Original Article

Temperature Rise in the Pulp Chamber during Different Stripping Procedures

An In Vitro Study

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ABSTRACT

Objective: To measure the temperature changes in the pulp chamber when different stripping procedures were used without any type of coolant.

Materials and Methods: Ninety intact, freshly extracted human teeth were used in this study. The teeth were separated into nine groups of 10 teeth each. Mesial and distal sides of the teeth were used separately. The stripping procedures were performed on three different tooth groups (incisor, canine, premolar) with a metal handheld stripper, perforated stripping disk, or tungsten carbide bur. A J-type thermocouple wire was positioned in the center of the pulp chamber and was connected to a data logger during application of stripping procedures. The results were analyzed by analysis of variance (ANOVA) and the Duncan test.

Results: Two-factor ANOVA revealed significant interaction between the stripping procedure and the tooth type ($P = .000$). The results of this study demonstrate that tungsten carbide burs used on mandibular incisors had the highest temperature variation (ΔT) values, which exceeded the critical level (5.5°C), and this was significantly higher than those of the other stripping procedures (ΔT: 5.63 ± 1.73°C). On the other hand, six of the nine groups also produced temperature increases above the critical level (5.5°C) for some of the specimens.

Conclusions: Frictional heat is a common side effect of stripping procedures, and appropriate measures (ie, cooling application) should be taken particularly for high-speed hand-piece stripping of mandibular incisors.

KEY WORDS: Stripping; Temperature; Pulp chamber; Thermocouple

INTRODUCTION

Stripping is defined as the act of clinically removing part of the dental enamel from an interproximal contact area. By this procedure, space is created to align teeth[1,2] and teeth can be reshaped to a more ideal form. This also may improve esthetics,[3–5] improve the gingival relationship,[6] and eliminate the need for lower retention[7,8] and is used for correction of the curve of Spee and to camouflage Class II and III malocclusions.[9]

Because this procedure has become more routine in orthodontic practice, several studies evaluated the detrimental effects of stripping. Some studies have indicated that iatrogenic injuries to the integrity of the proximal enamel surface can be predisposing factors for caries and periodontal disease. These studies include the work of Twesme et al,[10] who showed increasing susceptibility of proximal enamel surfaces to demineralization and also to caries. Radlanski et al[11] also showed that furrows resulting from the stripping caused increased plaque accumulation, and Joseph et al[12] stated that these furrows would remain permanently on enamel surfaces with no change of natural healing mechanisms aiding in the repair. On the other hand, Crain and Sheridan[13] and Sheridan and Ledoux[14] suggested that stripped posterior surfaces are no more susceptible to caries or periodontal disease than are unaltered surfaces but recommended sealant application for caries protection.

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Another possible side effect of stripping is the heat generated during this procedure. Therefore, Zachrisson[15] and Sheridan[8] emphasize cooling during stripping. Sheridan[8] suggested using a water 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[15] recommended water and air stream cooling; not to get odontoblast aspiration in the tubules; having smooth, self-cleansing surfaces; and reducing pain but called for greater visibility in fine tuning after gross recontouring.

Visibility is a crucial factor for stripping in order to get smooth surfaces and natural morphology and prevent creating ledges. Thus, wires, separators, and coil springs are used, but these applications can cause patient discomfort, especially in the anterior region. If you want to see exactly what you are doing, water and air streams can be a problem.

In general, temperature increases more than 5.5°C in the pulp lead to inflammation, according to Zach and Cohen.[16] Some techniques that incorporated the use of rotary instruments were found to generate heat[17–19] and may have adverse effects on the pulpal tissues if not dissipated with an appropriate coolant. Nonetheless, the amount of heat reaching the pulp chamber and the potential for pulpal damage during stripping have received scant scientific evaluation.

Therefore, the aim of this in vitro study was to measure the temperature changes in the pulpal chamber during different stripping procedures without any type of coolant. For the purposes of this study, the null hypothesis assumed that different stripping procedures did not induce different thermal changes in the pulp chamber.

MATERIALS AND METHODS

Sample Preparation

Ninety intact, freshly extracted human teeth were used in this study. The teeth were separated into nine groups of 10 teeth each. Mesial and distal sides of the teeth were used separately, and the data were recorded for each group. To evaluate temperature changes in teeth with different enamel thicknesses, three different types of human teeth were selected (30 teeth of each type, ie, mandibular incisors, canines, and premolars). Thus, thin, medium, and large enamel groups were generated, respectively. In each group, teeth of homogeneous size and shape were used to provide similar hard tissue structure and ensure equal distances from the pulp to the surface of the tooth.

