TITLE: Effect of intracanal cryotherapy on surface temperature change in the root apex with different thickness; an Ex Vivo Study

ABSTRACT

Aims: To evaluate the effect of intracanal cryotherapy on surface temperature change in the root apex with different thickness.

Study Design: Comparative Study

Place and Duration of Study: Operative Dentistry Department: Altamash Institute of Dental Medicine, Karachi, Pakistan: July 2020 till June 2021

Materials & Methods: Sixty extracted single-rooted teeth were randomly divided into two groups: 30 each with one group consisting of teeth with ≤3 mm root thickness and another group consisting of teeth with thickness >3mm. Both groups were equally subdivided into Group A and Group B. After endodontic preparation of teeth, Group A underwent room temperature saline irrigation and Group B cold temperature saline (2.5°C) irrigation. A digital thermometer was used to measure the external root surface temperature by placing the thermocouple at 2 mm from the apex of the root's buccal surface.

Results: Initial and final temperatures were compared using paired t-test. Independent t-test was applied to compare the final temperature between ≤3mm and >3mm thickness groups. P-value less than or equal to 5% level of significance was defined as statistically significant. In group A, An average temperature decrease of 4.4 ± 0.5°C was observed in the final temperature when thickness was ≤3mm ($p=0.040$) while a reduction of 2.6 ± 0.5°C was seen in the final temperature when thickness was >3mm ($p=0.008$). When thickness was ≤3 mm, final temperature among group A and Group B was significantly different with higher mean final temperature in Group A ($p<0.001$). At thickness >3mm, final temperature between Group A and Group B was different with significantly lower final temperature in Group B than Group A($p<0.001$).

Conclusion: The external root surface temperature reduction was found to be inversely related to the external root thickness. Thin roots showed greater temperature reduction compared to thick roots.

Key Words: Intra canal cryotherapy, external root surface temperature, negative apical pressure, root thickness

INTRODUCTION

Cryotherapy comes from the Greek word cryos, which means cold. In medicine, cryotherapy is used to reduce the temperature of tissue to induce healing. According to the literature, cryotherapy functions by extracting heat from the tissue it is applied on, [1,2] eventually changing local temperature of host tissues[3, 4]. Local changes in the blood flow after application of hot or cold stimulation lead to activation or deactivation in neural tissues, resulting in either activation or reduction in their metabolic activity[2]. Law of Van't Hoff states that cryotherapy produces vasoconstriction and decreases metabolism at the cellular level by restricting biochemical reactions. Hence reducing local inflammatory reaction, edema and slowing nerve signal conduction, possibly decreasing transmission of pain.[5][6]

Cryotherapy is primarily used in medicine for pain relief. It achieves this by reducing inflammation resulting from injuries related to sports, arthritis, tendonitis, sprains and swelling after replacement of hip or knee, pain related to lower back and to reduce pain or swelling which develops beneath the cast or a splint.[7]

In dentistry, cryotherapy is being used to reduce post-operative pain resulting from periodontal surgeries, tooth extractions and implant placements [8]. Recently the concept of cryotherapy has been applied in endodontics as well to reduce post endodontic pain.[9-13] Studies have reported that frequencies of pain that follow a root canal procedure extend from 1.5 to 53%. This pain happens in the course of first 24 to 46 hours and tends to reduce in a few hours; sometimes it can persist for several days [14]. There are many strategies proposed to deal with post-operative pain in endodontics but there is no standardized protocol [15,16-18]. Many in-vivo studies have been published and claim reduction of post endodontic pain by application of intra canal cryotherapy [9-13]. An in-vitro study evaluated the effect of intra canal cryotherapy on external root surface temperature reduction and found that cold irrigation (2.5C saline solution) reduced temperature upto 10°C. [19]. Root thickness varies with tooth type, gender, ethnicity, tooth surface and within a tooth in case of multirooted teeth [20]. Studies have been conducted which have evaluated the variation in external root surface temperature during endodontic procedures such as endodontic preparations, post preparations, and warm obturation techniques with respect to root thickness. Those studies found that roots with different root thickness show variation in external root surface temperature. Thin roots showed high temperature rise whereas thicker roots showed less external root surface temperature rise [21-23]. There is only one in vitro study in the literature which evaluated the change in external root surface temperature after intra canal cryotherapy but even that study has not taken root thickness into consideration which is a very important confounding factor. Therefore, the current study was conducted to assess the change in external root surface temperature after cryotherapy in teeth with different root thicknesses. Null Hypothesis is that there is no variation in temperature reduction regardless of root thickness.

