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Effect of cryoirrigation using Endovac and needle irrigation on reduction of the external root surface temperature of the mesial roots of mandibular first molars with different root canal configurations.

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Abstract:
Objective: The study was aimed to evaluate the Effect of cryoirrigation using Endovac and needle irrigation on reduction of the external root surface temperature of the mesial roots of mandibular first molars with different root canal configurations.
Methods: Out of 153 mature mandibular first molars, 20 teeth were selected. The selected teeth, 10 of them had mesiobuccal roots with type II root canal systems and 10 of them had mesiobuccal roots type III root canal systems according to weine classification. The teeth were divided according to the temperature of the irrigant used into two main groups, (A1), room temperature and, (A2) 2.5°C. Each group was further subdivided according to the anatomy of the root canal being irrigated into two more groups, (B1) root canals with one portal of exit (type II root canal system) and (B2) root canals with two portals of exits (type III root canal system). Finally, each subgroup was further subdivided according to the technique of irrigation used into two subgroups: (C1) Needle irrigation and (C2) Endovac irrigation. Access cavity was accomplished, root canal preparation was done using rotary NiTi files to a master apical size of #25 taper 0.06., cryo irrigation was done and the external root surface temperature was measured using type K thermometer attached to thermocouple.
Result: There was a significant difference in external root surface temperature between cryoirrigation groups and room temperature irrigation groups. Also, there was a significant difference in cryoirrigation groups between Endovac and needle irrigation techniques. **Conclusion:** cryoirrigation decreased external root surface temperature.
Key words: endodontics, cryoirrigation, Endovac.

Introduction:

Pain is unpleasant sensory and emotional experience [(1)]. It usually occurs few hours to a few days after root canal treatment. Post endodontic pain (PEP) may be caused by various factors such as presence of apical periodontitis, insufficient root canal instrumentation, extrusion of apical

[1] Kumar, K. Hanoch, and P. Elavarasi. "Definition of pain and classification of pain disorders." *Journal of Advanced Clinical and Research Insights* 3.3 (2016): 87-90.

debris, and apical injury during canal preparation [2]. Also, the type of tooth being involved affects the degree of post operative pain \(3,4)
.
(PEP) can be reduced by accurate determination of the working length (WL), careful irrigation and minimal over extension of instruments and obturating materials, [5,6]. More recently cryo-irrigation is being used to reduce (PEP). The term "cryo" originates from the Greek word "cryos" which means "very cold" [7]. Cryo-irrigation is achieved by irrigation of the root canal after completion of root canal preparation with cold irrigant. The idea of using cold application to reduce pain is based on decreasing the temperature of the injured site which results in reduction of the effect of edema by initiating vasoconstriction which reduces the amount of extravasated fluid into the injury site thus decreasing the interstitial tissue pressure and concurrently stimulus of the nerve endings [8]. Furthermore, reducing the tissue temperature slows down cellular metabolism by limiting biochemical reactions and limiting the production of inflammatory mediators within the tissues [9,10]. Another mechanism by which reduction of nerve conduction is achieved is by the release of β-endorphins which are endogenous opioid neuropeptide and peptide hormone that is produced and stored in the pituitary gland [11]. Furthermore,

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Neurologically, cryotherapy reduces pain by directly blocking nerve endings and reduction of peripheral nerve conduction. It has been found that at about 7°C there is complete deactivation of myelinated A-δ fibers whereas at about 3°C the non-myelinated C-fibers are completely deactivated [(12)]. For these reasons, cryotherapy has been widely used in providing relief from pain after sports injuries and surgical procedures [(13)].

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[12]. Modabber A, et. al. Three dimensional evaluation of postoperative swelling in treatment of zygomatic bone fractures using two different cooling therapy methods: a randomized, observerblind, prospective study.Trials 2013; 14: 238.

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It is common knowledge that after dental surgery ice packs are used to reduce post operative pain and swelling. In 2005, Felho et al. Found that application of ice packs after third molar surgery reduced pain, swelling and trismus [14].

In endodontics, the first research on the clinical application of cryotherapy in endodontics was done by Keskin et al. In 2016, they evaluated the use of cryoirrigation in reduction of postoperative pain after conventional endodontic therapy [15]. Following this research, other researchers evaluated the effect of cryoirrigation using different protocols ([16],[17],[18],[19]). With regards to the method of irrigation, negative pressure irrigation using a cryoirrigant has been shown to be more effective in reducing postoperative pain when compared to passive irrigation [17]. Because the field of cryoirrigation is still in its infancy, consensus has not been reached as to the optimum time and temperature for effective cryoirrigation. In previous researches, the temperature of the saline irrigant used ranged between 2.5 to 5 degrees and the time of irrigation from 5 to 10 minutes. ([16],[20],[21]). Moreover, some of the studies mentioned above evaluated single rooted teeth only, while others had no restrictions on the teeth being evaluated ([16],[22]). The numbers of portals of exit on the surface of the roots differ, hence this may affect the amount of

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postoperative pain felt by patients after treatment [23]. Also, the Dentin thickness around the root canals differs depending on the tooth being evaluated [24].

