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Evaluation of the temperature rise in the pulp chamber during different interproximal reduction procedures – an in vitro study

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Abstract

Introduction: Interproximal reduction of teeth is a common practice in orthodontic treatment with fixed and clear plastic appliances. The stripping technique is a clinical procedure characterized by reduction of mesiodistal dimensions of the teeth. The aim of the study was to evaluate the change in pulp temperature with different stripping techniques.

Materials & methods: 100 Extracted premolars were taken for the study which was divided into 5 groups. GROUP A: Tungsten carbide no. 26 bur was used along with high speed hand piece with water coolant. GROUP B: Tungsten carbide no. 26 bur without water coolant. GROUP C: Air rotor hand piece with mandrel inserted with double sided disc. GROUP D: Air rotor hand piece with mandrels without water coolant was used. GROUP E: Abrasive strips attached to handle.

Results: From the results of the present study it was observed that stripping procedures with bur without coolant showed increased intra pulpal mean temperature rise of 3.42^{0}C, bur with coolant showed a rise of 0.52^{0}C, disc without coolant showed a rise of 4.31^{0}C, disc with coolant showed a rise of 1.33^{0}C, hand held manual strips showed a rise of 1.39^{0}C all of which were statistically significant.

Conclusion: Comparison of all the 5 methods showed that bur with coolant had less increase in mean pulpal temperature which is most preferable method for inter proximal reduction whereas disc without coolant showed greater increase in mean temperature which is least preferable method. Hence it is advised for intermittent spray cooling during stripping procedures.

Keywords: Inter proximal Reduction, Pulp Temperature, Thermo-couple, abrasive strips, Tungsten Carbide Bur, Double Sided Disc

Introduction

Interproximal reduction of teeth (IPR) is a common practice in orthodontic treatment with fixed and clear plastic appliances. The stripping technique is a clinical procedure characterized by reduction of mesiodistal dimensions of the teeth. Space created by interproximal reduction is used for levelling and alignment in cases with mild crowding, to correct the curve of Spee and camouflage some malocclusions, enhancing dental esthetics by recontouring the proximal surfaces. In spite of being a procedure routinely performed in clinical orthodontics for non-extraction treatments, some studies evaluated the possible deleterious effects of stripping techniques on the proximal area.[1]

Radlanski et al. [2] showed that stripping of proximal surfaces result in formation of furrows on enamel leads to increased plaque accumulation, and **Joseph et al**[3] stated that there would be no change of natural healing mechanisms aiding in the repair of these furrows which would remain permanently on the enamel surfaces.

Performing an improper and inadequate interproximal reduction results in surface irregularities such as scratches and roughened surfaces which could increase the susceptibility of these teeth to the accumulation of plaque with an increased intensity to formation of decays and periodontal diseases. However, studies by **Craig and Sheridan**[4] and **Sheridan and Ledoux**[5] concluded that posterior teeth are less susceptible to decay or periodontal disease and suggested use of sealants. Another possible deleterious effect of the stripping technique is heat generated during the process which can damage the pulp tissue. Therefore, **Zachrisson**[6] and **Sheridan** and **Ledoux**[5] emphasize the need for cooling techniques like refrigeration during the procedure. However, visibility is a key factor to perform stripping procedures in order to avoid injuries to the periodontal tissues and scaring off the proximal enamel, which makes the use of coolant a negative factor. So, to properly visualize the procedure, the use of water can be a problem.

The classic study by **Zach** and **Cohen**[7] held in the teeth of primates showed that an increase in temperature of 5.5°C could cause considerably damage the pulp chamber, compromising the pulp health and producing irreversible inflammation in 40% of the specimens tested. The possible detrimental effect of the increased temperature in the pulp tissue during clinical procedures has been a matter of concern in dentistry. The heat transferred to the pulp can result in histopathological changes and necrosis of the pulp tissue.

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Stripping procedure can be performed by different techniques like handheld strippers, diamond and carbide burs cooling at high speed, and perforated stripping disks at low speed without refrigeration are the most common. Some factors, such as the size and type of burs used, the duration of contact, the use of abrasive tools, and the power employed, influence the heat generation during the procedure, which can produce enough heat to damage the pulp tissue permanently.[8] **Sheridan**[5] suggested using a water coolant spray to prevent the possible damaging effect of frictional heat during air rotor stripping (ARS) and indicator wire to prevent bleeding, thus getting greater visibility. **Zachrisson**[6] recommended water and air stream cooling, preventing odontoblast aspiration in the tubules; having smooth, self-cleaning surfaces; and reducing pain.

