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Clinical Evaluation of Pre-heated Versus Un-heated Bulk Fill Composite Resin in Class I Cavities

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Abstract
Keywords: *Bulk fill Composite, Preheating, Class I, USPHS criteria.*
Purpose: *to clinically evaluate pre-heated versus un-heated bulk fill composite resin in Class I cavities.*
Materials & Methods: *Following ethical approval, twenty patients were selected according to the inclusion criteria with minimum of two carious occlusal lesions in each patient. Restorations were randomly divided into two equal groups: group I (un-heated X-tra fil bulk-fill composite resin) and group II (pre-heated X-tra fil bulk-fill composite resin). Simple occlusal conventional Class I cavities were prepared with moderate cavity depth 3-4mm. All restorative materials were applied following manufacturers' directions. Each restoration was clinically evaluated at 24hours, 6 months, 9months and 1year for retention, marginal adaptation, marginal discoloration, secondary caries, surface texture and postoperative hypersensitivity using modified USPHS Criteria.*
Results: *The recall rate was 100% after 1 year clinical service. Using Chi-square test, there were statistically significant differences between the both tested groups for marginal adaptation, marginal discoloration criteria ($p<0.05$). All restorations in both groups recorded Alpha scores except for group I after twelve months of clinical service 25% of restorations recorded marginal deterioration with Bravo score. A significant difference was recorded between both groups since p-value =0.017. Also, after twelve months of follow up period 20% of restorations showed marginal discoloration with Bravo score for group I. A significant difference was recorded between both groups since p-value= 0.035.*
Conclusion: *Within the limits of the present study, it can be concluded that pre-heated bulk fill composite resin had superior clinical performance compared to unheated one by the end of the evaluation period.*

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I. Introduction

For several decades, growing demands have significantly increased the use of direct, light-activated resin composites in restorative dentistry [1]. They are considered as an essential treatment option in restorative dentistry which has been motivated by factors such as patient demand, an increased desire for minimally invasive restorations and more reliable dental adhesive systems [2].

Despite the continuous evolution of resin composite materials, polymerization shrinkage and marginal microleakage still compromise the resin composite restoration durability which induces internal and interfacial stresses at the tooth restoration interface, leading to gap formation. This allows ingress of fluid, microorganisms and ions across the tooth restoration interface which results in post-operative sensitivity, recurrent caries, pulpal inflammation and restoration failure [3,4].

Several approaches have been struggled in order to minimize polymerization shrinkage and its clinical side effects. One of them is incremental layering technique for optimizing composite polymerization and its internal marginal adaptation, using 2-mm-thick increment for each layer [5]. This procedure was assumed to reduce the material's final volumetric shrinkage and lessen the occurrence of internal gap formation. But, in clinical circumstances, incremental method was a complex technique and demand more chair-side time for placement of the restoration [6].

Bulk-fill composite resins have been introduced in the past few years, to replace the need for incremental layering technique [7]. These claim to allow the use of material increments up to 4mm in thickness with low volumetric polymerization shrinkage and greater depth of cure. Bulk-fill composites thus have the potential benefit of simplifying clinical technique and saving time. In addition, bulk placement prevents voids incorporation and contamination between composite layers, resulting in more compact fillings [8].

Moreover, studies reported that it is difficult to obtain perfect adaptation and proper marginal seal to prepared cavity walls with high-viscosity composite resin. Decreasing the composite resin viscosity such as (using flowable composites, lowering the viscosity of the monomer mixture, heating composite resins and applying sonic vibration technique) will improve its adaptation to prepared cavity walls and improve ease of placement [9].

Heating composite resins prior to placement in the cavity and immediately light-curing may increase the conversion rate of the monomer and thus decrease the duration of the irradiation period. Literature recommended that pre-heating of composite resins would improve the mechanical properties, increase wear resistance and thus increase the durability of the restorations [10].