Materials and Methods

We consecutively enrolled total 60 sixty freshly extracted single rooted teeth over a period of four to five months to get the specific type of teeth to match our inclusion criteria. Extracted single rooted teeth were collected in the Department of Oral Surgery at Altamash Institute of Dental Medicine after ethical approval from Ethical review committee Ziauddin University code: 2060320SFOM and divided into two groups: group 1 thin rooted (n=30 buccolingual ≤3 mm at 2 mm from the apex) and group 2 thick rooted (n =30 buccolingual thickness >3 mm at 2 mm from the apex). Root thickness was measured externally from buccal surface to the lingual surface using a vernier caliper at 2 mm from the apex. Both groups were randomly divided in two groups A and B through simple randomization using sequentially numbered opaque sealed envelops. Single rooted mandibular premolar teeth extracted for orthodontic reasons with mature apex (age 14 years and above) were included in the study. Teeth with resorptions, decay or fracture below cementoenamel junction, and developmental defects were excluded from the study. Residues of the ligament, soft debris and calculus were detached by using ultrasonic scaler tips (UDS-J, Guilin Woodpecker, Guilin, China) and 5% sodium hypochlorite (NaOCl) was used to immerse teeth in it for 30 minutes. Dehydration of teeth was prevented by immersing teeth in distilled water until the time the experiment was started. Teeth were decoronated using a diamond disk (IsoMet™1000; Buehler Ltd., Lake Bluff, IL, USA), standardization of roots was done to 15 mm and a marking was done at 2 mm from apex at the buccal root surface. K-file number 10 (sybron Endo) was placed inside the root canal and when it was visible at the apex, at this point 01 mm from the apex was subtracted to establish the working length. Canal instrumentation was performed till K-File number 20 up to to the working length, the teeth were further shaped up to Master Apical file of F3 using Protaper Gold Files (DENTSPLY Maillefer, Switzerland). Throughout instrumentation irrigant of 5% NaOCl was used and EDTA 17% irrigant (MD-Cleanser; Mera BIOMED) was used to remove the smear layer. The apex of prepared canal was sealed using flow-able composite to simulate a closed chamber. Rubber dam was also used for isolation of the teeth. To ensure complete isolation; “Block-Out Resin” (of the brand: Ultradent Products, South Jordan, UT) was applied as well. Digital thermometer was used along with Thermocouple type K (Thomas Edison Co, China), RoHs compliant [temperature range, 50C to 1350C] to record the temperature of the external root surface by placing thermocouple at 2 mm from the root apex. In this study, thermocouples were placed at 2 mm from the root apex for a number of reasons. The first reason was standardisation, secondly at 2 mm the stability of the thermocouple device was able to be achieved and lastly there are studies mentioning the distance between the root canal foramen and the root apex may range from 0 to 3 mm[24,25].

Group A was subjected to room temperature normal saline(20 mL) irrigation for 5 minutes using commercially available negative apical pressure irrigation system called EndoVac

(Kerr Dental). This system ensures irrigant delivery upto the apex [26]. EndoVac has a micro cannula and master delivery tip (both referred to as micros in the article). The syringe with a capacity of 20 mL solution and the Endovac micros used were at room temperature as well. Before starting the irrigation process initial temperature (point 1) and after irrigation lowest temperatures (point 2) were noted. A digital thermometer with its thermocouples described previously was placed at the marking at 2 mm buccal surface to measure these temperature readings.

Group B underwent 5 minutes of irrigation with a cold saline solution (2.5°C temperature). The temperature of the syringe and MICROs used were 2.5°C as well. 20 mL saline solution (2.5°C cold) was introduced into the canal and negative pressure irrigation applied for 5 minutes. Two temperature readings were recorded. Before starting the irrigation an starting temperature (point 3) and the lowest temperature attained after the experiment (point 4) were recorded by placing the thermocouple at the marking at 2 mm buccal surface.

Positive controls and negative controls were measured by designating 5 roots as positive controls and 5 roots as negative controls. Positive controls were kept in the compartment called the freezer and after 24 hours, external root surface temperature was recorded. The temperature of the external root surface of negative controls was noted at room temperature.

RESULTS

Data analysis plan

Data was entered in SPSS version 21 for statistical analysis. Normality assumption was tested with Shapiro-wilk test, after confirmation of normality assumption, data was presented as mean ± standard deviation. Initial and final temperatures were compared using paired t-test. Independent t-test was applied to compare the final temperature between ≤3mm and >3mm thickness group. The *P*-value less than or equal to 5% level of significance was defined as statistically significant.

Results

Total 60 teeth were selected which were equally distributed in group 1 (root apex thickness ≤3 mm) and group 2 (root apex thickness >3 mm). Both groups were equally subdivided into A and B.

Comparison of initial and final temperature in A and B with respect to two thicknesses.

In A, when thickness was ≤3mm, on an average a drop of 0.4 ± 0.3°C was observed in final temperature readings and this difference was statistically significant p=0.014) (Table 1). In A,

when thickness was >3mm, average reduction in final temperature was 0.4 ± 0.1°C with statistically significant difference (*P*<0.001) (Table 1).

An average temperature decrease of 4.4 ± 0.5 °C was observed in final temperature when thickness was ≤3mm in the Groups B (*P*=0.040) while a reduction of 2.6 ± 0.5°C was seen in final temperature when thickness was >3mm in the Groups B (*P*=0.008) (Table 2).