Very few studies have evaluated the change in the pulp chamber temperature during stripping procedures. Some techniques that incorporated the use of rotary instruments were found to generate heat and may have adverse effects on the pulpal tissues if not dissipated with an appropriate coolant.[9,10] Nonetheless, the amount of heat reaching the pulp chamber and the potential for pulpal damage during stripping have received a scant scientific evaluation. Hence the present study had done to evaluate the pulp temperature rise during different proximal stripping techniques with and without water coolant.

Aim & objectives

The aim of the study was to evaluate the change in pulp temperature with different stripping techniques.

1. To determine the change in pulp temperature in proximal stripping with coolant
2. To determine the change in pulp temperature in proximal stripping without any coolant.

Materials & methodology

For sample size calculation the alpha value of 5% was determined and confidence interval 95%, margin of error (E) 0.05.

100 extracted adult human premolar teeth with intact crown surfaces were taken for the study. The teeth were cleaned thoroughly, soaked, and stored in saline solution. The root portion of the teeth was fixed to an auto polymerizing acrylic resin support. The dental crown remained fully exposed to the implementation of research procedures.100 premolar teeth were divided into 5 groups, with 20 in each group.

Group A: Tungsten carbide no.26 bur with high-speed handpiece (150000 rpm) with coolant

Group B: Tungsten carbide no.26 bur without coolant

Group C: Double-sided disc with a mandrel inserted in air motor handpiece with coolant

Group D: Double-sided disc without coolant

Group E: Manual handheld abrasive strips.

A 2-mm diameter cavity was made with on the occlusal surface of premolars following the pulp chamber with spherical diamond burs. Pulp tissue debris was removed with a spoon excavator and irrigated with sodium hypochlorite at 1%. Pulp chamber was slightly dried and filled with Silicon heat transfer compound (MG chemicals) to facilitate heat transfer (Fig:1). Teeth with acrylising resin were mounted on plaster slab for stabilization; room temperature of 26^0 C was maintained for all the sample groups.

The temperature was measured before the procedure by placing thermocouple (Fig: 2), type K, TM-902C (-50^0C-1300^0C) in the silicon heat transfer compound. Interproximal reduction of 0.5mm was made for 10sec on the proximal side in all the groups. The post-procedure temperature was recorded. Pre and Post temperatures recorded in all the 5 groups were shown in Fig 3, 4, & 5.

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Statistical analysis

All the obtained data were entered into Microsoft Excel 2007 and analyzed using SPSS Software (Version 20). Descriptive statistics were done to obtain mean values, and standard deviation (SD) as the data was quantitative in nature (continuous variables). A paired T-test was done to compare the stripping with coolant and without coolant in each category of bur and disc usage. ANOVA test was done to compare all the five groups, and Tukey's Post-hoc test was applied for pairwise comparisons among the above five groups.

Results

The results of this study demonstrated that interproximal reduction in group D (Disc without coolant) showed highest rise in pulpal temperature of 4.310^0 C followed by group B (Bur without coolant) with a mean rise in pulpal temperature of 3.950^0 C. Group A (bur with coolant) showed lowest rise in pulpal temperature of 0.545^0 C followed by group C (disc with coolant) with 1.335^0 C and group E (manual hand strips) with 1.390^0 C.

Multiple comparisons of pre & post mean temperature rise in all the 5 groups showed that there was a significant rise in post interproximal stripping temperature in all the groups (Table No.1). Comparison of mean temperature rise in IPR using bur with coolant and without coolant showed that there was a significant increase in temperature of 3.420deg in bur without coolant indicating more temperature rise than bur with coolant (Table No.2). Mean temperature rise in IPR using disc with coolant and without coolant showed that there was a significant increase in temperature of 4.310deg in disc without coolant indicating more temperature rise in disc without coolant than disc with coolant (Table No.3).

Multiple comparisons of mean temperature rise in all the 5 groups showed highest temperature rise is seen in disc without coolant, the lowest temperature rise seen in bur with coolant which was statistically significant (Table No.4). Multiple comparisons of mean temperature difference in each group with other groups with 95% confidence interval showed comparisons between group A with group B and D were statistical significant ($p<0.001$) but with group C and E showed no sign of difference

Discussion

Inter-Proximal Reduction (IPR) is one of the common clinical procedure performed in orthodontics to alleviate various problems such as mild crowding, increased incisor flare, and tooth size discrepancies.[1]

Interproximal wear should be given priority when aiming at conservative treatment with minor changes in patients with a pleasant profile, class I malocclusion with mandibular tooth material excess (Bolton ≤ 3 mm), mild to moderate mandibular crowding, low incidence of caries, proper oral hygiene, teeth with a triangular shape, potential for maxillary wear, and treatment confirmed by set-up model tests.