To date, there is no definite protocol for cryoirrigation with regards to optimum temperature and time for reduction of (PEP). Furthermore, consideration for the effect of different root canal configuration and classes on (PEP) has also not been evaluated.

Materials and methods:

Selection of the teeth:

A total of 20 mature mandibular extracted first molars out of 153 selected teeth were used in the study. Teeth were obtained from patients ages between 20-40 years old from oral and maxillofacial department Al-Azhar university, Cairo. That were extracted either for caries or periodontal affection. The teeth were immersed in 5.25% NaOCl (Clorox, Egypt) for 30 minutes then cleaned from any existing debris using a periodontal scaler, the length of the teeth was calculated using microcaliber to determine the length with average of 20.5 mm then the teeth were radiographed using periapical X.ray from mesiodistal and buccolingual directions and examined under operating microscope at 8x (Zomzx, China) The teeth included in the study were selected to be non-endodontically treated, Only root canal systems type II and III Weine classification[25], with root curvature from 0 to 25 degree according to schneider method[26]. The following exclusion criteria were applied to the selected teeth and a total of 133 teeth were excluded.

7.3.1.2. Grouping of the teeth:

1. Group A1B1C1: the teeth in this group were irrigated with room temperature saline using needle irrigation and the teeth had one portal of exit.

2. Group A1B1C2: the teeth in this group were irrigated with room temperature saline using Endovac irrigation and the teeth had one portal of exit.

3. Group A1B2C1: the teeth in this group were irrigated with room temperature saline using needle irrigation and the teeth had two portals of exit.

4. Group A1B2C2: the teeth in this group were irrigated with room temperature saline using Endovac irrigation and the teeth had two portals of exit.

5. Group A2B1C1: the teeth in this group were irrigated with 2.5°C saline using needle irrigation and the teeth had one portal of exit.

6. Group A2B1C2: the teeth in this group were irrigated with 2.5°C saline using Endovac irrigation and the teeth had one portal of exit.

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7. Group A2B2C1: the teeth in this group were irrigated with 2.5°C saline using needle irrigation and the teeth had two portals of exit.
8. Group A2B2C2: the teeth in this group were irrigated with 2.5°C saline using Endovac irrigation and the teeth had two portals of exits.

Preparation of the specimens:

A. Access cavity preparation:

Before gaining access cavity all carious enamel and dentin and any defective restorations were removed using a high speed handpiece (Coxo handpiece CX207, China) with coolant and building up was done using a coomposite material (Composan, Promedica, Germany). Access cavity was accomplished using a round bur size 2 followed by a tapered stone with round end size 12 (White Burs, Inc., New Jersy, USA) with coolant.

B. Root canal preparation:

Following access cavity preparation, patency was done using a file #10(M access files, Dentsply Mailfere, Switzerland). Working length was determined by inserting a file into the canals till it was seen from the apex then subtracting 0.5mm from this length. Then, a glide path was created using a file number # 15 to the full working length, after that root canal preparation was done using rotary NiTi files (M pro NITI files, China) to a master apical size of #25 taper 0.06., Patency was achieved between each file using a #10 k file. During root canal preparation irrigation was done using 3 ml NaOCl between each file, a total of 12 ml of 5.25 % NAOCL. Also, Final irrigation was accomplished using 17%EDTA for 1 minute, with a total of 3 ml. Then, all canals were dried using #25 taper 0.04 paper points (Meta, Korea).

Attachment of the thermocouple and preparation of the specimens:

A K-type thermocouple connected to a digital thermometer was attached to the apical 3mm of the root. The distal canal orifice of the teeth was sealed with composite resin.

Mounting of the teeth:

Following attaching the thermocouple to the roots of the teeth, the teeth were mounted in a vice to secure it in place, then a rubber dam was applied (figure 1).

Figure 1: showing the tooth attached to the vice and the thermocouple and connected to the thermometer and rubber dam was applied

Irrigation of the canals:

A. Temperature of irrigant:

1. Room temperature (24 - 26°C)

In groups in which room temperature irrigantion was used, each tooth was irrigated with saline solution at room temperature (24 - 26°C) at a rate of 20 ml/min).

2. Cryo irrigation (2 - 2.5 °C):

In groups in which Cryo-irrigation was used the irrigating solution and the plastic syringes used for irrigation were placed in an ice box containing water, ice blocks and a thermometer to keep the water path and the irrigating solution at the need temperature. Each tooth was irrigated with 140 ml cold saline (2-2.5°C at a rate of 20 ml/min.).

