A Thermographic Study of Heat Generation During All Ceramic Preparation

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Absract:

Statement of problem: *Saving pulp vitality is the great priority during all ceramic preparation.All ceramic preparation can cause pulpal lesionsif the temperature isn't controlled.**Purpose**:The study was conducted to highlight two factors that may affect the heat generation during all ceramic preparation: 1**-** Type of stone according to their abrasivenessgrit size (Fine , medium , Coarse).* ***2-****Pattern of reduction (Continuous , Intermittent).**Materials&Methods:** Ninety freshly extracted sound,single rooted teeth was selected for this study and divided into two groups according to pattern of reduction (45 teeth for each group).Each group was subdivided into 3 subdivisions according to the type of stones used in the preparation. Copper-constantan thermocouple wire joined with digital thermometer used to measure the temperature rise in the pulp chamber at different places**.** **Results:** 1-The intermittent reduction produced lesser increase in tooth temperature and was statistical different than the increase of temperature of continuous reduction.2-The fine grit size stones produce the least temperature rise then the medium grit size stone then the coarse grit size.**Conclusion:** All ceramic preparation should be done as intermittent reduction using fine grit size rotary instruments with sufficient water coolant in the high-speed handpiece.*

Keywords:All ceramic preparation, Stones ,Copper-constantan thermocouple,heat generation.

INTRODUCTION

Dental pulp is restricted by inflexible walls with a confined circulation supplied by an arteriole through a narrow apical foramen. Circulation disorders determine the reversibility limit for pulpal lesions and are precipitated by physical, chemical, thermal, or biologic stimuli.[1,2] Several essential procedures may contribute to pulpal necrosis. Heat is a major factor in pulpal injury .Other procedures include desiccation, pressure applied during tooth reduction,chemical injury,ill-fitting provisional restorations, bacterial infection, cementation, and occlusion. [3]. Dental pulps can't survive temperature increases greater than 5.5°C. [3] Crown/bridge abutment preparations produce some of the most damaging effects on the pulp. 16% of pulps became non-vital within a 10-year observation period, and 32% of previously confirmed vital pulps became necrotic following bridge abutment preparations.

Anterior abutment preparations resulted in pulp necrosis in over 50% of teeth examined in the study.Nine previous studies found that pulp necrosis occurred 10-18% of the time following crown preparations on vital teeth.Patients should be forewarned of the possibility of endodontic treatment being required following extensive crown/abutment preparations.[4] Thermal or non-thermal stimuli applied to dental structures can produce pulpal responses.Various alterations can occur by heat generation, such as tissue burning, the development of reparative dentin, postoperative sensitivity, and pulpal necrosis.[5]

Tooth preparations generate heat because the use of rotary cutting instruments on dental tissues creates friction. So Ultrahigh-speed tooth preparation can traumatize the hard dental tissues and the dental pulp.[6] Factors that influence heat generation include size and type of bur, contact intermittence, torque, instrument abrasiveness, load, and the amount of tissue removed. These should be routinely observed and controlled by the dentist to eliminate heat production.[6,7] Other factors that should be observed are the number of coolant apertures on the handpiece and their direction, which should be toward the tip of the bur. [8] Air-water spray cooling is essential in high-speed procedures, regardless of the pressure applied or type of bur associated with the equipment. Water temperature should not exceed 35°C. Adequate cooling prevents excessive drying and promotes drilling efficiency with diamond points or steel or carbide burs. [4,8] Standards to test the cutting efficiency of dental rotary cutting instruments are either nonexistent or inappropriate, and knowledge of the factors that affect their cutting performance is limited. Therefore, rotary cutting instruments for crown preparation are generally marketed with weak or unsupported claims of superior performance. [9]

Thermography was employed to determine the pattern of heat generation, distribution and dissipation during ultra-speed cavity preparation indicating an increase in intrapulpal temperature during cutting procedures. [10]

As clinical efficiency is increased with faster and more aggressive cutting tools. It is clinically imperative that tooth preparation avoid the excessive heat generation that could possibly damage the remaining tooth structure and endanger the health of the pulp.Many factors such as type of stone and pattern of reduction used are questionable controversial on the heat generation during all ceramic preparation, this study is conducted to highlight these factors.

REVIEW OF LITERATURE

Bhaskar SN et al (1965)[11] investigated the intrapulpal temperature during cavity preparation. An instrument consisting of a thermister probe for insertion into the pulp,a telethermometer, and a recorder, was specially designed for this study.Cavities were cut at low speed, at low speed with a coolant, at high speed, and at high speed with a coolant.They found that with low speeds without a coolant, the mean intrapulpal temperature increase was 5.4°C., with low speeds with a coolant the mean intrapulpal temperature dropped by 5.3°C and with high speed and high speed with a coolant, the mean intrapulpal temperature drop was 2.5°C. and 8.1°C., respectively.It can be assumed that under the usual operative procedures there is a drop in the intrapulpal temperature. Consequently, the well-known pulpal changes associated with cavity preparation cannot be due to heat production.It is most likely that these occur as a consequence of severance of the odontoblastic processes, dehydration, and perhaps the "cooling effect" of cavity preparations.