Interproximal enamel reduction is performed by either manual methods like handheld abrasive strips or mechanical methods. **Chudasama and Sheridan**[11] suggested the use of a safe tipped Air- rotor stripping (ARS) burs to reduce interproximal enamel and prevent surface irregularities of the proximal walls. Alternatively, metallic strip systems, diamond discs, or the most recently developed segment discs adapted to a shuttle head with oscillation movement have become increasingly popular. Segment disc systems enhance further visual and geometric access in relation to full 360° discs. Disc guards that fit over the handpiece or contra-angle mounted diamond-coated stripping discs can be used to protect the adjacent tooth that is not being slenderized.

Scanning Electron Microscopic (SEM) observations showed that all stripping methods would affect the enamel

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morphology by producing scratches and furrows compared with untreated surfaces. Experimental studies showed increased incidence of demineralization on human proximal enamel significantly with air-rotor stripping.[12,13] Stripping procedures done by using rotary instruments can generate frictional heat which is a registered side effect results in damage to pulp tissue. **Schuchard** [14] and **Sato** [15] reported that excessive heat adduction could result in irreversible structural changes to the hard dental tissues and damage the dental pulp. In their investigation with Macaca rhesus monkeys, **Zach and Cohen** [16] reported that a 5.5°C rise led to necrosis of the pulp in 15% of teeth, an 11.1°C rise resulted in necrosis of the pulp in 60% of teeth, and a 16.6^{0}C rise led to necrosis of the pulp in 100% of teeth.

Baysal [17] and colleagues suggested that stripping done with high-speed tungsten carbide burs recorded a significant temperature rise in pulp chamber and stressed the need for simultaneous coolant application.

Sheridan [11] suggests, in particular, the use of water spray with the ARS technique to reduce any pain and dissipate the generated heat. **Zachrisson** [6] recommends, for greater visibility and optimal results, airstream cooling by a dental assistant while performing interdental enamel reduction with extra-fine diamond disks.

For the present comparative study, extracted adult human premolars were selected to assess the thermal changes in different teeth groups with different enamel thicknesses. Teeth with abnormally large or small pulp chambers were excluded from the study. This procedure was followed by the elimination of any possible structural variables of teeth that may manifest as differences in the thermal conductivity and specific heat.

However, even after stringent selection, teeth exhibited some differences in tooth morphology, enamel, and dentin structure, and enamel and dentin thickness was a variable in this experimental design. This may explain the temperature differences between the teeth tested in the same group. On the other hand, the teeth used in this study were collected from an adult sample, so the thermal conduction to the pulp chamber during stripping procedures might have been limited compared with the actual scenario in orthodontic patients who are usually 13–16 years of age. Therefore, one would expect to record higher temperature increases when younger teeth are used for a similar study.

To standardize the procedures in this study, 20 strokes were performed for metal strips, and 10secs of the application was preferred for perforated discs and carbide burs. Thermocouples were selected to evaluate pulp temperature alterations because of high precision and reliable readings associated with this technique in orthodontics and operative and prosthetic dentistry.[10]

Results of the present study showed that there was an average increase of 0.545^{0}Cincrease in temperature in bur with coolant and 3.420^{0}C increase in bur without coolant, suggesting more temperature rise in bur without coolant, which was statistically significant.

As **Raab**[18] and **Uysal et al.** [19] said, in this in-vitro experimental study, we did not consider the dissipation of heat inside the pulp chamber due to the effect of blood circulation and fluid movement in the dentinal tubules. On the other hand, the pulp temperature increase may be clinically greater in young teeth because of the smaller thickness when compared with the dentin present in adult teeth in which the deposition of secondary dentin is enhanced.

Results of the present study showed that there was an average increase of 1.335^{0}Cincrease in temperature in disc with coolant and 4.310^{0}C increase in disc without coolant, suggesting more temperature rise in disc without coolant, which was statistically significant.

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Results of the present study showed that there was an average increase of 1.390^{0}C increase in temperature in handheld strips which was statistically significant

The condition and quality of the pulpal vascularity may determine the degree of damage caused by thermal trauma. **Zachrisson** [20] suggested an air stream to reduce pain during gross recontouring. It has been concluded that painful stimulation can induce significant increases in blood flow in the region adjacent to the stimulus. In clinical conditions, pain during stripping may increase the temperature in the pulp chamber. The experimental design of the present study did not consider heat conduction within the tooth during the in vivo stripping process because of the effect of blood circulation in the pulp chamber and fluid motion in the dentin tubules. In addition, the surrounding periodontal tissues can promote heat convection in vivo, limiting the intra pulpal temperature rise.

