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Evaluation and Comparison of Thermal Changes in the Pulp Chamber in Different Inter Proximal Reduction Techniques: An *In-vitro* Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Interproximal reduction (IPR) is a common orthodontic treatment procedure that is used which involves tooth reduction, anatomic recontouring, and protecting permanent teeth proximal enamel surfaces. Sheridan described the air-rotor stripping technique as an alternative to extraction in borderline cases. Though there are many studies, it was not clearly differentiated regarding the pulpal temperature changes during IPR.
Materials and Methods: In this in vitro study, 63 extracted human premolar teeth were randomly assigned to three groups (n=21). Group-1 (Strauss diamond stripping bur) at high speed above

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20,000 rpm, Group-2 (Manual Handheld metal stripper). Group-3 (Strauss diamond stripping disc) at a low speed below 15,000 rpm. The average mean temperature is assessed for each tooth during various techniques using K-type thermocouple. During the procedure, the thermometer display was covered, and the temperature was revealed after all the stripping procedures had already been performed. Data were analyzed using IBM SPSS version 20 software. Descriptive statistics, one way analysis of variance with Tukey's post hoc tests were done to analyze the study data.

Results: The mean rise in temperature was highest with disc & micromotor (4.3ºC) followed by airotor & bur (4.02ºC) and manual method (2.52ºC) ($p \leq 0.05$).

Conclusion: There was an increase in the pulpal temperature using diamond stripping disc with micromotor followed by the airotor and bur, manual hand held stripping.

Keywords: Inter proximal reduction; airotor; micromotor; strauss diamond bur; disc.

1. INTRODUCTION

"Interproximal reduction (IPR) is a common orthodontic treatment procedure that is used in a variety of clinical cases. It involves tooth reduction, anatomic recontouring, and protecting permanent teeth proximal enamel surfaces. Slicing, Hollywood trim, selective grinding, mesiodistal reduction, reapproximating, interproximal wear, and coronoplasty are all synonyms for this procedure" [1].

"Correction of Bolton tooth-size discrepancies, mild or moderate crowding, morphologic dental anomalies, relapse prevention, and reduction of interdental gingival papilla retraction are the main clinical indications" [2]. Raleigh Williams lists interproximal reduction as one of the six keys to eliminate lower retention. But it has also been used to stabilise post-orthodontic results in retreatment orthodontic patients.

More than 20 years ago, Sheridan [3] described "the air-rotor stripping technique as an alternative to extraction in borderline cases". "Several IPR systems have been developed and gradually modified over the years" [4]. "Many powered IPR systems, such as mechanical oscillating abrasive strips or diamond-coated segmented discs, have recently become popular. Since these IPR procedures have become more common in orthodontic practise, several studies have been conducted to investigate their effects on the surface of the enamel" [5].

Most orthodontic patients enter the clinic with an inherent irrational fear to extraction, even if it provides the best possible treatment plan, and thus the emphasis has shifted toward non extraction therapy over time [6]. Several methods (mechanically driven, manual, and/or chemical) have been used to remove enamel in a controlled and calculated manner, with the goal of minimizing roughness on the proximal surface post reduction to avoid undesirable hard and soft tissue effects [7].

Many side effects have been reported with a broad range of IPR applications. Some of these are greater surface roughness [8] after IPR and enamel demineralization, have been studied in the literature.

Furthermore, the friction between the IPR According to a histological study, the critical temperature change during which dental pulp tissues degenerate is 5.5 °C. Only a few studies have investigated the heat generation related with the IPR procedure. Factors that could influence the amount of heat generated, such as stripping tool grit size, motorized tool speed, and cooling systems, were not taken into account. According to Zach and Cohen [9], temperature increases of more than 5.5°C in the pulp cause inflammation. Some techniques that used rotary equipment were found to produce heat, which could be harmful to the pulpal tissues if not dissipated with a suitable coolant. Nonetheless, there has been little scientific research into the amount of heat reaching the pulp chamber and the ability for pulpal damage during stripping.

This study aims to measure the amount of temperature change that occurs in the dental pulp during interproximal stripping using different reduction tools and the tooth surface generates heat, which may spread to the dental pulp.