Dahl et al (1977) **[12]** studied the dentinopulpal reactions to full crown preparation procedures.He used an electron microscopy scanning and histological techniques to study the formation of a dentine smear in ten premolars ground with a water-cooled diamond in an air turbine.He revealed the formation of a dentine smear which was easily removed by light polishing with wet pumice, leaving plugs of debris in the tubule apertures.No bacteria were demonstrated on the prepared surfaces either in the scanning electron micrographs or histologically when stained with Brown & Brenn stain. Severe, acute pulp reactions were observed subjacent to the dentinal tubules cut in full crown preparation.

Pashley DH et al(1983)[13] studied the effect of temperature on dentin conductance (dentin permeability) by measuring the rates of fluid movement across dentin discs, in vitro at 10, 20, 30, 40, and 50°C in unetched and acid-etched dentin. They found that Increasing the temperature 40° (i.e., from 10 to 50°C) resulted in a 1.8-fold increase in fluid flow in unetched dentin, which was of a magnitude similar to the decrease in viscosity that occurred over the same temperature range. In acid-etched dentin, the 40°C temperature change produced more than a four-fold increase in fluid conductance, more than double that which could be accounted for by changes in viscosity. Analysis of the data suggests that this additional increment in hydraulic conductance is due to thermal expansion-induced increases in tubular diameter.

Laforgia PD et al(1991)[(14)] studied temperature changes in the pulp chamber during tooth preparation for a complete crown. Twelve extracted, morphologically intact human teeth were chosen: four canines, four premolars, and four molars. Six teeth, two of each, were cooled during preparation with an air-water spray; the remaining six were air-cooled. . They found that minimal reduction of dentin using an air-water spray coolant resulted in a lowered temperature in the pulp chamber, mainly with the cross-grooved diamond stones. The application of an air coolant resulted in a temperature rise in the pulp chamber.

Ulusoy N et al(1992)[(15)] studied the injurious thermal changes occurred in the pulp chamber if a twist drill is used 10 times, and if there is a correlation between temperature rise and distance between a drilled channel and the pulp chamber. Twenty caries-free, human, premolar teeth were randomly distributed to two dentists. With a new 2 mm twist drill, each dentist prepared 10 pinholes (one hole per tooth). Intrapulpal temperature change during the drilling procedure was recorded. The data were statistically analyzed by the Spearman rank order correlation coefficient. The results showed that twist drills should not be used for more than five pinholes. The distance between the pin channel and the pulp chamber does not influence heat generation in the pulp chamber.

Myers et al (1999)[(16)]carried out an investigaion upon the effect of extreme heat on teeth under laboratory conditions and the subsequent effect of decalcification and histologic processing. Physical and microscopic findings were evaluated in relation to temperature and duration of thermal insult.They found that microscopic examination following decalcification and histologic processing revealed changes including severe tissue fragmentation, vapor bubbles within dentinal tubules, altered histologic staining, charring and tissue shrinkage. Dentin appeared to be the most reliable microscopic identifier of incinerated dental tissues. Temperatures above 600 degrees C strongly predicted tooth disintegration following decalcification. This finding has implications in incineration cases where histologic evidence must be maintained and examined intact.

Lockard MW (2002)[(17)] studied the clinical and radiographic records for evidence of pulpal necrosis in teeth prepared for complete coverage restorations at ultrahigh speed with air coolant alonewas used. The 1847 teeth in this study (182 fixed partial denture abutment teeth and 1665 single teeth restored with 21 all-ceramic, 1095 metal-ceramic, and 731 all-metal restorations) were prepared with diamond instruments (burs) in a sweeping or painting motion with the use of light pressure at ultrahigh speed with air coolant alone from the handpiece. New burs were used for each patient and then discarded. Each bur was used on no more than 4 teeth. All impressions were made with reversible hydrocolloid. Provisional restorations were fabricated on a stone cast and cemented with zinc oxide and eugenol cement. Provisional restorations were removed at 3 to 4 weeks and definitive restorations placed. All patients were questioned about symptoms of tooth sensitivity, tenderness, or pain at their regular (4 to 6 month) hygiene recall appointments. Success was defined as any definitively restored teeth that remained free of radiographic evidence of periapical radiolucency and clinical signs and symptoms of pulpal sensitivity in the clinical record.They found that tooth reduction procedures can be completed with minimal damage to the pulp when only air coolant from the dental handpiece is used.