Pre-heating is done by placing composite compules or syringes into a heating device that allows easy extrusion and enhanced resin adaptation to the walls of preparation. Composite warmer devices are the most popular, widely reported in literature and effective devices for preheating dental composite resins. These devices can heat the resin to 37°C, 54°C and 68°C and also maintains a constant temperature according to the clinician's needs [11].

Clinical testing of the materials is important in order to determine its durability and performance compared to in vitro screening. In the oral cavity, multiple interactive clinical variables related to the tooth substrate and oral environment which can compromise the longevity of restorative materials such as the outward flow of fluids through the dentinal tubules, the surface tension and the functional stresses caused by mastication cannot be simulated with in vitro tests [12]. The current research hypothesis is to there might be significant difference in clinical performance between pre- heated and un- heated bulk fill composite resin.

II. Materials

The materials used in this study were tabulated in Table (IV-1) involving their chemical composition, figures, manufactures and website.

III. Methods

Twenty patients of an age (30-45) had at least two simple occlusal Class I carious lesions were selected from the clinic of Restorative Dentistry Department, Faculty of Dentistry, Tanta University. The patients signed a written consent. They were given oral hygiene instructions before restorative treatment.

Teeth preparation and grouping:

Simple occlusal conventional class I cavities were prepared according to caries extension with moderate cavity depth 3-4mm. All the cavities were prepared using carbide burs[*] held in high speed contrangled hand piece with water cooling system. All internal line angles were slightly rounded. The operating field was completely isolated using rubber dam[†].

A thin layer of glass ionomer cement[‡] was used as a liner in thickness of ≤0.5 mm. After completing and finishing the cavity preparations, selective enamel etching was done with 37% phosphoric acid[§] for 20s then the gel was rinsed off and the tooth was dried. Futurabond M+ universal adhesive was applied to all cavity surfaces in all groups using a disposable micro-brush and light cured for 10 s according to manufacturer's instructions followed by application of X-tra fil composite resin material.

The distribution of restorative materials and locations were randomized and listed in Table (IV-2). A total of forty Class I cavities were prepared and restored with the tested resin materials and grouped as follow: **Group** (**I**): Un-heated X-tra fil bulk-fill composite resin and Futurabond M+ adhesive system. **Group** (**II**): Pre-heated X-tra fil bulk-fill composite resin and Futurabond M+ adhesive system

For group I:

X-tra fil composite resin material was placed in bulk up to 3-4 mm and adapted to the cavity walls using plastic instrument then directly light cured according to manufacturer's instructions using LED curing light unite[**] with soft start curing mode (ramping mode). In this mode, the dental composite is initially submitted to a low light intensity (100-200 mw/cm²) followed by final polymerization with high light intensity (850-1000 mw/cm²).

After curing of composite resin restorations, finishing was performed using finishing kit[††]. Articulating paper[‡‡] was used to adjust occlusal contacts with the opposing teeth. Polishing was performed using polishing paste and aluminum oxide polishing cups and disks.

[*] DENTSPLY, United Kingdom
[†] Sanctuary Dental dam, Malaysia
[‡] Riva, SDI , Victoria, Australia
[§] HoEtch SPIDENT Co. Ltd, Korea
[**] LED. D (curing light unite) China
[††] Enhance finishing&polishing systems, Dentsply, Caulk, Milford
[‡‡‡‡] Bausch, Nashua, NH, USA

For group II:

X-tra fil composite resin compule was placed directly into the dispenser gun to be preheated to 54^{0}C in the C- warmer device[§§] before application then placed, cured, finished and polished as previously mention in group I.

Each restoration was evaluated clinically at baseline (after 24 hours), 6, 9 months and after one year using modified United States Public Health Service USPHS Table (IV-3). The criteria to be evaluated include teeth hypersensitivity, retention rate, marginal adaptation, marginal discoloration, surface texture and secondary caries [13]. Two calibrated investigators who were not involved in the placement of the restorations evaluated the restorations clinically under a dental operating light, using an intra-oral camera, flat surfaced mouth mirrors and dental explorer. If disagreement occurred between the examiners, a third equally calibrated expert was asked for evaluation.