B. Management of irrigation in different root canal types:

1. Canals with one portal of exit:

Canals with one portal of exit were irrigated for a total of 7 minutes, as irrigation time was divided between the two canals (3.5 minute for each).

2. Canals with two portals of exit:

Canals with two portals of exit were irrigated for a total of 7 minutes, as irrigation time was divided between the two canals (3.5 minute for each)

C. Technique of irrigation:

1. Needle irrigation:

In this group Irrigation was done using normal saline in a 30 gauge side vented needle (Fanta blue, China) at a rate of 20 ml/min and the reading of the external root temperature was taken every minute. (a total of 8 readings including the initial temperature).

2. Endovac irrigation:

In this group irrigation was done using Endovac device using its microcannula mounted on a 20 ml plastic syringe at a rate of rate of 20 ml per minute and the reading of the external root surface temperature was taken every minute. (a total of 8 readings including the initial temperature).

Results:

Statistical analysis:

all data was collected and statistically analyzed

The comparison of the two temperatures, two types of portals, and two types of irrigation techniques was done using the Mann-Whitney test (non-parametric test).

The comparison of the different times of irrigation was done using Kruskal-Wallis followed by the Mann-Whitney test for pairwise comparisons different times (non-parametric test). P-value $\leq$ 0.05 was considered statistically significant (95% significance level). Shapiro Wilk test was used for testing the normality of data. Data were analyzed using the statistical software SPSS (version 25, IBM Co. USA).

1. Effect of irrigation temperature on external root surface temperature:

1.1. Endovac, one portal of exit:

there was a significant difference in external root surface temperature at all measuring times from minute 1 to minute 7 between 2.5 c irrigation and room temperature irrigation (P-value < 0.05).

1.2. Endovac, two portals of exit:

there was a significant difference in external root surface temperature at all measuring times from minute 1 to minute 7 between 2.5 c irrigation and room temperature irrigation (P-value < 0.05).

1.3. Needle irrigation, one portal of exit:
there was a significant difference in external root surface temperature at all measuring times from minute 1 to minute 7 between 2.5 c irrigation and room temperature irrigation (P-value < 0.05).

1.4. Needle irrigation, two portals of exit: there was a significant difference in external root surface temperature at all measuring times from minute 1 to minute 7 between 2.5 c irrigation and room temperature irrigation (P-value < 0.05)

Table (1): showing the Mean ±SD values and the temperature of the external root surface (˚C) when comparing between the two temperatures of the irrigant used (room temp. and 2.5 degree) at different irrigation times for two types of portals (one portal and two portals) with the two techniques of irrigation.

		Needle			Endo vac		
		Room	2.5 Degree	P-value*	Room	2.5 Degree	P-value*
One Portal	1 min	25.14±0.22	19.98±0.19	< 0.001^{S}	25.15±0.2	15.88±0.13	< 0.001^{S}
	2 min	25.11±0.2	18.66±0.49	< 0.001^{S}	25.15±0.15	15.47±0.3	< 0.001^{S}
	3 min	25.14±0.18	17.40±0.62	< 0.001^{S}	25.14±0.18	15.6±0.24	< 0.001^{S}
	4 min	25.14±0.13	17.01±0.59	< 0.001^{S}	25.14±0.18	15.4±0.23	< 0.001^{S}
	5 min	25.16±0.16	16.64±0.62	< 0.001^{S}	25.15±0.2	15.31±0.2	< 0.001^{S}
	6 min	25.2±0.19	16.44±0.5	< 0.001^{S}	25.16±0.16	15.25±0.18	< 0.001^{S}
	7 min	25.17±0.18	16.31±0.42	< 0.001^{S}	25.15±0.17	15.14±0.13	< 0.001^{S}
Two Portal	1 min	25.14±0.22	21.91±0.22	< 0.001^{S}	25.15±0.2	17.15±0.27	< 0.001^{S}
	2 min	25.11±0.2	20.80±0.84	< 0.001^{S}	25.15±0.15	16.84±0.31	< 0.001^{S}
	3 min	25.15±0.18	19.16±0.45	< 0.001^{S}	25.14±0.18	16.5±0.17	< 0.001^{S}
	4 min	25.13±0.12	18.32±0.68	< 0.001^{S}	25.14±0.18	16.31±0.07	< 0.001^{S}
	5 min	25.17±0.16	17.79±0.35	< 0.001^{S}	25.15±0.2	16.25±0.1	< 0.001^{S}
	6 min	25.18±0.18	17.49±0.18	< 0.001^{S}	25.14±0.16	16.19±0.12	< 0.001^{S}
	7 min	25.17±0.18	17.38±0.19	< 0.001^{S}	25.14±0.16	16.12±0.1	< 0.001^{S}

** Overall P-value for comparison between different groups (Mann-Whitney test).*
- S= Statistically significant at P ≤ 0.05 - NS= Non-significant P < 0.05.