Galindo DF et al (2004)[(18)] studied the different variables involved in tooth cutting to characterize intrapulpal temperaure generation,cutting efficiency and bur durability when using conventional and channeled diamond burs. They found that channeled burs showed no significant advantage over convenional diamond burs when evaluating temperature generation and bur durability.Moreover,the cutting efficiency of conventional burs was greater than that of channeled burs.

Vitalariu A et al (2005) [(19)] investigated the immediate changes in the pulp-dentin complex that result from crown preparation, and their correlation with the thickness of remaining dentin and the preparation technique (with or without water spray cooling). They proved that there are several differences according with the preparation technique in the pulp morphology. The most severe changes appear after the profound preparation without water-cooling, the odontoblastic layer being extremely affected.Also, vascular reactions and inflammatory infiltrate (in the absence of bacteria) were present. They revealed that the histologic changes in the pulp and dentin following complete crown preparation occur anyway and they are considered difficult to avoid, even if an adequate technique of preparation is used. The dental pulp shows structural changes, especially in the odontoblastic zone, its reactivity being correlated with the depth and the technique of preparation.

Wilson GJ et al (2005) [20] investigated the temperature changes in the dentalpulp associated with dental procedures using power grinding equipment.They found thatthermal insult to the dental pulp from the use of power instruments have a significant risk to the tooth. This risk can be reduced or eliminated by appropriate selection of treatment time and by the use of water irrigation as a coolant. The increased dentine thickness in older horses appears to mitigate against thermal injury from frictional heat.

Thomas J et al (2005) [21]investigated the effect of bur type (single/multi-use) and grit size on buccal and pulpal wall temperatures simultaneously during high-speed tooth preparation. Forty diamond burs were divided into 4 groups. Lingual tunnel preparations were performed to expose 4 mm of axial wall of pulpal chamber. Buccal walls of 40 extracted third molars were prepared in occluso-gingival direction for 2 minutes under standardized conditions. Reflectance of APC through a first-surface high-reflectance and minimal energy-loss mirror provided simultaneous thermal recordings of APC and buccal walls using a thermocamera. Continuous thermal recording provided 923 images/tooth that were analyzed thermographically using ThermaCAM™ Software. They found thattooth preparation caused overall buccal temperature increase. APC temperature decreased with multiuse burs of various grit sizes. Bur type rather than the grit size plays a major role in heat generation. Caution should be taken using single-use burs.

Materials and Methods:-

Materials

1-Wax blocks (Cavio,Egypt)

2-Copper mold:

A specially designed copper mold used for standerdization of resin blocks .Its is formed of two copper blocks which are assembled together using two screws and two guidind rods . At the middle of the assembled blocks, an oval shaped mold cavity of 35 mm length,20 mm width and 25 mm height.

3-Self cure acrylic resin (Acrostone,Egypt)

4- High speedContra angle (T3 racer sirona handpiece,Germany)

T3 racer with fixed connection(Midwest/ 4-hole) was used.Its head diameter 11.4 mm and the head weight is 14.8 mm. The handpiece weight is 53 g and the recommended bur size is 314/315 and the driving air pressure recommended is 2.3 bar. The speed of T3 racer without tooth contact is approximately 400.000 rpm. It has an anti-retraction valve to ensure no contamination of the ball bearing which made it more durable than other handpiece.

5-Rotary instruments (Diamond burs) (DIAKET, switzerland)

DIAKET multilayer gold diamonds (FG 314) were used

A-Depth marker (834-021-6.8 ML)

The size of the depth marker was 0.5 mm for all ceramic preparation of 1.5 mm thickness.

B- Two types of diamond stones (Taper wih flat end and football stone)

Each type have three types according to their grit size: (Fine grit stones, Medium grit stones, Coarse grit stones).

-Fine grit stones(Red coded) with its grit size 45

Tapered with flat end (847-016-8F)

Football stone (368-020-5F)

-Medium grit size stones (blue coded) with its grit size 105-125

Tapered with flat end (847-016-8ML*)

Football stone (368-020-5ML*)

-Coarse grit size stones (black coded) with its grit size 150

Tapered with flat end (847-016-8MLX*)

Football stone (368-020-5MLX*)

6-Thermocouple (copper-constantan thermocouple) (Philips,Kassel,Germany) with digital thermometer.

Methods:-

Grouping of the samples:-

The teeth were divided into two groups(45 teeth for each group) according to the pattern of reduction

A-Continuous reduction

B-Intermittent reduction . (The interval time of reduction & the total time of reduction were fixed).[6]

Each group was subdivided into three subgroups (15 teeth for each subgroup) according to type of stone according its abrasives grit size used fine, medium and coarse grit.