All data along the evaluation periods were collected, tabulated and statistically analyzed using software Statistical Package for Social Sciences (SPSS version 26) computer program by Chi Square test. P-value <0.05(*) was considered significant difference & P-value <0.001(**) was considered highly significant difference.

IV. Result

Regarding the retention rate, group I and II recorded Alpha score (retention rate 100%); no restoration was lost throughout the whole follow up period of the study. This was illustrated in Table (V-1) and Fig (V-1).

Concerning marginal adaptation results were illustrated in Table (V-2) and Fig (V-2). For group I all restorations record Alpha scores (100%) at base line, six and nine months. However, after twelve months of clinical service five restorations (25%) recorded marginal deterioration with Bravo score. A statistical significant difference was recorded where p-value= 0.001.

On the other hand, group II all restorations recorded Alpha scores (100%) at different follow up periods. After 12 months follow-up period, both groups were statistically subjected to Chi- Square test where group II considered better than group I. A significant difference was recorded since p-value =0.017.

Concerning marginal discoloration disorder; Table (V-3) and Fig (V-5) showed the results of marginal discoloration of both tested groups at different follow up periods. All restorations of group I recorded Alpha scores (100%) at base line, six and nine months. However, after twelve months of clinical service four restorations recorded Bravo score (20%). So, concerning the effect of time, group I showed a significant difference between the different evaluation periods since p-value= 0.006.

For group II all restorations recorded Alpha scores (100%) at all evaluation periods. Comparing both groups at the end of follow up periods a significant difference was recorded since p-value= 0.035.

In relation to the presence of secondary caries criterion, table (V-4) and Fig (V-8) showed that both groups were not suffering from secondary caries at different follow-up periods where all groups showed 100% recording Alpha rating.

Regarding the surface texture criterion, alpha score was observed as 100% at the base line, six and nine months recall periods for both tested groups as shown in Table (V-5) and illustrated in Fig (V-9). Surface texture began to change at twelve months follow up period where in group I three restorations (15%) versus only one restoration (5%) in group II and recorded Bravo score. There was no statistical significant difference found between the two groups using Chi-square test at 12 month follow-up period where (p-value =0.292).

The collected data from the clinical assessment of postoperative hypersensitivity of teeth was translated to scores as shown in Table (V-6) and illustrated in Fig (V-13).At the base line, five cases suffering from post-operative hypersensitivity (25%) of cases recorded Bravo score for group I. While in group II, four cases with tooth hypersensitivity (20%) recorded Bravo score.

Using Chi-square test; no statistically significant difference was recorded at the base line between both tested groups (p-value= 0.705). However, comparing the different recall periods there was a significant difference at both groups I and II with p-values (0.001 and 0.006) respectively.

Spearman's correlation test at a significant level of $p \leq 0.05$ to fetch out the statistical relationship between some of the tested criteria versus each other and when any of these criteria recorded only Alpha score no statistical analysis was computed. Regarding the relationship between marginal adaptation, marginal discoloration and surface texture, a statistical positive strong relation was recorded in group I at 12 months follow up period as shown in Table (V-7, 8, 9).

[§§] Anesthetic / Composite Warmer DXM Co. Ltd, Korea

V. Discussion

In the present study **Xtra-fil nano-hybrid composite (bulk- fill)** was used which has been reported to have distinct mechanical and physical properties. It exhibits minimal polymerization shrinkage 1.7% and excellent depth of cure. Xtra-fil can even be cured reliably in increments of 4 mm and with very short polymerization times. It contains 86 % by weight inorganic filler in a methacrylate matrix [14].

