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A comparison of temperature rise in pulpal chamber during fabrication of provisional restorations by direct method-an in vitro study

[1]Dr Rupal J Shah, [1]Dr Sanjay Lagdive, [1]Dr Bhavisha Gadhiya, [2]Dr Urvashi Rai, [2]Dr Anchal Kapoor, [3]Dr Nikita Goel

[1,2,3]Department of Prosthodontics and Crown & Bridge, Government Dental College and Hospital, Ahmedabad, Gujarat University, Ahmedabad, India.

Corresponding Author: Dr Bhavisha Gadhiya, Department of Prosthodontics and Crown & Bridge, Government Dental College and Hospital, Ahmedabad, Gujarat University, Ahmedabad, India

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Abstract

Provisional restoration is integral part of fixed prosthodontics. A well-made provisional restoration is a blueprint for the final prosthesis and enhances the health of abutment and Periodontium.

Objectives of this in vitro study is to compare temperature rise in the pulpal chamber during direct fabrication of provisional restoration using different auto poly merising resin materials and matrices. Intact extracted teeth were used and thermo couple probe was attached to the pulp chamber. Samples were divided into two groups according to provisional restorative materials used i.e., Self-cure polymethyle methacrylate resin (DPI) group and auto polymerizing b is acryl resin (Accutemp) group. They were further subdivided into two groups according to the material of the matrices i.e., polyvinyl siloxane putty index groups and vacuum formed template groups. Results obtained showed that PMMA with vacuum formed template group showed the highest temperature rise and b is acryl resin with putty index showed least temperature rise. Hence, in conclusion bis acryl composite is more preferable for direct method of fabrication.

Keywords: Temporization, Provisionalization, Temperature Changes, Direct Method.

Introduction

Provisional restoration is integral part of fixed prosthodontics. An optimum fixed interim restoration must fulfill the requirements1of pulp protection, maintain periodontal health, positional stability, good marginal adaptation, occlusion function, aesthetics, retention and resistance to dislodgement during normal masticatory function, strength, ability to be cleansed, wear resistance. Apart from all these it must be non-irritating to the dental pulp. A well-made provisional restoration is important for successful completion of fixed partial denture as it provides

blueprint for the final prosthesis and enhance the health of abutment and Periodontium [2]. It also protects freshly cut dentine from dentinal hypersensitivity and restores function. By successful treatment with temporization dentist can achieve the patient's confidence which is one of the influencing factor for success in the final restoration. In the literature there are various techniques for the fabrication of the provisional restoration. Custom provisional restoration can be made using a direct, indirect or combination of direct-indirect technique from auto polymerizing resin. Direct method of temporization is fast and economical. An extra clinical appointment both for the dentist and the patients reduced. But direct technique has few major disadvantages like presence of free monomer which comes in direct contact with dentine and adjacent soft tissues which may leads to allergic reaction. Second major disadvantage is materials which are used for fabrication of provisional restoration generate heat during polymerization. This temperature rise may introduce biological problem due to pulpal trauma. As the provisional restoration offer a wide range of therapeutic objectives, their fabrication should be done with care to avoid iatrogenic trauma to the pulp. If certain precautions are not taken, materials may cause detrimental effect to the pulp. Irreversible damage occurs when increase in temperature exceeds the physiologic heat dissipation mechanisms of the dental-periodontal system. A temperature change of 5.5℃ can lead to a 15% loss of vitality in the pulp, a 11℃ temperature rise causes about60% and a 16.6℃ temperature causes 100% necrosis of the pulp3.All the materials used for fabrication of provisional restorations have in common that they produce notable amount of heat during curing process. Because they cure by radical polymerization which leads to a non or highly cross-linked polymer network. This exothermic heat partially is absorbed by matrix used to form external surface form of interim restoration. Hence, the material which generate minimal amount of the heat with matrix which absorbs more heat should be used. Considering all these factors objectives of this in vitro study is to compare temperature rise in the pulpal chamber during direct fabrication of provisional restoration using different auto polymerising resin materials and matrices.