Temperature was measured at 3 levels (classes): incisal 1/3, middle 1/3, cervical 1/3

Factorial Design:

Pattern of reduction	Group 1 Continuous reduction									Group 2 Intermittent reduction									
Subgroubs	A 15teeth			B 15teeth			C 15teeth			A* 15teeth			B* 15teeth			C* 15teeth			
Classes	I	M	C	I	M	C	I	M	C	I	M	C	I	M	C	I	M	C	
Total	45 Teeth									45 Teeth									90 Teeth

(I) Incisal 1/3 (M) Middle 1/3 (C) Cervical 1/3

Specimen Preparation:-

Ninety freshly extracted sound,single rooted, crack and caries free teeth With mature apices and normal root morphology extracted for orthodontic or periodontal reasons were selected for this study.All teeth were stored in 10% formalin solution at room temperature. In addition, all teeth in the study were approximately the same shape and size, so that the hard tissue layers surrounding the pulpal chamber were similar. After extraction, the teeth were stored in isotonic saline solution for a maximum of 8 hours before testing to prevent desiccation of the pulpal tissues.

The roots of the teeth were sectioned with serrated double sided diamond disc 6 mm below the cement-enamel junction(CFJ).The root canal of each tooth was enlarged to file #70 to accommodate the thermocouple wire without modifying the dimensions of the pulp chamber. A special silicone material (Optosil P Comfort, Heraeus Kulzer, Hanau, Germany), was injected into the pulp chamber to facilitate the heat transfer from the walls of the pulp chamber.

Every 3 teeth was embeded into wax block by their roots and the wax block was inserted into the closed copper flask and then the cold cured acrylic resin was poured into the flask till the cement-enamel junction (CEJ).The resin blocks was removed from the flask after acrylic resin setting by opening the copper flask from the two screws .

Thermocouples were placed inside the pulp chanmer and their position was confirmed radiographically.The pulp chamber was then filled with heat conductor paste.The openings resulting from root removal were sealed with cement (Cavit,ESPE,Seefield,Germany) and each tooth and thermocouple wire were partially embedded in silicone (Optosil P Comfort Haraeus Kulzer,Hanau,Germany)so that only the buccal surface remained exposed.The purpose of these procedures was to immobilize the thermocouple.

Tooth reduction:-

Cutting was performed with (T3 racer sirona handpiece) with fixed connection (Midwest/ISO 4-hole).The handpiece weight was 53 g and the recommended bur size[ISO] was 314/315 and the deriving air pressure recommended was 2.3 bar.The T3 racer was operated at 400.000 rpm a constant air pressure of 0.23 MPa (33 psi) and a water-coolant supply rate of 15 ml/min.Before each series of cuts,the handpiece was sprayed with lubricant spray for 1 sec and thenrun without load for 60 sec.All of the cutting studieswith the handpiece were performed at maximum outputpower,torque and bur roation speed.The depth marker rotary instrument was used to standardize the depth of preparation for all samples to be 1.5mm.

One stone was used for each sample

Results:

Statistical Analysis

Differences in temperature between the two groups : Group 1 (Continuous reduction)&Group 2 (Intermittent reduction)at different sites (Classes) : I (incisal) ,M (middle) & C (cervical)

	Group1 (N = 45)	Group2 (N = 45)	Mean Difference	T	P-value
	Mean ± SD	Mean ± SD			
I	39.31 ± 0.93	38.66 ± 0.79	0.65	3.59	0.001**
M	39.45 ± 0.92	38.81 ± 0.79	0.64	3.53	0.001**
C	39.67 ± 0.95	38.96 ± 0.80	0.71	3.79	0.000**

Table 1

** The mean difference is significant at the 0.05 level.

There was significant statistical difference at the 0.05 level between group 1 and group 2 in the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeth .

Group 2 had a lower tooth temperature average.