The current participants were selected following a special inclusion and exclusion criteria. Most of the patients evaluated presented good oral hygiene and had no periodontal problems. These patients should had at least two simple occlusal carious posterior teeth, one in each side to receive both tested restorations. So, both restorations were subjected to the same environmental conditions. The age of the selected patients was ranging between (30-45) years old to avoid high pulp horns, huge pulp chambers and hidden microscopic pulpal exposures which are always associated with young age of patients [15].

The Class I cavity design was currently selected in the present study because it resembles clinically with complex cavity preparation and restoration. The configuration factor of these cavities is high and it impairs the composite resin flowing during the polymerization shrinkage, increasing the contraction stresses over the bonding interface and therefore increase chance of microleakage which very often cause postoperative sensitivity [16].

In the current study, rubber dam isolation had been performed. It has become an essential component of modern adhesive dentistry, as it provides moisture control, improves access and visibility, and enhances time and treatment efficiency. Furthermore, rubber dam improves cross infection control, provides an aseptic field, prevents the ingestion or aspiration of foreign objects, and protects and retracts the surrounding tissues [17].

The use of GIC as an intermediate layer between resin composite and cavity walls is likely to promote a decrease in polymerization contraction stresses and provide a better adaptation of the restoration at the cavosurface margin. This was followed in the current research [18]. **Chole, D et al** [19] reported that the use of glass ionomer cement as a liner underneath composite resins significantly reduce microleakage.

An universal adhesive especially developed for the selective enamel etching technique was selected (Futurabond M+).Since it was found that the bond strength to enamel is increased by pre-etching with phosphoric acid, while the self-etch approach provides reliable adhesion to dentin. It contains highly functionalized SiO2 nano particles which facilitate a cross-link of the resin components and enhance its film-building properties and reinforce the hybrid layer for long lasting high bond strength [20].

Goracci C et al [21] reported that pre-etching enamel may enhance the bond strength of selective-etch adhesive systems to values comparable with those found with etch and rinse adhesive systems, which may improve their overall performance in clinical use. Moreover, **Gopikrishna et al** [22] reported that applying self-etch adhesive over glass ionomer cement creates a stronger bond of composite resin to glass ionomer cement compared with total-etch adhesive.

Pre-heating was done by placing composite compules with composite gun dispenser applicator into a C- warmer composite heating device to allow easy extrusion, manipulation as it could be easily injected into a cavity without using hand instruments, preventing sudden drop in temperature and enhancing resin adaptation to the walls of preparation [23]. **Daronch et al** [24] recommended the placement of the composite resin compule directly into the delivery syringe during compule preheating seems advantageous over preheating only the individual compule itself to counter the cooling effect when the composite compule is removed from the heating unit.

The selected pre-heated temperature in the present study is 54°C because much higher temperature was reached as 60°C, the elastic deformation would even faster. **Yang JN et al** [25] found out that preheated composite restoration at 50°C showed an intact tooth-restoration interface with no micro leakage. However, the preheated composite at 60°C showed large amount of microleakage. Also, composite resin could be placed with relative safety to dental tissues at this selected temperature [26].

In the present study, the preheated composite resin was immediately light-cured. **Wagner et al** [27] who found out that delaying the curing of preheated composite after placement was also found to be counterproductive as the drop in temperature of composite allowed the viscoelastic nature of the restoration to pull away from the walls of the tooth surface faster and diminishes the positive effects from the preheating treatment.

Light-emitting diode light curing unit (LED .D) was used in the present study as it became more popular than halogen light curing unites in routine dental restorative treatment. **Yaman BC et al** [28] concluded that LED light curing units are found to be more successful than the halogen units with respect to curing depth, microhardness properties, heat generation, and better light intensity output. Soft-start curing mode was used as the composite was first cured at low intensity then stepped up to a high intensity light to reduce polymerization stresses by inducing the composite resin to flow in the gel state during the first application, and improving marginal integrity of the restoration [29].