2. MATERIALS AND METHODOLOGY

Sixty-three freshly extracted premolar teeth were collected over 6 months. Inclusion criteria Teeth

extracted due to severely compromised periodontium, Non-carious teeth, Teeth with intact buccal and proximal surfaces Exclusion criteria: Teeth damaged due to caries or trauma, Teeth with compromised enamel, Teeth with broken crowns, Teeth underwent any chemical treatment, Endodontically treated teeth. The teeth were preserved at 4°C in 0.1% thymol solution and used within 6 months of extraction. The sample was randomly assigned to three groups (n=21). Group-1 (Strauss diamond stripping bur) at high speed above 20,000 rpm, Group-2 (Manual Handheld metal stripper). Group-3 (Strauss diamond stripping disc) at a low speed below 15,000 rpm. The teeth were separated into three groups of 21 teeth each. The mesial and distal sides of the teeth were used separately, and the data were recorded for each side. The root portions were sectioned with a Carborundum disk approximately 5 mm below the cemento-enamel junction perpendicular to long axis of the tooth. The opening into the pulpal chamber was enlarged as needed to insert the thermocouple wire with gates glidden files. The pulpal chamber was cleaned of remnants of soft tissues with a spoon excavator and 1% sodium hypochlorite application for 1 minute. The pulp chambers of the teeth were rinsed with distilled water and air-dried. Teeth were then placed on cold cure acrylic in the form of blocks of 10 teeth each and labelled according to tooth group and stripping procedure.

Acrylic blocks of each group are secured in heavy body putty elastomeric material. Three different stripping procedures were used as follows.

A) Group-1 (Strauss diamond stripping bur) at high speed above 20,000 rpm,
B) Group-2 (Manual Handheld metal stripper).
C) Group-3 (Strauss diamond stripping disc) at a low speed below 15,000 rpm,

2.1 Measurement of Temperature

A K-type thermocouple wire with a 0.36-inch diameter was connected to a digital data display during the application of all stripping procedures. A silicone heat transfer compound was injected into the pulpal chamber to assess the rise in pulpal temperature. This compound facilitated the transfer of heat from the walls of the pulpal chamber to the thermocouple wire. The thermocouple wire tip was placed into the pulp chamber by touching the centre region of the crown. The sampling rate of the data display was set to one sample every 2 seconds for a recording period, starting with stripping for approximately 10 seconds. Calibration of the digital data display was not required. Specification accuracy was maintained without user adjustment. The teeth were randomly divided per side into three groups. In order to perform 1mm stripping of interproximal enamel, the digital calliper is placed on the buccal surface of each surface of the tooth to assess the amount of stripping. The stripping was performed by a single operator with various techniques. During enamel stripping, the temperature rise is measured.

The maximum and minimum temperatures produced during various stripping processes were recorded on the thermometer display. The minimum temperature is subtracted from the maximum temperature to determine the temperature range throughout the procedure. The average mean temperature is assessed for each tooth during various techniques. During the procedure, the thermometer display was covered, and the temperature was revealed after all the stripping procedures had already been performed. A temperature increases of 5.5ºC was set as the baseline, according to Zach and Cohen. All the results of the testing were recorded.

3. RESULTS

Data were analyzed using IBM SPSS version 20 software (IBM SPSS, IBM Corp., Armonk, NY, USA). Descriptive statistics, one way analysis of variance with Tukey's post hoc tests were done to analyze the study data. Bar chart was used for data presentation.

Table 1 shows the descriptive statistics for the mean rise in temperature on the mesial and distal sides along with the average rise in temperature. It was observed that the mean rise in temperature was highest with disc & micromotor followed by airotor & bur and manual handheld metal stripper methods on both the sides. The average rise in temperature also followed the same order ($p \leq 0.05$) (Table 2). In post hoc tests, manual method demonstrated a significantly lesser mean rise in temperature compared to airotor & bur and disc with disc & micromotor. There were no significant differences in mean temperature rise between airotor & bur, disc & micromotor (Table 3).

Table 1. Descriptive Statistics for Rise in Temperature on the Mesial, Distal Sides and the Average Rise in the Study Groups

Parameter	Group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Mesial	Stripping Bur	21	4.00	.632	.138	3.71	4.29
	Handheld stripper	21	2.33	.483	.105	2.11	2.55
	Stripping Disc	21	4.33	.483	.105	4.11	4.55
Distal	Stripping Bur	21	4.05	.669	.146	3.74	4.35
	Handheld stripper	21	2.71	.717	.156	2.39	3.04
	Stripping Disc	21	4.29	.644	.140	3.99	4.58
Average	Stripping Bur	21	4.0238	.46033	.10045	3.8143	4.2333
	Handheld stripper	21	2.5238	.43232	.09434	2.3270	2.7206
	Stripping Disc	21	4.3095	.46033	.10045	4.1000	4.5191

Table 2. Comparison of rise in temperature on the mesial, distal sides and the average rise between the study groups

Parameter	Group	N	Mean	Std. Deviation	Std. Error	F value	P value
Mesial	Stripping Bur	21	4.00	.632	.138	83.46	<0.001*
	Handheld stripper	21	2.33	.483	.105		
	Stripping Disc	21	4.33	.483	.105		
Distal	Stripping Bur	21	4.05	.669	.146	32.83	<0.001*
	Handheld stripper	21	2.71	.717	.156		
	Stripping Disc	21	4.29	.644	.140		
Average	Stripping Bur	21	4.0238	.46033	.10045	94.91	<0.001*
	Handheld stripper	21	2.5238	.43232	.09434		
	Stripping Disc	21	4.3095	.46033	.10045		