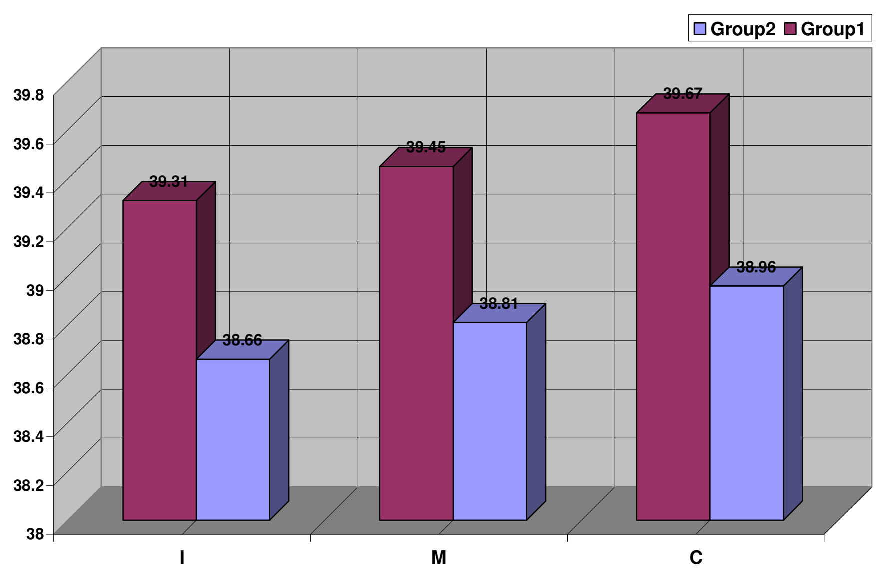


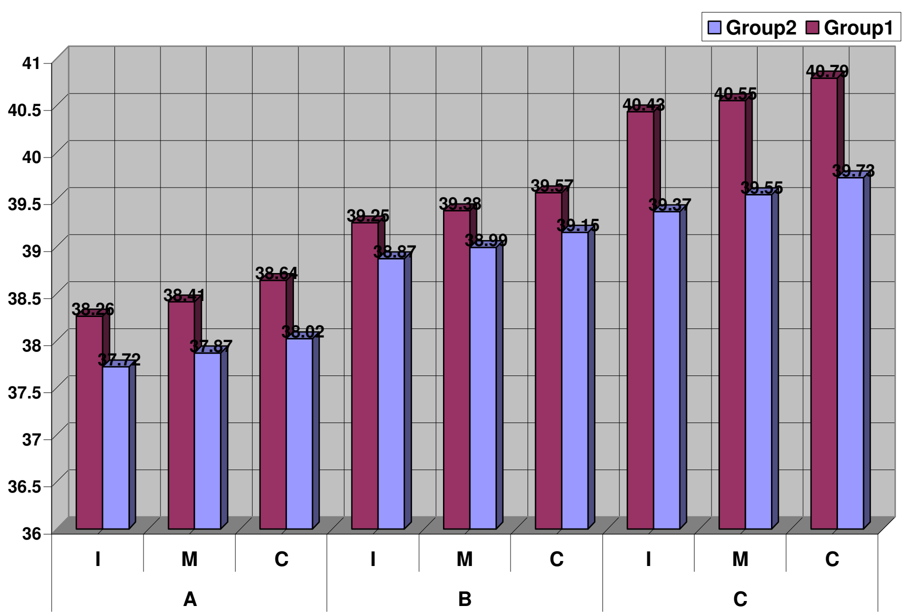
Figure (1)

Differences in temperature between the two groups : Group 1 (Continuous reduction) & Group 2 (Intermittent reduction) when using stones of different grit size (Subgroups)at different sites (Classes) : I (incisal) ,M (middle) & C (cervical).

		Group1(N = 15)	Group2(N = 15)	Mean	T	P-value
		Mean ± SD	Mean ± SD	Difference		
A	I	38.26 ± 0.21	37.72 ± 0.22	0.54	6.76	0.000**
	M	38.41 ± 0.26	37.87 ± 0.22	0.54	6.10	0.000**
	C	38.64 ± 0.36	38.02 ± 0.25	0.62	5.45	0.000**
B	I	39.25 ± 0.36	38.87 ± 0.31	0.38	3.05	0.005**
	M	39.38 ± 0.33	38.99 ± 0.30	0.39	3.34	0.002**
	C	39.57 ± 0.36	39.15 ± 0.31	0.42	3.44	0.002**
C	I	40.43 ± 0.23	39.37 ± 0.52	1.06	7.17	0.000**
	M	40.55 ± 0.21	39.55 ± 0.53	1.00	6.81	0.000**
	C	40.79 ± 0.36	39.73 ± 0.51	1.06	7.29	0.000**

Table 2

There was significant statistical difference at the 0.05 level between the subgroups (A,B,C) of group 1 and group 2 in the tooth temperature.The subgroups of group 2 had a lower tooth temperature average.



In group 1 (Continuous reduction)

Temperature differences between subgroups (A)-Fine grit stones,(B)-Medium grit,(C)-Coarse grit at different sites (Classes) : I (incisal) ,M (middle) & C (cervical).

		Mean ± SD	Maximum	Minimum
I	A	38.26 ± 0.21	38.70	37.90
	B	39.25 ± 0.36	39.80	38.70
	C	40.43 ± 0.23	40.80	40.00
M	A	38.41 ± 0.26	38.90	38.00
	B	39.38 ± 0.33	39.80	38.80
	C	40.55 ± 0.21	40.90	40.20
C	A	38.64 ± 0.36	39.40	38.20
	B	39.57 ± 0.36	40.20	39.00
	C	40.79 ± 0.36	41.20	40.30

Table 3

		um of Squares	df	Iean Square	F	P-value
I	etween Groups(A,B,C)	35.30	2	17.65		
	Vithin Groups(A,B,C)	3.14	42	0.08	235.89	0.000^{**}
	Total	38.44	44			
M	etween Groups(A,B,C)	34.23	2	17.12		
	Vithin Groups(A,B,C)	3.16	42	0.08	227.60	0.000^{**}
	Total	37.39	44			
C	etween Groups(A,B,C)	35.00	2	17.50		
	Vithin Groups(A,B,C)	4.52	42	0.11	162.67	0.000^{**}
	Total	39.52	44			