Materials and method

An intact extracted maxillary first molar and first premolar was employed for the study. The molar was sectioned 3mm horizontally approximately apical to the cement enamel junction (CEJ) with the help of a carborundum disc. Access is established from radicular portion of the tooth. All the pulp tissue is removed from the pulp chamber with the help of 5.25% sodium hypochlorite.

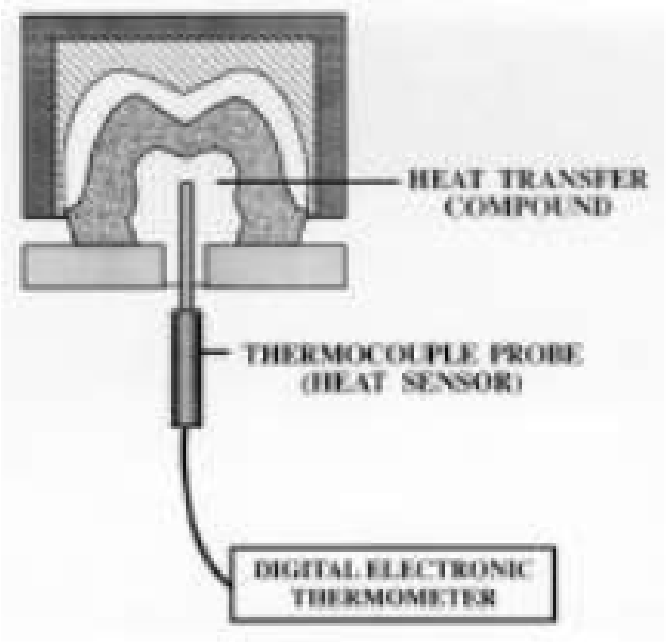


Fig.1: Schematic diagram of temperature measuring apparatus.

K type Thermocouple probe (heat sensor) was placed in pulp chamber contacting the roof of pulp chamber of

molar. Silver amalgam is condensed around thermocouple probe. This facilitated the transfer of heat from the walls of the pulpal chamber to the thermocouple. A thermocouple probe was then connected to an electronic digital thermometer. Fig. 1 shows schematic diagram of temperature measuring assembly4.Radiographs were carried out to confirm the position of thermocouples.

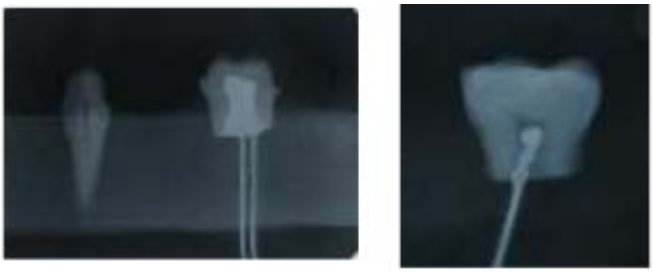


Fig.2: Radiographic confirmation of thermocouple molar.

The tooth was then stabilized with the help of minimal amount of sticky wax in a vertical position in a box fabricated of boxing wax. Auto polymerizing acrylic resin was then poured using sprinkle on method in the wax box, covering the root portion of the tooth. Molar was prepared for a metal-ceramic complete crown with a shoulder margin. The prepared tooth was 5mm high from the shoulder finish line to the occlusal surface. Wax pattern was fabricated. Putty index was made with the help of polyvinyl siloxane impression material.

Fig 3: teeth prepared with finish lines

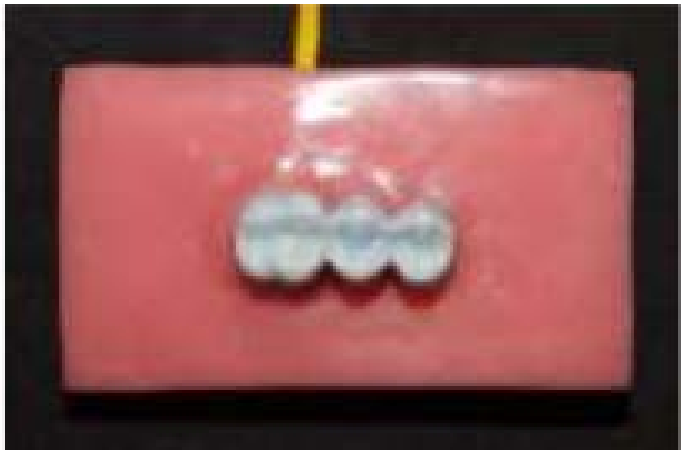


Fig.4: wax pattern fabricated on prepared tooth.