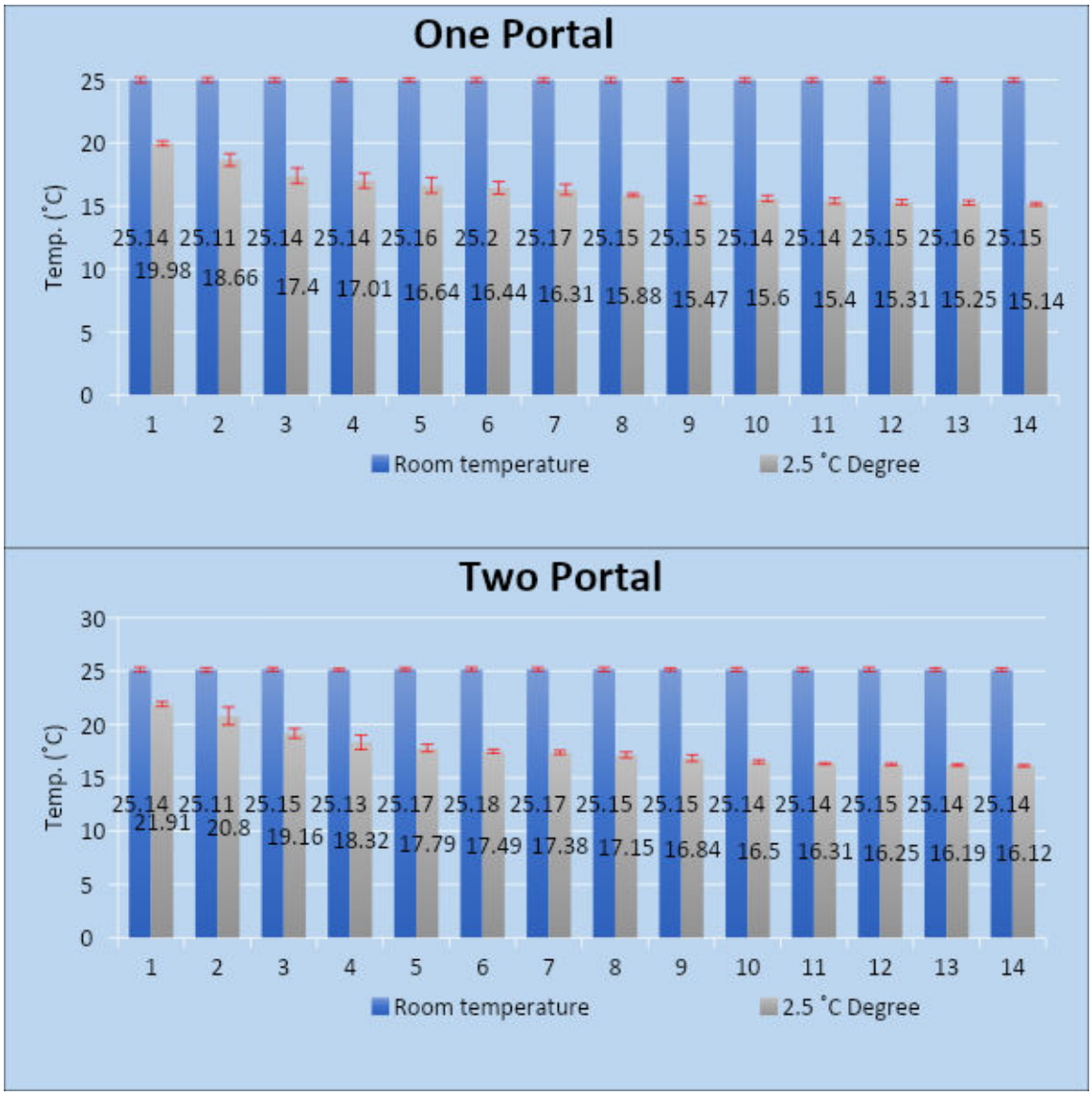

Figure (2): Bar chart showing the Mean and SD of the temperature of the external root surface (˚C) when comparing between the two temperatures of the irrigant used (room temp. and 2.5 degree) at different irrigation times for the two types of portals of exit (one portal and two portal) under the two techniques of irrigation

2. Effect of number of portals of exit on external root surface temperature:

2.1. Endovac irrigation,2.5 c:

there was a significant difference in external root surface temperature at minute 1 and minute 2 between one portal and two portals (P-value < 0.05) and there was no significant difference from minute 3 to minute 7 (P-value > 0.05).

2.2. Endovac irrigation, room temperature:

there was no significant difference in external root surface temperature between one portal of exit and two portals of exit at all measuring times from minute 1 to minute 7 (P-value > 0.05).