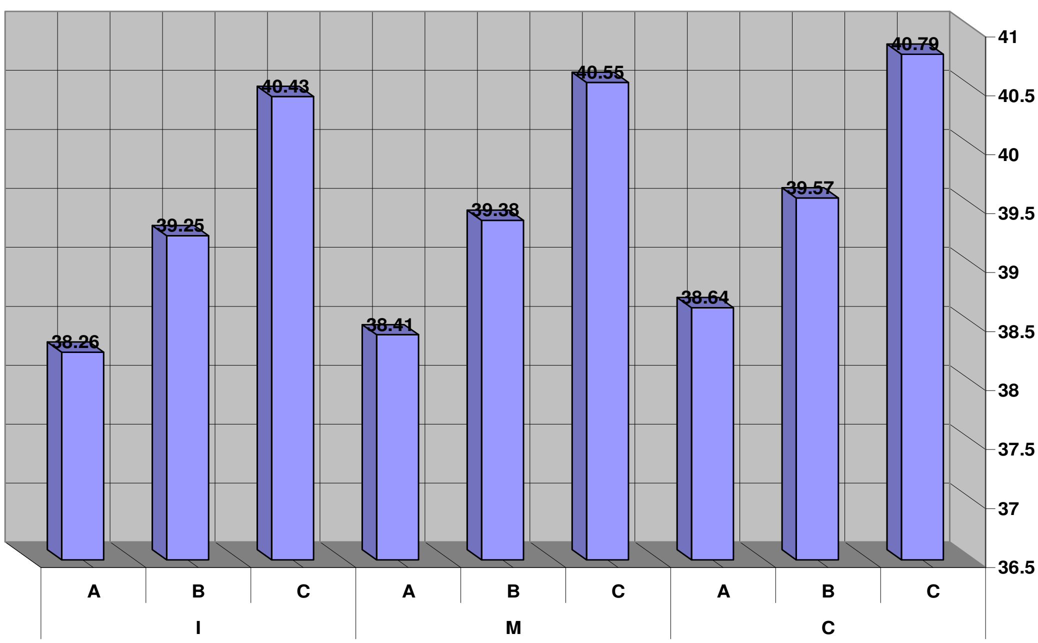
Table 4

There was significant statistical difference at the 0.05 level between the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeh in subgroups (A,B,C) for group 1 and so we needed to do one of the comparative tests to determine the direction of these comparisons .Scheffe test was used .

C	B	A		
0.000**	0.000**	-	A	I
0.000**	-		B	
-			C	
0.000**	0.000**	-	A	M
0.000**	-		B	
-			C	
0.000**	0.000**	-	A	C
0.000**	-		B	
-			C	

Table 5

There was significant statistical difference at the 0.05 level between subgroups (A,B,C) for group 1 in the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeh and for the subgroup (A). There was significant statistical difference at the 0.05 level between subgroups (B,C) for the group 1 in the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeh and for the group (B).



In group 2 (Intermittent reduction)

Temperature differences between subgroups (A)-Fine grit stones,(B)-Medium grit,(C)-Coarse grit at different sites (Classes) : I (incisal) ,M (middle) & C (cervical).

		Mean ± SD	Maximum	Minimum
I	A	37.72 ± 0.22	38.10	37.40
	B	38.87 ± 0.31	39.30	38.40
	C	39.37 ± 0.52	40.30	38.40
M	A	37.87 ± 0.22	38.20	37.50
	B	38.99 ± 0.30	39.40	38.60
	C	39.55 ± 0.53	40.40	38.60
C	A	38.02 ± 0.25	38.30	37.60
	B	39.15 ± 0.31	39.80	38.80
	C	39.73 ± 0.51	40.50	38.80

Table 6

		n of Squar	df	lean Square	F	P-value
I	etween Groups(A,B,C)	21.38	2	10.69	76.78	0.000**
	Vithin Groups(A,B,C)	5.85	42	0.14		
	Total	27.23	44			
M	etween Groups(A,B,C)	21.95	2	10.98	79.81	0.000**
	Vithin Groups(A,B,C)	5.78	42	0.14		
	Total	27.73	44			
C	etween Groups(A,B,C)	22.59	2	11.30	81.37	0.000**
	Vithin Groups(A,B,C)	5.83	42	0.14		
	Total	28.42	44			