To avoid possible side effects of enamel reduction plaque control methods like topical use of concentrated fluoride mouth rinses and dentifrices, and part-time wear of a thermoformed retainer containing fluoridating solution have been recommended. Application of low concentrations of calcium-fluoride solution for 5 and 10-hour periods on chemically stripped enamel surfaces has been found to produce marked crystal growth in vitro. Nevertheless, it is questionable whether fluoride treatment and smear plugs during brushing results in clinically significant benefits.[21,22,23]

Although a potential hazard to the dental pulp may exist with stripping procedures, only a well-designed histological study can accurately assess the actual damage to the pulp odontoblasts. The data on temperature elevation recorded while preparing extracted teeth have limited applications in determining clinical pulpal reactions.

Conclusion

From the results of the present study by comparing 5 different methods of interproximal reduction, it can be concluded that

1) IPR with disc and slow speed handpiece without coolant showed the highest rise in intra pulpal temperature.

2) IPR with bur and high-speed handpiece with coolant and disc with coolant showed the lowest rise in intra pulpal temperature followed by handheld stripping. Hence use of high-speed handpiece with coolant can be suggested as the best methods of IPR without causing pulpal damage.

3) Hence it is advised for intermittent spray cooling during stripping procedures.

List of Abbreviations:

IPR: Inter Proximal Reduction

WC: With Coolant

WOC: Without Coolant

ARS: Air Rotor Stripping

SEM: Scanning Electron Microscope

Legend Figures and Tables

Fig 1: Silicon heat transfer compound

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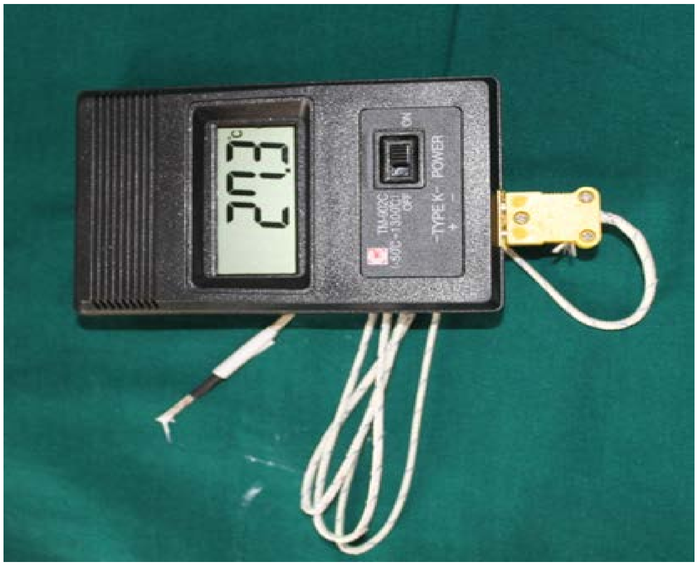