2.3. Needle irrigation,2.5 c:

there was a significant difference in external root surface temperature at all measuring times from minute 1 to minute 7 between one portal of exit and two portals of exit (P-value < 0.05).

2.4. Needle irrigation, room temperature:

there was no significant difference in external root surface temperature between one portal of exit and two portals of exit at all measuring times from minute 1 to minute 7 (P-value > 0.05).

Table (2): showing the Mean ±SD and the temperature of the external root surface (˚C) when comparing between the two types of portals of exit (one portal and two portals) with the two techniques of irrigation at different times of irrigation for the two temperatures of the irrigant used (room temp. and 2.5 degree).

		Needle			Endovac		
		One Portal	Two Portals	P-value*	One Portal	Two Portals	P-value*
Room Temp.	1 min	25.14±0.22	25.14±0.22	1.000^{NS}	25.15±0.2	25.15±0.2	1.000^{NS}
	2 min	25.11±0.2	25.11±0.2	1.000^{NS}	25.15±0.15	25.15±0.15	1.000^{NS}
	3 min	25.14±0.18	25.15±0.18	0.912^{NS}	25.14±0.18	25.14±0.18	1.000^{NS}
	4 min	25.14±0.13	25.13±0.12	0.953^{NS}	25.14±0.18	25.14±0.18	1.000^{NS}
	5 min	25.16±0.16	25.17±0.16	0.912^{NS}	25.15±0.2	25.15±0.2	1.000^{NS}
	6 min	25.2±0.19	25.18±0.18	0.912^{NS}	25.16±0.16	25.14±0.16	0.915^{NS}
	7 min	25.17±0.18	25.17±0.18	1.000^{NS}	25.15±0.17	25.14±0.16	0.994^{NS}
2.5 Degree	1 min	19.98±0.19	21.91±0.22	0.004^{S}	15.88±0.13	17.15±0.27	0.027^{S}
	2 min	18.66±0.49	20.80±0.84	< 0.001^{S}	15.47±0.3	16.84±0.31	0.013^{S}
	3 min	17.40±0.62	19.16±0.45	0.011^{S}	15.6±0.24	16.5±0.17	0.066^{NS}
	4 min	17.01±0.59	18.32±0.68	0.015^{S}	15.4±0.23	16.31±0.07	0.061^{NS}
	5 min	16.64±0.62	17.79±0.35	0.037^{S}	15.31±0.2	16.25±0.1	0.057^{NS}
	6 min	16.44±0.5	17.49±0.18	0.042^{S}	15.25±0.18	16.19±0.12	0.056^{NS}
	7 min	16.31±0.42	17.38±0.19	0.040^{S}	15.14±0.13	16.12±0.1	0.052^{NS}

** Overall P-value for comparison between the two types of portals exit (Mann-Whitney test).*

- S= Statistically significat at P ≤ 0.05 - NS= Non-significant P < 0.05.