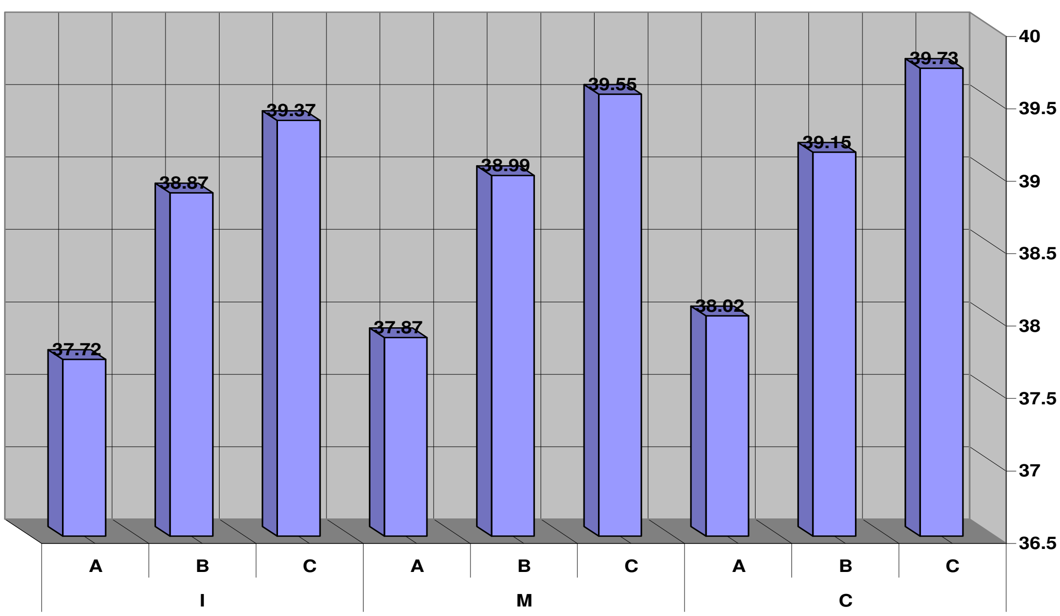
Table 7

There was significant statistical difference at the 0.05 level between the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeh in subgroups (A,B,C) for group 2 and so we needed to do one of the comparative tests to determine the direction of these comparisons .Scheffe test was used .

C	B	A		
0.000**	0.000**	-	A	I
0.003**	-		B	
-			C	
0.000**	0.000**	-	A	M
0.001**	-		B	
-			C	
0.000**	0.000**	-	A	C
0.001**	-		B	
-			C	

Table 8

There was significant statistical difference at the 0.05 level between subgroups (A,B,C) for group 2 in the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeh and for the subgroup(A). There was significant statistical difference at the 0.05 level between subgroups(B,C) for the group 1 in the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeh and for the group(B).



Disscusion

As the demands of patients for improvement of appearance are continuously increasing, the use of all-ceramic materials became increasingly relevant to restorative dentistry. All ceramic restorations are characterized by enhanced esthetic properties, high biocompatibility, diminished plaque accumulation, low thermal conductivity, abrasion resistance and color stability.[24]

For many years, the potentially damaging effect of temperature increases on pulpal tissue during restorative treatment has been a concern. Dental pulps can't survive temperature increases greater than 5.5°C.[3,11,26]

Samples selection and preparation:-

The samples selected in that study as **Galindo DF et al(2004)**.The teeth were single rooted and single canal premolars to facilitate the introduction of the thermocouple from the root to the pulp chamber .They were recently extracted and had intact enamel and dentin without carious lesions or resorations. After extraction teeth were stored in an isotonic saline solution to prevent desiccation of the denal tissue.[18]

However others as **Ottle P(1998)** selected the tooth specimens that were recently extracted , intact human third molars . The teeth were fully erupted, namely, nonimpacted. They had well-developed, not extremely conical roots, undamaged dental pulps,and an intact enamel and dentin structure without any carious lesions or fillings.[6]

The root portions were sectioned as **Wilson GJ (2005)** and **Baysal A (2007)** (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 gatesglidden 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) as **Baysal A (2007)** and **Hannig M. (1999)** .[20,25,26]

However others as **Carson J (1979)** sectioned the samples transversely with a diamond disc in the cervical one-third of the anatomical crown then the samples were mounted in dental stone such that the occlusal surface of the tooth and the roof of the pulp chamber were exposed.[10]

Pulp residues was removed from retrograde after root resection as **Hannig M. et al (1999)** to make a space for the thermocouple wire .[26]
Teeth were placed on acrylic blocks of and labeled according to tooth group as **Baysal et al (2007)** to facilitate the differentiation between samples and the fixation of the samples during preparation and temperature measurement.[25]

Tooth preparation for samples:-

The teeth were prepared as **Attia A (2004)** with the following preparation criteria for all-ceramic crowns: 6-degree axial taper, 1.5-mm shoulder finish line placed 0.5 mm occlusal to the cemento-enamel junction, 2-mm occlusal reduction, and occluso-gingival height of 5 mm.[27]

However **Chiodera G (2009)** made the tooth preparations using a water-cooled air turbine handpiece and HiDi 501 bur. The design was that for an all-ceramic crown with 1.2 mm reduction on all surfaces determined by comparing the prepared tooth with pre-operative indices.[28]

