness of the root canal, ultrasonic tip type & power setting [26]. Higher temperature is generated in absence of coolant as compared to its presence [27]. However operating the instrument at high power settings for long periods of time will potentially lead to thermal damage of the surrounding periodontal ligament [21]. In this study, as shown in table (3) the higher power-setting induced a greater temperature rise than lower power-settings when ultrasonic tips were activated against the dentine of root canal walls for 30s in absence of coolant which is similar to the study done by Madarati *et al* [3]. The lowest temperature rise was seen in group with coolant at low power setting for T1(32˚C) & T2 (35˚C). At lower power-settings, the outputdose of the ultrasonic unit decreases, hence the tip oscillation, & displacement amplitude also decreases. However the temperature rise that occurs during lower power setting is minimal. Also the ET 20 tip used in the current study is a fine tip which allows water spray to exit from the instrument and pass around its abrading part leading to fall in temperature.

In the intergroup comparison at T1 & T2, as shown in table (3,4) the group with coolant at lower power setting was compared with the groups without coolant at lower power setting & without coolant at high powersetting the results were statistically highly significant with p value $p < 0.001$. As shown in table (4) the temperature rise at T2 was higher as compared to T1. When the ultrasonic tip is operated at both power settings i.e. higher & lower there is increased temperature rise at the apical part of the root as compared to that at the junction of ultrasonic tip and the fractured NiTi file [26]. In the current study as shown in table (5) overall, the highest mean temperature rise was recorded at apical part of root surface. This can be due to reduced thickness of dentin at this level (5mm from apex), that exceeds the thermal tolerance & insulating capacity of the dentin leading to temperature rise [24]. Also the dentin thickness is less in the apical part of the root as compared to the middle part of the root. Therefore the ultrasonic tips should be activated in presence of a coolant for a relatively short time duration [27,28]. When the intra-group comparison of temperature rise at T1 and T2 was done as shown in table (5) there was statistically highly significant difference with p value $p < 0.001$ seen in the group with coolant at Lower power setting and there was no statistically significant difference found in group with higher power setting in presence & absence of water. This can be because at higher power setting there is increased oscillations of the ultrasonic tip along with continous water spray. However, the flow of cooling water over a maximally oscillating tip will also maximize aerosol formation, which will in turn result in a reduction of cooling action produced by water [21].

Thus from the results obtained from current study it can be suggested that the temperature rise was highest in absence of coolants whereas in presence of coolants the temperature rise was drastically reduced [28]. This is due to the cooling effect of water on the heat that is generated. Also the temperature rise at T2 i.e near the apex was seen to be higher ascompared to that at T1 i.e junction of ultrasonic tip and broken instrument fragment which is due to the reduced dentinal thickness at the apex. Whenever the dentin thickness is reduced this can cause transfer of the heat to the surrounding tissues [25] which can be hazardous [9]. However this is an in-vitro study & it may be quite different from the biological root canal system. Variations in the canal morphology would affect the efficacy of ultrasonic tips during instrument retrieval & further studies should be conducted to evaluate the effectiveness of this technique in-vivo.

CONCLUSION

Conclusions Drawn from this in- Vitro Study are as Follows

The highest temperature rise was seen in the group without coolant at higher power setting. At high power setting the chipping action of the ultrasonic tip is maximized due to increased longitudinal oscillation, thereby apparently increasing the efficiency of the instrument leading to heat generation.

The lowest temperature rise was seen in the group with coolant at lower power setting. This is due to the cooling effect of water on the heat generated inside the root canal.

3. The temperature rise at T2 i.e near the apex was seen to be higher as compared to that at T1 i.e junction of ultrasonic tip and broken instrument fragment which is due to the reduced dentinal thickness at the apex. This reduced dentinal thickness leads to heat transfer to the external root surface.

The temperature rise was highest in absence of coolants whereas in presence of coolants the temperature rise was drastically reduced. This is due to the cooling effect of water on the heat that is generated. Hence we can conclude that the group with coolant at lower power setting generated reduced temperature rise on external surface of root and is safe for the surrounding periodontal ligament.

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How to cite this article:

Seema B Jadhav *et al* (2018) 'Evaluation of Temperature Rise on External Surface of Root During Ultrasonic Retrieval of Fractured Niti File From the Canal', *International Journal of Current Medical And Pharmaceutical Research,* 04(8), pp. 3562-3568.

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