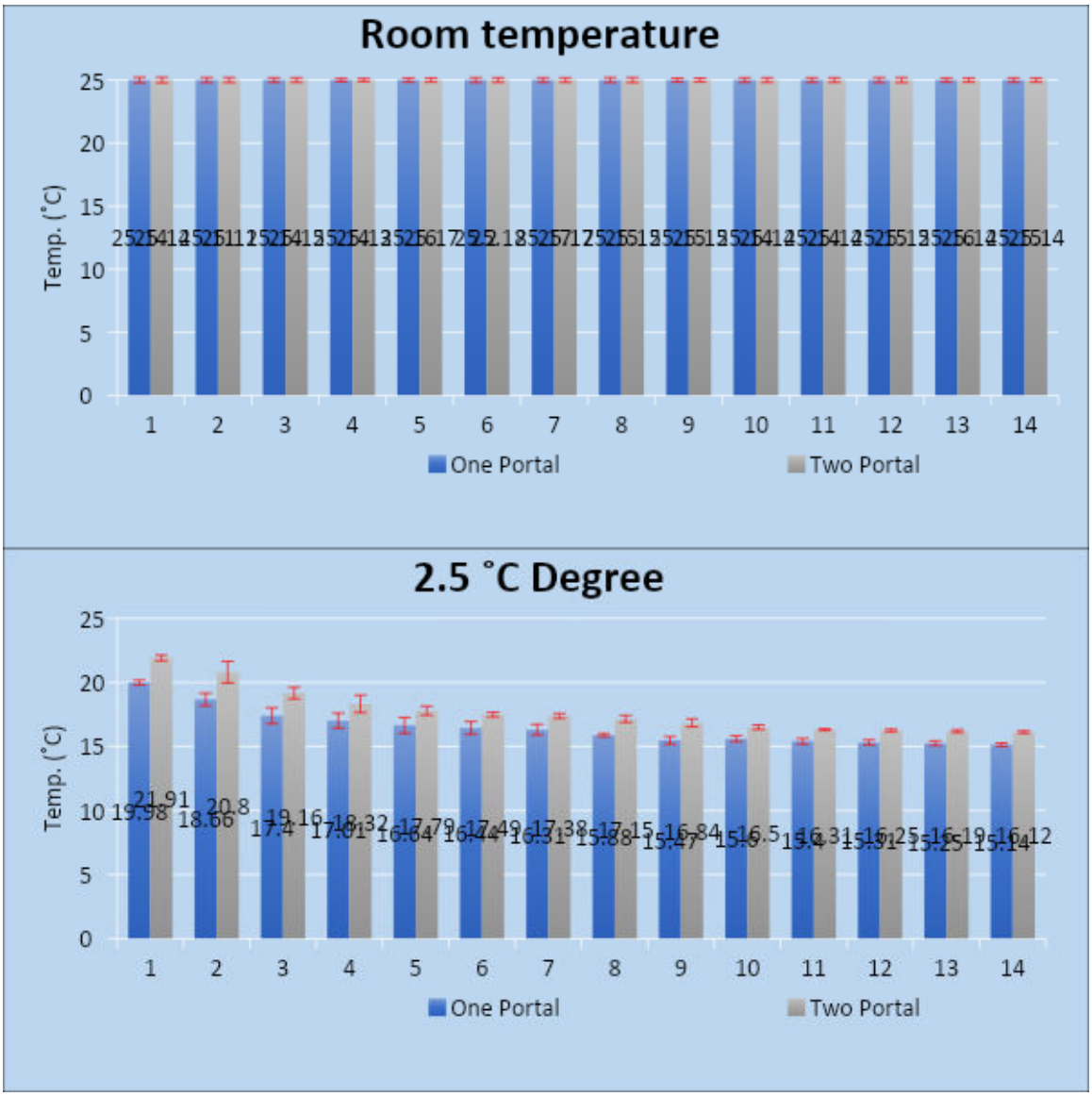

Figure (3): Bar chart showing the Mean and SD of the temperature of the external root surface (˚C) when comparing between the two types of portals of exit (one portal and two portals) under the two techniques of irrigation at different times of irrigation for the two temperatures of the irrigant used (room temp. and 2.5 degree).

3. Effect of irrigation technique:

3.1. One portal of exit, 2.5c:

there was a significant difference in external root surface temperature at all measuring times from minute 1 to minute 7 between Endovac irrigation technique and needle irrigation technique (P-value < 0.05).

3. 2. Two portals of exit, 2.5 c:

there was a significant difference in external root surface temperature at all measuring times from minute 1 to minute 7 between Endovac irrigation technique and needle irrigation technique (P-value < 0.05).

3.3. room temperature, one portal of exit:

There was no significant difference in external root surface temperature between Endovac irrigation technique and needle irrigation technique at all measuring times from minute 1 to minute 7 (P-value > 0.05).

3. 4. room temperature, two portals of exit:

There was no significant difference in external root surface temperature between Endovac irrigation technique and needle irrigation technique at all measuring times from minute 1 to minute 7 (P-value > 0.05).

Table (3): showing the Mean ±SD values of the external root surface temperature(˚C) when comparing between the two techniques of irrigation for the different portals of exit (one portal and two portals) at different times of irrigation for the two temperatures of the irrigant used (room temperature. and 2.5 degree).

		One Portal			Two Portals		
		Needle	Endovac	P-value*	Needle	Endovac	P-value*
Room Temp.	1 min	25.14±0.22	25.15±0.2	1.000^{NS}	25.14±0.22	25.15±0.2	1.000^{NS}
	2 min	25.11±0.2	25.15±0.15	0.992^{NS}	25.11±0.2	25.15±0.15	1.000^{NS}
	3 min	25.14±0.18	25.14±0.18	1.000^{NS}	25.15±0.18	25.14±0.18	1.000^{NS}
	4 min	25.14±0.13	25.14±0.18	1.000^{NS}	25.13±0.12	25.14±0.18	1.000^{NS}
	5 min	25.16±0.16	25.15±0.2	1.000^{NS}	25.17±0.16	25.15±0.2	1.000^{NS}
	6 min	25.2±0.19	25.16±0.16	1.000^{NS}	25.18±0.18	25.14±0.16	1.000^{NS}
	7 min	25.17±0.18	25.15±0.17	1.000^{NS}	25.17±0.18	25.14±0.16	1.000^{NS}
2.5 Degree	1 min	19.98±0.19	15.88±0.13	< 0.001^{S}	21.91±0.22	17.15±0.27	< 0.001^{S}
	2 min	18.66±0.49	15.47±0.3	< 0.001^{S}	20.80±0.84	16.84±0.31	< 0.001^{S}
	3 min	17.40±0.62	15.6±0.24	0.009^{S}	19.16±0.45	16.5±0.17	< 0.001^{S}
	4 min	17.01±0.59	15.4±0.23	0.011^{S}	18.32±0.68	16.31±0.07	< 0.001^{S}
	5 min	16.64±0.62	15.31±0.2	0.018^{S}	17.79±0.35	16.25±0.1	0.017^{S}
	6 min	16.44±0.5	15.25±0.18	0.029^{S}	17.49±0.18	16.19±0.12	0.014^{S}
	7 min	16.31±0.42	15.14±0.13	0.031^{S}	17.38±0.19	16.12±0.1	0.025^{S}