Tooth temperature measurment:-

A retrograde endodontic approach was done as **Wilson GJ (2005)** and **Hannig M. (1999)** to locate a thermocouple (diameter 0.7 mm, with measurement increments of 0.1oC) within the pulp chamber against the dentine directly opposite the site of grinding. The thermocouple was coupled thermally to the dentine using heat conductive heat sink compound.[20,26]

The tooth temperature was measured as **Ottle P(1998)** by using thermocouples (Philips, Kassel, Germany), 0.25 mm in cross section that was inserted from the apex into each tooth canals until they contacted the roof of the pulpal chamber. Before temperature measurements, the positions of the thermocouples were checked by radiographic films and corrected as needed.[6]

The thermocouple was placed inside the pulp chamber adjacent to the cutting area and their position was confirmed radiographically and the pulp chamber was then filled with heat conductor paste as **Wilson GJ (2005)**.The apertures resulting from root removal were sealed with cement (Cavit; ESPE, Seefield,Germany) and each tooth and thermocouple wire were partially embedded in silicone (Optosil P Comfort, Heraeus Kulzer, Hanau, Germany), The purpose of these procedures was to immobilize the thermocouple and to provide a steady base for the dental crown during cavity cavities and temperature variation measurements.[20]

The temperatures was recorded with Digital Thermometer and a thermocouple as **Mizrahi E. et al(1996)** and **Hannig M. et al(1999)** . Readings were taken directly from the digital display or from the graphic output of a chart recorder.peratures The thermocouple maintained immediate contact with the dentin by means of a thin layer of a silicon oil-based thermal joint compound [26,29]

However **Carson J et al (1979)** used a thermographic imager to detect the emission of infra-red radiation during the experimental procedures.The intensity of the emission is proportional to the temperature. The imager scans the tooth and detects radiation of wavelengths 7-13microns.[10]

Smith E et al (2004) used miniature thermometers to measure the relationship between surface temperature of teeth and internal flow of 37 C water (in vitro) or blood (in vivo). In addition, thermal stimuli were applied to the external surface of the teeth, and the rate of temperature recovery was related to internal flow.[30]

Disscusion of results

Ottle P et al (1998) demonstrated that the coarser the grit of diamond bur, the more pronounced the temperature elevation within a pulpal chamber during tooth preparation. They concluded that coarse diamond burs resulted in more pronounced temperature increases within the pulpal chamber during tooth preparation. In addition, the benefit of short intervals between grinding steps and a cooling water temperature between 30° C and 32° C was confirmed to control the temperature rise. [6]

Ozturk B. et al(2004) showed that when high water cooling was utilized, the critical 5.5 degrees C value was not reached with any air pressure or load.[22]

Ercoli C et al (2009) found that tooth preparation with an adequate water flow does not cause harmful temperature changes in the pulp chamber, regardless of rotary cutting instrument type.[9]

Thomas J et al (2005) found that tooth preparation caused overall buccal temperature increase. APC temperature decreased with multiuse burs of various grit sizes. Bur type rather than the grit size plays a major role in heat generation.[21]

Kramer I R et al (1952), Marsland E A et al (1957) , Orban B (1941) , James V E (1955), Mjor I A et al (2001) & Christensen G J (1997) showed that displacement " aspiration"of odontoblastic nuclei into the dentinal tubules following the teeth preparation is a phenomenon taken into account when high-speed dental engines were introduced. (32-37)

Seltzer S. (1958) , James V. E. (1954) & About I. et al (2001) showed that odontoblast numbers and dentine repair activity were found to be influenced more by cavity restoration variables and aspiration of odontoblastic nuclei. (38-40)

Summary and Conclusion

The purpose of this study was to evaluatethe thermographic changes occurred from the heat generated during all ceramic preparation using rotary instruments of different grits.

Data were collected, tabulated and statistically analyzed with the following conclusions:

1-The intermittent reduction produced lesser increase in tooth temperature and was statistical different than the increase of temperature of continuous reduction.
2-There was significant statistical difference between the using of (fine, medium,coarse)grit sizes stones for the continuous reduction in the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeh.The fine grit size stones produce the least temperature rise then the medium grit size stone then the coarse grit size.

3- There was significant statistical difference between the using of (fine, medium,coarse)grit sizes stones for the intermittent reduction in the tooth temperature at the incisal , middle and the cervical 1/3 of the studied teeh.The fine grit size stones produce the least temperature rise then the medium grit size stone then the coarse grit size.

4- There was no significant statistical difference at the 0.05 level between the tooth temperatures at the incisal , middle , cervical 1/3 of the studied teeth in the continuous or intermittent reduction

Clinical recommendations:

All ceramic preparation should be done as intermittent reduction using fine grit size rotary instruments with sufficient water coolant in the high-speed handpiece.

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