An impression of the tooth and the resin block was made. Type III stone was mixed under vacuum and the impression was poured under vibration. After setting of the stone, template was fabricated using a thermal vacuum-forming machine and thermoplastic sheet.

Fig.5: Polyvinyl siloxane matrix

Fig.6 Vacuum formed template matrix

Samples were divided into two groups according to provisional restorative materials used

•Group A –Self cure polymethylmethacrylate resin (DPI) group

•Group B –Auto polymerizing bis acryl resin (Accutemp) group

Group A and B is further subdivided into two groups

•Subgroup A1 and B1-polyvinyle siloxane putty index groups

•Subgroup A2 and B2-vacuume formed template groups

A thin layer of petroleum jelly lubricant as separating medium was applied to the total assembly to facilitate ease of removal of provisional prosthesis. The template filled with mixed resin was positioned on the prepared molar tooth. Excess resin material was removed and the temperature change in the pulp chamber was recorded at intervals of 30 sec during polymerization with the help of digital thermometer. This digital thermometer can measure temperature with the precision of 0.1℃. Temperature monitoring was done till peak temperature had been reached. After complete polymerization of the resin material, the template was separated from the tooth and the temporary crown was retrieved. The tooth was cleaned to remove any resin residue, same procedure was repeated to fabricate the remaining provisional restorations. Both the specimens were stored in distilled water when not being used. Total 40 samples were fabricated, 10 samples from each subgroup. Temperature rise was measured using this formula:

Temperature change = peak temperature noted during fabrication – temperature recorded at the start of temporization.

Fig.7: Temporary crown and bridge resins

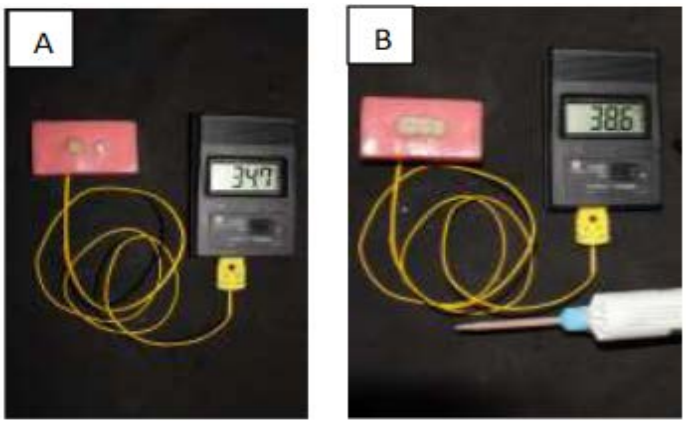


Fig.8: Complete set up used in the study. A temperature before fabrication of bis-acryl provisional restoration, B peak temperature.