** Overall P-value for comparison between the two irrigation techniques (Mann-Whitney test).*

- S= Statistically significant at P ≤ 0.05 - NS= Non-significant P < 0.05.

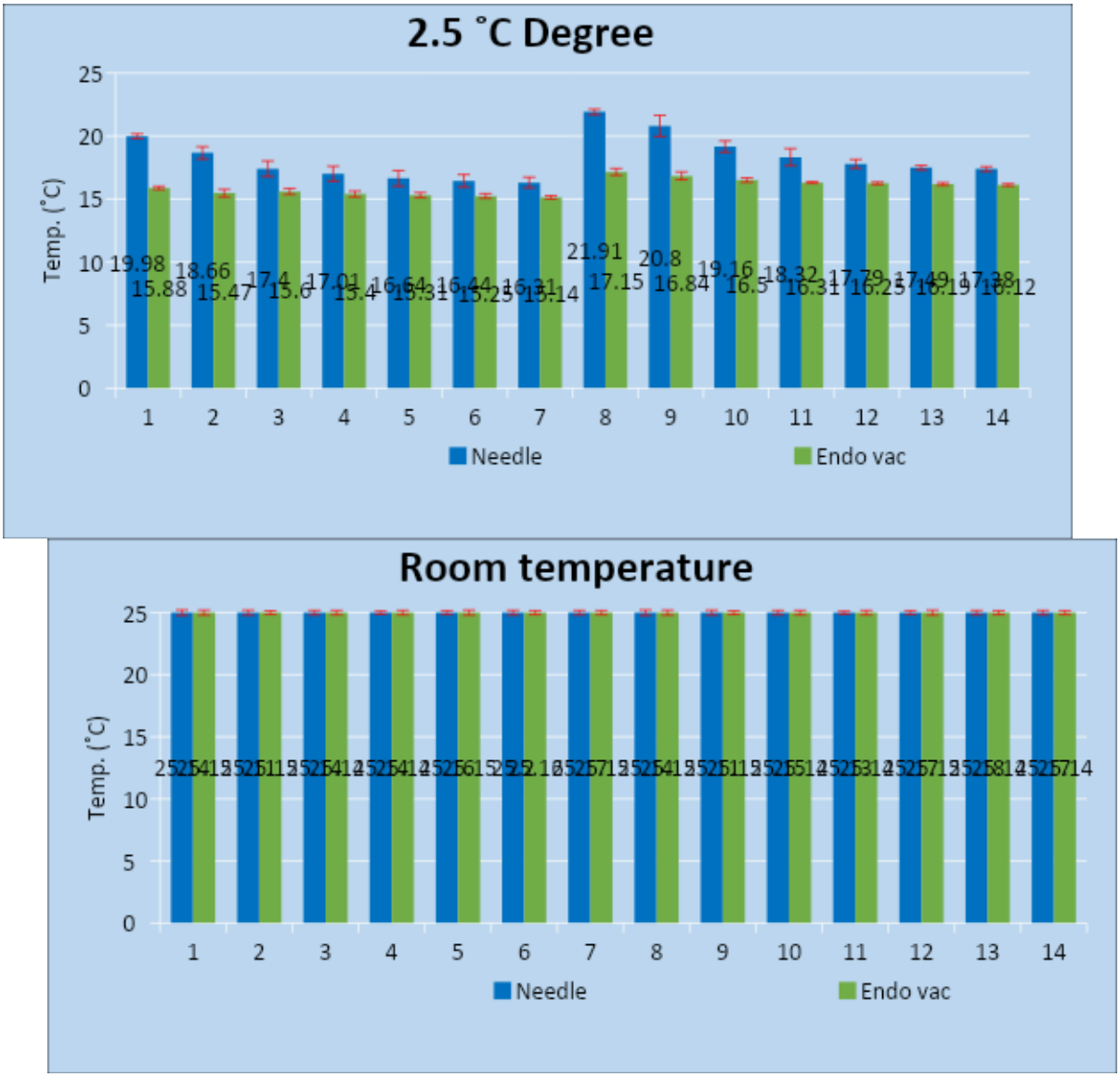

Figure (4): Bar chart showing the Mean and SD values of the temperature of the external root surface (˚C) between the two techniques of irrigation for the different portals exit (one portal and two portals) at different times of irrigation for the two temperatures of the irrigant used (room temp. and 2.5 degree).