*One way analysis of variance; p≤0.05 considered statistically significant; * denotes statistical significance*

Table 3. Multiple pairwise comparisons for rise in temperature on the mesial, distal sides and the average rise between the groups

Parameter	Reference Group	Comparison Group	Mean Difference	Std. Error	P value	95% Confidence Interval	
						Lower Bound	Upper Bound
Mesial	Stripping Bur	Handheld stripper	1.667*	.166	<.001*	1.27	2.07
		Stripping Disc	-.333	.166	.119	-.73	.07
	Handheld stripper	Stripping Disc	-2.000*	.166	<.001*	-2.40	-1.60
Distal	Stripping Bur	Handheld stripper	1.333*	.209	<.001*	.83	1.84
		Stripping Disc	-.238	.209	.494	-.74	.26
	Handheld stripper	Stripping Disc	-1.571*	.209	<.001*	-2.07	-1.07
Average	Stripping Bur	Handheld stripper	1.50000*	.13924	<.001*	1.1654	1.8346
		Stripping Disc	-.28571	.13924	.109	-.6203	.0489
	Handheld stripper	Stripping Disc	-1.78571*	.13924	<.001*	-2.1203	-1.4511

*Tukey's post hoc tests; * denotes statistical significance*

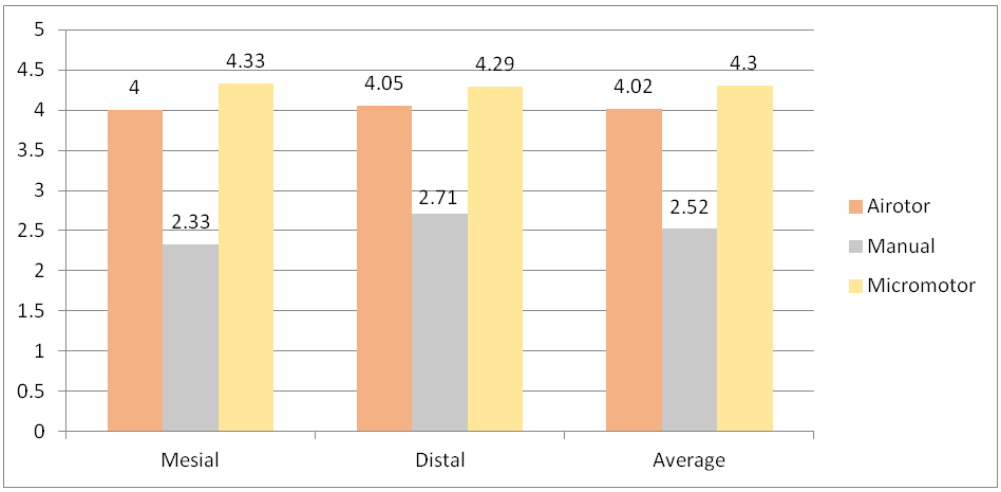

Fig. 1. Comparison of Rise in Temperature on the Mesial, Distal Sides and the Average Rise Between the Study Groups

4. DISCUSSION

Interproximal reduction (IPR) is a common orthodontic treatment procedure that is used in a variety of clinical cases which involves tooth reduction, anatomic recontouring, and protecting permanent teeth proximal enamel surfaces. Raleigh Williams lists interproximal reduction as one of the six keys to eliminate lower retention. But it has also been used to stabilise post-orthodontic results in retreatment orthodontic patients [10].

In the current study, the temperature variations in the pulpal chamber during various slenderization techniques were examined in vitro since the evaluation of thermal changes producing pulpal injury during enamel reduction operations has received relatively little scientific review. In order to compare the temperature changes using various techniques, extracted adult premolars were chosen. Following this technique, all potential tooth structural factors that might show up as variations in thermal conductivity and specific heat were eliminated. Enamel and dentin thickness were variables in this experimental design because teeth still showed some variances in dental morphology, enamel, and dentin structure even after careful selection. The variations in temperature among the teeth tested within the same group may be explained by this. Because of the high precision and reliability of readings associated with this technique in orthodontics, operative and prosthetic dentistry, thermocouples were chosen to evaluate temperature changes. A K-type thermocouple unit was used instead of a J type due to the reason that these K-type thermocouple's show high precision, reliability, and wider temperature range, as demonstrated by previous studies.

Several factors contribute to pulp and dentin trauma when using rotary instruments. The pressure, revolutions per minute, bur design, and type of coolant all have an impact on temperature rise and vibration. The interconnected factors are responsible for the various clinical reactions of the pulp and dentin. According to Schuchard [11] and Sato [12] excessive heat adduction can cause structural changes in hard dental tissues as well as damage to the dental pulp.