The root portions were sectioned with a Carborundum disk (Komet, Gebr Brasseler, Lemgo, Germany) approximately 4 mm below the cemento-enamel junction perpendicular to the long axis of the teeth. 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 sodium hypochlorite application for 1 minute. The pulp chambers of the teeth were rinsed with distilled water, air dried, and filled with silicone transfer compound (Philips ECG Inc, Waltham, Mass). Teeth were placed on acrylic blocks of 10 teeth each and labeled according to tooth group and stripping procedure. Three different stripping procedures were used (Table 1), and the groups were as follows:

Table 1. Experimental Groups of the Study

	Tooth Type		
	Incisor	Canine	Premolar
Metal handheld stripper	Group 1	Group 2	Group 3
Perforated stripping disk	Group 4	Group 5	Group 6
Tungsten carbide bur	Group 7	Group 8	Group 9

Group 1: A metal handheld stripper (LSDSM6M, double side 6 mm, GH Company, Hanover, Germany) was used (20 strokes for each tooth) on mandibular incisors.

Group 2: A metal handheld stripper (LSDSM6M, double side 6 mm, GH Company) was used (20 strokes for each tooth) on mandibular canines.

Group 3: A metal handheld stripper (LSDSM6M, double side 6 mm, GH Company) was used (20 strokes for each tooth) on mandibular premolars.

Group 4: A perforated stripping disk (Komet, 8934 A.220, Lemgo, Germany) was used on mandibular incisors at low speed (below 15,000 rpm) with a contra-angle hand piece for 10 seconds.

Group 5: A perforated stripping disk (Komet, 8934 A.220) was used on mandibular canines at low speed (below 15,000 rpm) with a contra-angle hand piece for 10 seconds.

Group 6: A perforated stripping disk (Komet, 8934 A.220) was used on mandibular premolars at low speed (below 15,000 rpm) with a contra-angle hand piece for 10 seconds.

Group 7: A tungsten small tapered fissure carbide bur (Raintree Essix Inc, ARS Bur Kit, Metairie, La) was used on mandibular incisors at high speed (above 20,000 rpm) with a contra-angle hand piece for 10 seconds.

Group 8: A tungsten small tapered fissure carbide bur (Raintree Essix Inc) was used on mandibular canines at high speed (above 20,000 rpm) with a contra-angle hand piece for 10 seconds.

Group 9: A tungsten small tapered fissure carbide bur (Raintree Essix Inc) was used on mandibular pre-

Table 2. The Results of Two-way Analysis of Variance Performed on the Stripping Procedure and Tooth Type

Source[a]	Type III Sum of Squares	*df*	Mean Square	*F*	*P*
Corrected model	488.17	8	61.021	25.385	<.001
Intercept	1206.06	1	1206.06	501.721	<.001
A	372.68	2	186.34	77.518	<.001
B	222.19	2	11.109	4.621	<.05
A × B	93,272.00	4	23.318	9.7	<.001
Error	411,057.00	171	2.404		
Total	2105.28	180			
Corrected total	899,228.00	179			

[a] A indicates different stripping procedures; B, different tooth groups.

molars at high speed (above 20,000 rpm) with a contra-angle hand piece for 10 seconds.

Temperature Measurement

A J-type thermocouple wire with 0.36-inch diameter (Omega Engineering Inc, Stamford, Conn) was connected to a data logger (XR440-M Pocket Logger, Pace Scientific, Mooresville, NC) during application of all stripping procedures. All stripping processes and measurements were performed by the same operator to ensure uniformity in the procedures. A silicone heat transfer compound (Philips ECG Inc) was injected in the pulpal chamber. This compound facilitated the transfer of heat from the walls of the pulpal chamber to the thermocouple. Thermocouple wire was put into the pulp chamber by touching the center region of the roof. The sampling rate of the data logger was set to one sample every 2 seconds for a recording period starting with stripping for approximately 10 seconds. Calibration of the data logger was not required. Specification accuracy was maintained without user adjustment. The temperature accuracy reported by the manufacturer was ±0.15°C from 0°C to 40°C. The collected data were monitored in real time and were transferred to the computer. The data were available in both tabular and graphic form.

For each group, the temperature variation (ΔT) was determined as the change from baseline temperature (T_0) to the highest or lowest temperature (T_{max}) recorded after various stripping procedures. A positive ΔT value indicated an increase in pulp temperature, whereas a negative ΔT value indicated a decrease in pulp temperature. Fifteen calculated temperature changes were averaged to determine the mean value in temperature rise. A temperature increase of 5.5°C was set as the baseline according to Zach and Cohen.[16]

The results of testing were entered into an Excel (Microsoft, Seattle, Wash) spread sheet for calculation of descriptive statistics. Statistical analysis was performed by analysis of variance (ANOVA) (after confirmation of normal distribution and homogeneity of variance) and then Duncan tests (Statistical Package for Social Sciences Version 10.0, SPSS, Chicago, Ill) for comparisons among groups at the .05 level of significance.

RESULTS

According to two-way ANOVA, a temperature rise in the pulp chamber varied significantly depending on the stripping procedures used ($P < .001$). The null hypothesis was thus rejected. ANOVA revealed significant interactions among the stripping procedure and different tooth groups ($P = .000$) (Table 2). The descriptive statistics, including the mean, standard deviation, minimum and maximum values, and comparisons for stripping procedures and different tooth groups, are presented in Table 3.