Discussion:

Pain is very annoying sensation that may interrupts the patient's daily activity, so deceasing or elimination of pain is very important step for getting patients confidence [(27)]. Many studies have reported that the prevalence of (PEP) after single visit endodontic treatment ranging from 1.7-70

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% [28] . Furthermore, cryoirrigation has been previously used for pain reduction in many medical specialties and recently has been used in endodontics for reduction of post operative pain [29,30,31,32,33,34].

on the other hand, the results have shown that negative apical pressure irrigation system (Endovac) has been shown to irrigate the root canals resulting in less post-operative pain [35,36]. Furthermore, Endovac has been used in combination with cryoirrigation to decrease post operative pain but with no differentiation between different root canal classes [17] and this has been justified in this study.

The aim of this study was:

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1. To evaluate the reduction of the external root surface temperature of different root canal classes of mesial root of mandibular first molars using different cryoirrigation techniques & protocols.

The null hypothesis was that there was no difference between using cryoirrigation in combination with needle or Endovac irrigation on external root surface temperature and the null hypothesis was rejected.

Twenty teeth were selected out of a pool of 153 teeth, As the most common reason for exclusion was root caries and the least common reason for exclusion was root fracture. Only 20 teeth used in the study based on a power analysis conducted using a previous study by Vera et al (2015) to evaluate the optimum sample size. The selected teeth all were with mesial root canals type Ⅱand type ⅢI wine classification as roots with root canal type Ⅰ will have more dentin thickness all around the canal while type Ⅱand type ⅢI will have a different architectural of dentine thickness around the root canals that may affect the transmition of heat, Also several studies have been done on type Ⅰ root canal system [16] The selected teeth were obtained from patients with ages between 20-40 years old as old patients may have very narrow canals and young patients may have very wide canals and the teeth were with average length of 20.5 mm for standardization purposes. The selected teeth were molars as many studies have been done to evaluated the reduction in external root surface temperature in anterior or premolars but not molars and it's the most affected tooth with caries [37]. The selected teeth were with root curvature not exceeding 25 degrees according to Schneider method to make it easier for root canal preparation and to avoid root canal preparation errors such as instrument breakage or ledges and to allow for the needle and the micro canula of Endovac to reach the needed length and for standardization purposes. K type thermometer was used as its accurate device for measuring the temperature changes and for its availability in the market and as previous researches [16] The thermocouple was attached to the apical part of the root to detect the temperature changes in this part of the root canal as its nearest part to the apical area where tissue injury happens due to severing of pulp neurovascular bundles and extrusion of debris during root canal treatment [38]. Also, the teeth were mounted on a vice and rubber dam was applied to prevent the irrigation from seepage on the root surface and reaching the thermocouple thus affecting the reading of the thermometer and for simulating clinical situation. Cryotherapy has proven an anti-inflammatory effect so 2.5 c was used to decrease the external root surface temperature to produce anti-inflammatory effect according to the studies in this field as different temperatures has been used in this field but 2.5c looks to be the most effective [15,16,20], the temperature was maintained at this point by immersing ice in water in the ice box which containing the irrigation, also a thermometer was placed in the iced water for temperature checking and also as done previous studies [16,17]. Room temperature was

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used as a control group. Endovac is an innovative method for root canal irrigation activation [39] so it's compared with needle as a gold standard irrigation technique. Also, one portal of exit is compared with two portals of exit to detect weather will be a difference in irrigation diffusion within the root canal thus affecting external root surface temperature due to difference in root canal architecture. The irrigation time was divided between the two root canals for standardization purposes. In case of room temperature there was no significant difference in the external root surface temperature between Endovac and needle irrigation as the temperature of the irrigant is the same as the room temperature so there was no root surface temperature changes but, in case of 2.5 c there was a significant reduction in external root surface temperature in both needle irrigation and Endovac irrigation due to the irrigant temperature. on the other hand, the significant difference between Endovac irrigation and needle irrigation in 2.5 c may be because of the apical negative pressure that ensures reaching the irrigation with adequate contact to the dentine walls of the root canal which results in decreasing the external root surface temperature, also This mechanism helps to overcome the vapor lock so it was more effective in temperature transfer [(29)]. the significant difference between one portal and two portals at 2.5 c was due to the constricted diameter of the mesial root of the lower first molar in case of root canal type Ⅱrather than the diameter in case of type ⅢI which resulted in less amount of isolating dentine which leads to more heat transfer resulting in less external root surface temperature [(40)]

References:

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