The baseline temperature readings were recorded in all the groups prior to IPR procedure. Strauss diamond bur attached to contra-angle airotor has been used in one group, whereas strauss diamond disc attached to micromotor was used in another group. This Rotating discs adapted to a contra angle hand piece movement have gained popularity. Disc systems provide even more visual and geometric access in 360°. Gazzani et al. [13] reported that use of disc for enamel reduction not only efficient but also reduces chairside time. A handheld metal stripper was used in the manual stripping group. The use of handheld metal strips resulted in a mean temperature rise of 2.52 degrees Celsius. The minimum and maximum temperature rises observed were 2.3 and 2.7 degrees Celsius, respectively. According to Baysal et al. [14] the average temperature rise was 1.21°C ± 1.48°C, with a minimum of 0.23°C and a maximum of

6.26°C. Banga et al. [15] reported *In-vivo* that the average temperature rise was 0.52°C, with a minimum of 0.3°C and a maximum of 0.9°C. Pereira et al. [16] reported a 1.24°C± 0.3°C mean temperature change and a 1.7°C maximum temperature rise. According to Al–Hassan Omer et al. [17] the average temperature rise was 0.27°C± 0.15°C, with a minimum of 0.10°C and a maximum of 0.70°C.

By using the rotating disc there was a mean temperature rise of 4.3 degrees Celsius. The minimum and maximum temperature rises observed were 4.29 and 4.33 degrees Celsius, respectively. According to Baysal et al. [14] the average temperature rise was 3.84°C ±2.21°C, with a minimum of 0.23°C and a maximum of 6.25°C. Pereira et al. [15] reported a 2.64°C± 0.29°C mean temperature change and a 3.2°C maximum temperature rise. Banga et al. [16] reported in-vivo that the average temperature rise was 2.08°C, with a minimum of 1.4°C and a maximum of 3°C. According to Al–Hassan Omer et al. [18] the average temperature rise was 1.37°C ± 0.75°C, with a minimum of 0.30°C and a maximum of 3.00°C.

Upon using bur and airotor there was a mean temperature rise of 4.02 degrees Celsius. The minimum and maximum temperature rises observed were 4.0 and 4.05 degrees Celsius, respectively. According to Baysal et al. [14] the average temperature rise was 5.63°C ± 1.73°C, with a minimum of 2.11°C and a maximum of 8.37°C. Banga et al. [16] reported *In-vivo* that the average temperature rise was 2.08°C, with a minimum of 1.4°C and a maximum of 3°C. According to Al–Hassan Omer et al. [18] the average temperature rise was 1.90°C ± 0.76°C, with a minimum of 1.00°C and a maximum of 3.50°C.

The current study's results were found to be higher than those of previous studies, with greater change observed than the critical threshold. The reason can be due to variations in the morphology of enamel and dentin thickness. Another reason can be due to use of teeth extracted in young adults seeking orthodontic treatment. Usually, use of coolant in the above studies by Asli baysal et al. [13] and Al-Hassan Omer et al. [18] have recorded lesser rise in temperatures. But in the present study no coolant has been used. This might be one of the contributing factors for increased rise temperature. It is, however, recommended to use intermittent spray cooling with stripping procedures.

Robinson [19] and Lefkowitz [20], Taira et al. [21] and Moulding and Loney [22] reported that cooling techniques, such as the use of an air-water spray, were effective in limiting the temperature rise in the pulp chamber. Regardless of visual inspection, the use of intermittent water spray will help to remove debris and furrow [23].

Also the pulpal temperature recorded in the present study was evaluated only on the premolars which may not be sufficient to conclude the temperature rise in general to all the dentition. This is because the enamel thickness varies between anterior and posterior teeth.

5. CONCLUSION

- There was an increase in the pulpal temperature using diamond stripping disc with micromotor followed by the airotor and bur, manual hand held stripping.
- Manual method demonstrated a significantly lesser mean rise in temperature compared to airotor & bur and disc with disc & micromotor.
- There were no significant differences in mean temperature rise between airotor & bur, disc & micromotor

6. LIMITATIONS

1. Although all the stripping procedures may pose a risk to dental pulp, only a well-designed histological study can accurately assess the actual damage to the pulp or odontoblasts.
2. The temperature elevation data collected while preparing extracted teeth has limited applications in predicting pulpal reactions because the pulp chamber is exposed to the external environment as the pulpal temperatures recorded in a closed area vary.
3. The values are also recorded manually which may be less accurate. So a software should be designed in future for recording values with more accuracy.
4. Other factors like individual needs, stripping duration or number of strokes it may differ between patients, so the temperature change may exceed.
5. Also the sample size of 21 in each group might also be a factor that should be taken into consideration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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