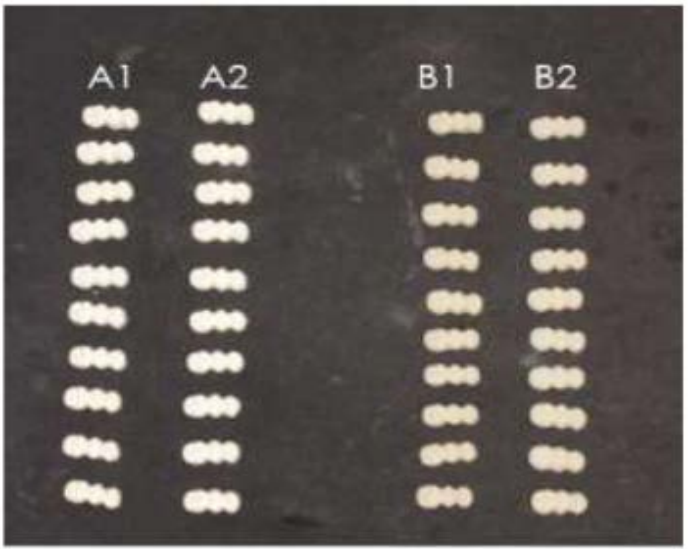


Fig.9: Samples

Results

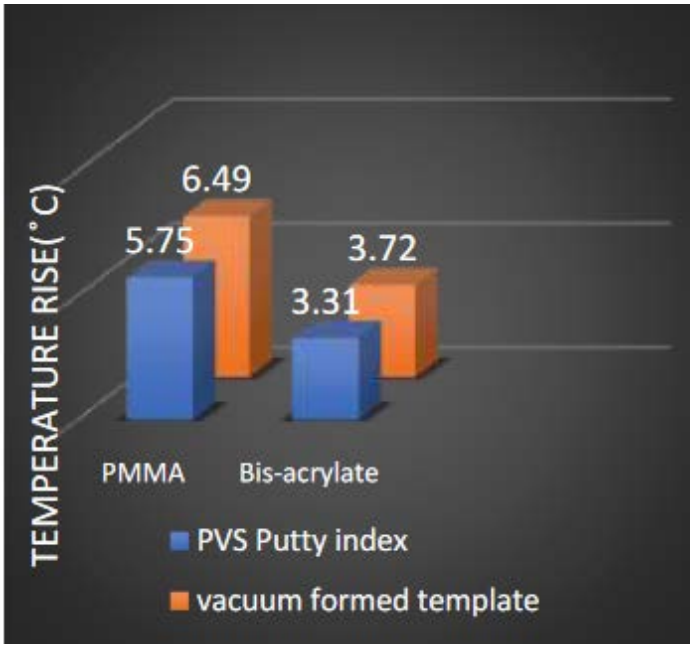
The mean temperature rise of Groups A (A1, A2) and B (B1, B2) were calculated and are presented in Table 1.Student's t test was applied to determine the significance of statistical difference between the means within the groups (intragroup comparison) and across the groups (intergroup comparison). The results of Student's t-test for intragroup comparison and intergroup comparison (Table 1) showed statistically significant differences between the means of temperature rises of resins within each main group and subgroups.

Discussion

The differences in temperature rise were statistically significant for the two resins ($p < 0.05$). The intrapulpal temperature rise was greater with PMMA (DPI) followed by Bis-acryl (AccuTemp). This present study is supported by the studies done by Tjan et al5, Moulding6and Michalakis et al7which illustrates PMMA has highest exotherm release than other materials tested. Both PMMA and bis-acryl resins produce exothermic heat as they polymerize by addition polymerization mechanism8. Driscoll et al9has explained the temperature rise during setting reaction of provisional restoration based on Table 1.

group	subgroup	mean ± SD	comparison	Df	P value
PMMA	PVS putty index(A1)	5.75 ± 0.218	A1 vs. A2	18	<0.05
	Vacuum formed template(A2)	6.49 ± 0.341	B1 vs. B2	17	<0.05
Bis-acrylate	PVS putty index(B1)	3.31 ± 0.096	A1 vs. B1	18	<0.05
	Vacuum formed template(B2)	3.72 ± 0.370	A2 vs. B2	18	<0.05

Table 1: Mean values, range and standard deviation for the temperature rise values of the specimens in the study, intergroup and intragroup comparison.



Graph 1: Mean peak temperature in two subgroups of groups A and B

Discussion

The differences in temperature rise were statistically significant for the two resins ($p < 0.05$). The intrapulpal temperature rise was greater with PMMA (DPI) followed by Bis-acryl (AccuTemp). This present study is supported by the studies done by Tjan et al5, Moulding6and Michalakis et al7which illustrates PMMA has highest exotherm release than other materials tested. Both PMMA and bis-acryl resins produce exothermic heat as they polymerize by addition polymerization mechanism8. Driscoll et al9has explained the temperature rise during setting reaction of provisional restoration based on chemical reaction of the polymer based provisional materials. As the polymerization proceeds, the carbon-carbon double bond (pi-bond) which has energy of about 350kj/mol gets converted to the new carbon-carbon single bond (sigma-bond) having energy of about 270kj/mol. Exothermic heat is released due to the difference in the energy between the two bonds which is 80kj/ mol. This exothermic heat needs to be controlled otherwise may cause irreversible thermal injury to the pulp. This study