Fig 2: Thermocouple for measuring temperature

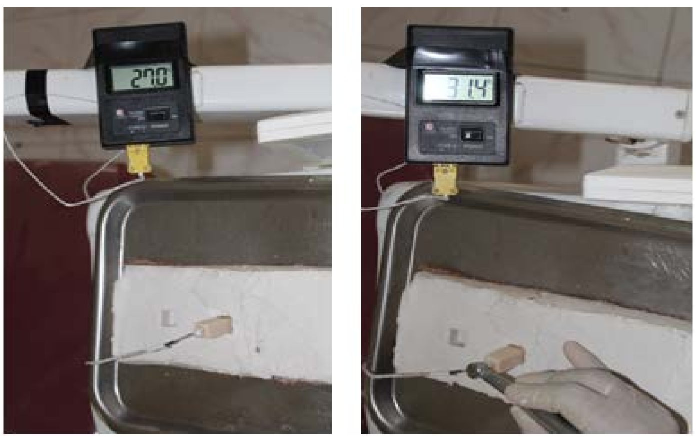

Fig 3: showing pre & post temperature in proximal reduction with

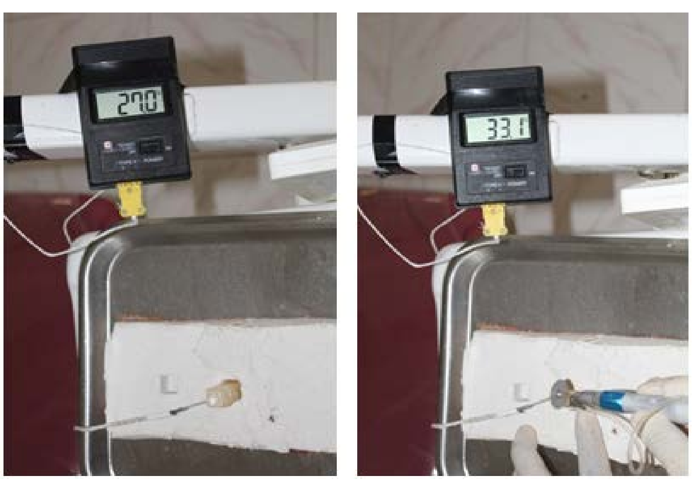

Fig 4: showing pre & post temperature in proximal reduction with disc

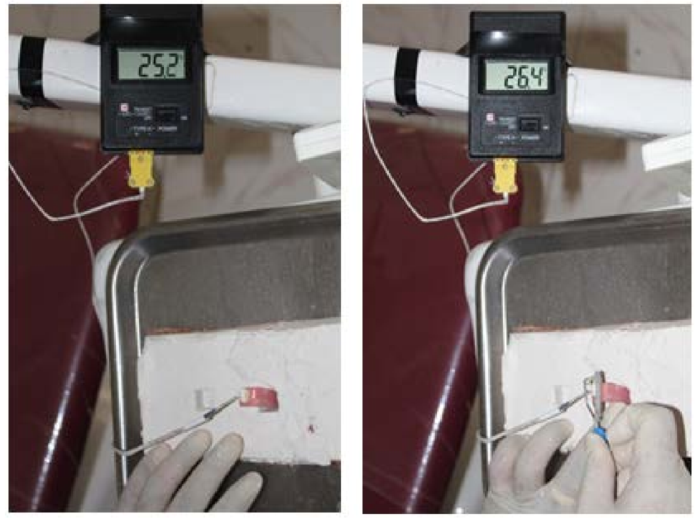

Fig 5: showing pre & post temperature in hand held manual abrasive strips

Table 1: Multiple comparisons of pre &post mean temperature in all the 5 groups

Paired Samples Statistics						
Group	**Parameters**	**Mean**	**N**	**Std. Deviation**	**Std. Error Mean**	**p**
A	BUR PRE WC	27.545	20	0.4298	0.0961	<0.001**
	BUR POST WC	28.090	20	0.4621	0.1033	
B	BUR PRE WOC	27.475	20	0.8181	0.1829	<0.001**
	BUR POST WOC	30.895	20	1.2484	0.2791	
C	DISC PRE WC	27.275	20	0.2381	0.0532	<0.001**
	DISC POST WC	28.610	20	0.9403	0.2103	
D	DISC PRE WOC	27.685	20	0.3066	0.0685	<0.001**
	DISC POST WOC	31.995	20	1.5185	0.3395	
E	HAND PRE	27.245	20	0.5010	0.1120	<0.001**
	HAND POST	28.635	20	0.6184	0.1383	

Paired T-test comparing means of pre and post measurements in groups A-B, C-D, E was the (P<0.001). WC: with coolant; WOC: without coolant. ** Highly significant

Table 2: mean temperature rise in IPR using bur with coolant and without coolant

Parameters	Mean temperature rise	N	Std. Deviation	Std. Error Mean	p
Bur with coolant	0.545	20	.2964	.0663	<0.001**
Bur without coolant	3.420	20	.8823	.1973	

Unpaired T-test. ** Highly significant

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Table 3: mean temperature rise in IPR using disc with coolant and without coolant

Parameters	Mean temperature rise	N	Std. Deviation	Std. Error Mean	P
Disc with coolant	1.335	20	.7768	.1737	<0.001**
Disc without coolant	4.310	20	1.4843	.3319	

Unpaired T-test. ** Highly significant

Table 4: Comparison of mean temperature rise in all the 5 groups

	N	Mean temperature rise	Std. Deviation	Std. Error	F	Sig.
Bur with coolant	20	0.545	.2964	.0663	45.491	<0.001**
Bur without coolant	20	3.950	1.8409	.4116		
Disc with coolant	20	1.335	.7768	.1737		
Disc without coolant	20	4.310	1.4843	.3319		
Manual	20	1.390	.3042	.0680		

Multiple comparisons between 5 groups using ANOVA showed a statistically significant (p<0.001) with the least difference between the temperature for group A (0.545) and high temperature is group D (4.310). ** Highly significant.

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