The results of this study demonstrated that group 7 (tungsten carbide bur used on mandibular incisor teeth) had the highest ΔT values and was statistically significantly higher than the other stripping procedures. (ΔT: 5.63 ± 1.73°C). This was the only group

Table 3. The Descriptive Statistic Values of Thermal Changes in the Pulp Chamber during Different Stripping Procedures[a]

Group	Stripping Procedure	Teeth Group	Sample Size, n	Temperature, °C					Test[b]	*P*
				Side	ΔT	SD	Minimum	Maximum		
1	Metal strip	Incisor	10	20	1.21	1.48	0.23	6.26	A	
2	Metal strip	Canine	10	20	1.03	1.30	0.23	6.07	A	
3	Metal strip	Premolar	10	20	−0.18	0.97	−2.31	2.30	B	
4	Perforated disc	Incisor	10	20	2.37	1.31	0.23	5.14	C	
5	Perforated disc	Canine	10	20	2.51	1.25	0.23	4.67	C	<.001
6	Perforated disc	Premolar	10	20	3.84	2.21	1.39	6.25	CD	
7	Tungsten carbide bur	Incisor	10	20	5.63	1.73	2.11	8.37	E	
8	Tungsten carbide bur	Canine	10	20	3.22	1.70	1.18	7.43	D	
9	Tungsten carbide bur	Premolar	10	20	3.65	1.67	0.47	7.37	D	

[a] ΔT indicates mean difference between maximum and minimum temperature values; SD, standard deviation.
[b] Groups with different letters are significanlty different from each other.

in which the average ΔT values exceeded the critical 5.5°C level. Nonetheless, when the maximum values for all groups were evaluated, all the procedures except group 3 (metal stripper used on premolar), group 4 (perforated disk used on incisor), and group 5 (perforated disk used on canine) produced higher temperature increases above the critical level for some of the specimens.

DISCUSSION

In this in vitro study the heat generated by different stripping procedures were measured. If one also takes into account that even a few seconds of external thermal stress with a temperature of 275°C has the potential to produce irreversible pulp damage, it becomes obvious that the pulp tissue is very susceptible to thermal stress even within a short time.[20]

For the present comparative study, extracted adult mandibular incisors, canines, and premolars were selected to assess the thermal changes in different teeth groups with different enamel thicknesses.[21,22] Teeth with abnormally large or small pulp chambers were excluded from the study. This procedure was followed by 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.[22] 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.

Thermocouples were selected to evaluate temperature alterations during the removal of the remnant adhesive because of high precision and reliable readings associated with this technique in orthodontics and operative and prosthetic dentistry.[16,17,19,23,24]

Trauma to the pulp and dentin during the use of rotary instruments results from several factors.[25,26] The pressure,[19] revolutions per minute,[19] bur design, and type of coolant[27] influence the temperature rise and the degree of vibration. The various clinical reactions of the pulp and dentin are attributed to the interrelated factors. Schuchard[28] and Sato[29] reported that excessive heat adduction can result in 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°C rise led to necrosis of the pulp in 100% of teeth. A soldering iron was applied to the tooth surfaces to produce the temperature rise. Because the temperature rise does not appear to have been monitored after removal of the soldering iron, the results must be treated with caution.

To standardize procedures for the study, 20 strokes were performed for metal strips, and 10 seconds of application was preferred for perforated discs and carbide burs. Sheridan[8] stated that initial tooth structure reduction lasts for 30 seconds and must be performed with cooling. Robinson and Lefkowitz,[30] Taira et al,[31] and Moulding and Loney[32] reported that cooling techniques, such as the use of an air-water spray, were effective in limiting the temperature rise in the pulp chamber. According to individual needs, stripping duration or number of strokes may differ, so the temperature change may exceed the critical level of 5.5°C.

The condition and quality of the pulpal vascularity may determine the degree of damage caused by thermal trauma.[33] Zachrisson[15] 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.[34] In clinical conditions, pain during stripping may increase 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.[35] In addition, the surrounding periodontal tissues can promote heat convection in vivo, limiting the intrapulpal temperature rise.[36]

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

CONCLUSIONS

a. Mean temperature changes exceeded the critical level of 5.5°C only when the incisor teeth were stripped with a tungsten carbide bur with a high-speed hand piece. A metal strip used on premolar teeth seems to be the safest procedure for thermal changes in the pulp chamber.
b. There were also individual samples with critical temperature increases almost in all other test

groups. This finding calls for caution during stripping of premolars and canines by other methods as well.

c. Stripping procedure done with a tungsten carbide bur showed greater temperature rise among all the procedures.
d. Clinicians must be aware of the detrimental effects of heat during stripping, and air cooling should be preferred because of greater visibility than with air-water sprays.

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