Comparison of initial and final temperature between Group A and Group B with stratification of two thickness groups

When thickness was ≤3mm, initial temperature was not significantly different between Group A and Group B (*P*=0.464). When thickness was ≤3 mm, final temperature among group A and Group B was significantly different with higher mean final temperature in Group A (*P*<0.001). When thickness was >3mm, Group A and Group B did not differ on the basis of initial temperature (*P*=0.195). When stratification was done with respect to thickness >3mm, it was observed that final temperature between Group A and Group B was different on the basis of final temperature with significantly lower final temperature in Group B than Group A(*P*<0.001).(table 3)

Table 1: Comparison of initial and final temperature with respect to tooth thicknesses for Group A

Teeth thickness	**A**		***P*-value**
	Initial temperature	**Final temperature**	
≤3mm	23.6 ± 0.3	23.2 ± 0.4	*0.014
>3mm	23.8 ± 0.3	23.4 ± 0.3	**<0.001

Data is presented as mean ± standard deviation, *significant at *P*<0.05, **significant at *P*<0.01

Table 2: Comparison of initial and final temperature with respect to tooth thicknesses for B

Teeth thickness	B		*P*-value
	Initial temperature	Final temperature	
≤3mm	23.6 ± 0.4	19.2 ± 0.5	*0.040
>3mm	23.6 ± 0.3	21 ± 0.6	**0.008

Data is presented as mean ± standard deviation, *significant at *P*<0.05, **significant at *P*<0.01

Table 3: Comparison of initial and final temperature between Group A and Group B with stratification of two thickness group

Thickness groups	Temperature			*P*- value
		Group A	Group B	
≤3mm	**Initial temperature**	23.6 ± 0.3	23.6 ± 0.4	0.464
≤3mm	**Final temperature**	23.2 ± 0.4	19.2 ± 0.5	**0.001

>3mm	**Initial temperature**	23.8 ± 0.3	23.6 ± 0.3	0.195
>3mm	**Final temperature**	23.4 ± 0.3	21 ± 0.6	**0.001

Data is presented as mean ± standard deviation, **significant at $P<0.01$

DISCUSSION

This Ex Vivo study was intended to evaluate the effect on root thickness on external surface temperature reduction. Studies have been conducted which have shown that the temperature of the external root surface was altered by the tooth type and proved that this is associated with the variation in thickness of roots among different types of teeth. [27]

In the present study, the magnitude of the temperature change varied with varying root thickness that is in agreement with the studies that concluded root thickness plays a role in degree of temperature change of external root surface. The degree of temperature drop was inversely related to the root thickness. [28,29].

The difference of temperatures at room temperature saline irrigation and cold saline irrigation were statistically significant corroborating with the results of an in-vitro study [20]. The room temperature saline irrigation slightly reduced the initial temperature (mean difference = 0.4 ± 0.3°C), the cold saline irrigation reduced it more (mean difference = 4.4 ± 0.5 °C) similar to the results of an in-vitro study [20]

In an In-vitro study [20], the temperature on the external surface of the root was reduced more than 10°C, contradicting the results of the present study. In the present study, the maximum magnitude of temperature reduction was 4.4°C. The possible reason could be the root thickness of the teeth included in the previous study, the level and the surface at which the thermocouple was placed.

Studies have proven that the temperature of the tooth can differ from 5°C to 76.3°C on a daily basis [30]. Dentin thermal conductivity ranges from 0.11 [31] to 0.96 to 0.98 W m1 K–1 [32]. At the same time, human dentin has shown limited thermal conductive properties [30]. This is in agreement with the results of the magnitude of temperature drop in the present study.

Studies have proven that root thickness varies with tooth type, position of the tooth in the arch, surfaces of the tooth root, gender and ethnicity [28, 29]. The results of present study prove that intracanal cryotherapy has an effect on teeth with different root thicknesses. Hence Root thickness seems to be a major confounding factor which must be taken into account as it can limit the effect of cryotherapy and perhaps same effect of intra canal cryotherapy cannot be expected in all the teeth. Clinical significance of intra canal cryotherapy in endodontics is that it reduces post endodontic pain which has been proven by many in vivo studies [9-13,20].

One of the limitations of the present study is the fact that periodontal simulation was not employed and only external root thickness was evaluated. If CBCT facility was readily available it would have been possible to measure the internal root dentine thickness as well. Another limitation is the sample size hence future studies should be conducted on a relatively larger sample size to verify study findings. The results of present study can serve as a baseline and contribute in future studies to identify temperature of the irrigant required to achieve greater external root surface temperature drop in thicker roots. Some future recommendations would be to evaluate other parameters of cryotherapy before clinical implementation of this system. Examples include root canal curvature, simulation of periodontium, maintenance of cold irrigant temperature throughout the duration of cryotherapy and effect of different temperatures on magnitude of temperature reduction.

CONCLUSION:

Based on the results obtained and within the limitations of the methodology used, it could be concluded that when the external root thickness was less than or equal to 3 mm there was greater reduction of external root surface temperature compared to when external root thickness was >3 mm. Thus root thickness must be taken into consideration while applying intra canal cryotherapy.

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Conflict of Interest: The study has no conflict of interest to declare by any author.

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