showed that with each matrix or in each group, the temperature rise was greatest with PMMA (DPI) and vacuum formed template group and least with bis acrylate and PVS putty group. The heat transferred to the tooth is also influenced by the choice of matrix used to hold the provisional material, as the matrix acts as a heat sink to some extent. When the effect of presence of matrices on intrapulpal temperature rise was analyzed, the results were also found to be statistically significant ($P > 0.05$) (Table 1). The intrapulpal temperature rise was highest with vacuum formed polypropylene matrix material followed by PVS putty. The use of Polyvinyl siloxane materials as the matrix has been shown to significantly reduce peak polymerization temperature as compared with the use of vacuum formed polypropylene matrix material.As Cohen and Zach3has reported a temperature rise of 5.5℃ can lead to a 15% loss of vitality in the pulp, a 11℃ temperature rise causes about 60% and a 16.6℃ temperature causes 100% necrosis of the pulp. Hence, every effort should be made to control exothermic heat as low as possible. An ample amount of literature describing various techniques to control exothermic heat is available from different authors.The temperature rise in direct technique may be reduced by employing various cooling techniques like removal: removing the provisional restoration after the initial polymerization of resin; using air/water spray: leaving the resin on the abutment teeth throughout the polymerizationand spraying air/water once the initial reaction has occurred; on/off: removing the provisional restoration after initial polymerization, flushing the tooth with air/water and then replacing the restoration10.Various suggestions such as use of condensation and addition silicones as putty matrices,7precooling of putty matrix and use of desensitizer has found to be effective in reduction of intrapulpal rise in temperature11. Akova et al12and Usumez et al13investigated the effects of different matrices andapplication of desensitizer on rise in temperature and found no effects of matrix and desensitizer on the temperature rise. Yondem et al14conducted a study to evaluate the temperature rise during polymerization of resin composite by various light polymerization units and found the temperature rise much below the critical temperature of 5.5°C. Hence, light cure or dual cure composites can also be suggestive of provisional crown materials.Altintas et al15has studied the effect of remaining dentine thickness on the net temperature rise in the pulp chamber during fabrication of direct provisional restoration using dentine disc of varying thickness (1.2 mm) and found that temperature rise was more when the dentinal thickness was reduced (as in deep cavity preparations).The amount of exothermic heat released by resins is directly related to resin volume16. So fixed partial dentures generates more heat as compared to single unit due to increased resin volume in the pontic area. So the use of direct technique is compatible for single crowns, short span (three unit) fixed partial dentures or interim restoration for endodontically treated tooth and indirect technique is indicated for FPDs with multiple pontics or multiple interim crowns. Direct-indirect technique can also be used because in this technique provisional restoration is fabricated on the cast and relined intra orally on the prepared teeth. As very less amount of material used for relining, intrapulpal temperature rise is low during relining procedure.

Conclusion

Within the limitations of the study following conclusions were drawn:

•The type of resin used during direct fabrication of provisional restorations affects the intrapulpal temperature rise.

•Polymethyl methacrylate (DPI) showed the highest temperature rise value followed by bis-acrylate composite (accutemp).

•Intrapulpal temperature rise also depends on type of matrix used during direct fabrication of provisional restorations. The maximum temperature rise was found with vacuum formed template followed by poly vinyl siloxane putty impression index.

•Polymethylmethacrylate (DPI) used with vacuum template as matrix in the study caused highest temperature elevation i.e. 6.49℃ (temperature above which 15% of pulpal necrosis has been found in a previous study3). So, this combination of resin and matrix should be avoided when using direct technique to protect pulp from iatrogenic thermal damage.

•The resin material recommended for clinical use when direct technique is employed for fabrication of provisional restorations, among the materials tested in the study is bis-acryl composite resin as it caused minimal temperature rise in the pulpal chamber and PVS putty impression index is the recommended matrix material.

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