Clinical studies are the most reliable for screening the quality of restorative materials. Due to the rapid technological developments and the appearance of new materials, as well as the time required for clinical trials, the number of published clinical studies dealing with the quality of restorative materials have significantly reduced [30]. **Lopes LC, et al** [31] investigated that there is a lack of clinical studies to confirm the advantages of preheating technique of composite resins.

The criteria used for evaluation in the present study were modified USPHS criterion (Ryge criteria) which are widely used for long-term evaluation of restorations, and are considered valid for comparison purpose among studies at different observation periods [32]. The protocol for the present clinical study on composite restorations typically includes a baseline evaluation of the restorations and then periodic evaluations at yearly intervals. The present study was a double-blinded in order to eliminate investigator or patient-related bias. During clinical evaluation, two calibrated examiners usually evaluate the restorations independently and then compare their scoring. If there are any discrepancies between the two examiners, a third equally calibrated expert was asked for evaluation [33].

Retention rate represents the most important evaluation criterion. It was found that 100% of the restorations were retained by the end of this study. This is a very objective criterion by which clinical efficacy of the applied adhesive systems and restorative materials are estimated. Currently, these restorations were rated acceptable according to the American Dental International Guidelines. It indicated that no more than 5% of the restorations should have been lost at the 6 months recall and, to obtain full acceptance, the cumulative incidence of clinical failures in each of the two independent clinical studies needs to be <5% of the restorations lost by the 6 months recall visit and <10% by the 18 months recall [34].

Similar to our results regarding retention rates, a study done by **Rashmi NC et al** [35] who revealed that all bulk fill Class I composite resin restorations recorded alpha score at all follow up periods. There was no loss of any restoration at the end of one year evaluation period; a 100% retention rate was recorded for all restorative materials. However, **Attia RM** [36] found that regarding retention rates, 10 % of bulk fill composite resin restorations were lost at the end of the 18 months follow up periods. It was explained that the loss of retention of restorations as a result of a technical fault when placing the restorative material.

The current clinical assessments of **marginal adaptation** of all tested restorations were evaluated using modified USPHS system. Concerning group I all restorations record Alpha scores (100%) at base line, six, nine months but after twelve months of clinical service (25%) restorations recorded Bravo score. An acceptable explanation might be due to the generation of stresses because composite resins contract during the setting process. Polymerization shrinkage stresses occurs when the material is rigid enough to resist the sufficient plastic flow that is required to compensate for the original volume. The magnitude of contraction stresses is highly dependent on the visco-elastic properties of the material. Clinically, these stresses could be transferred to the margins of the restoration, possibly affecting the marginal adaptation quality of the restoration [37].

For group II all restorations record Alpha scores (100%) at different follow up periods. An explanation for the present findings might be concerned to the fact that since composite resin is a viscoelastic material, an increase in temperature decreases its viscosity and increases its flowbility, which is due to the thermal vibration of the resin monomers and an increase in their separation. Under these conditions, if the film thickness of the resin decreases and if it is placed in the cavity rapidly, it will be easily adapted to the prepared cavity walls. Therefore, a decrease in the marginal gaps after preheating the composite resin can be justified [38]. After 12 months follow up period, both groups were statistically subjected to Chi- Square test. A significant difference was recorded since p-value =0.017.

This confirmed with the results obtained by **Taraboanta I et al** [39] who compared the **marginal adaptation** of three different resin-based materials used for direct restoration applied at room temperature or after preheated at preheating 50 and 60^{o}C in Class II cavities. Results revealed that decreased microleakage, fewer gap formations and improved the adaptation were recorded for all filling materials after they have been heated at 50 or 60^{o}C.

Also, **Fróes-Salgado NR et al** [40] reported that the pre-heated composite showed better **marginal adaptation** than the room-temperature groups. It was concluded that pre-heating the composite prior to light polymerization similar in a clinical situation did not alter the mechanical properties and monomer conversion of the composite, but provided enhanced composite adaptation to cavity walls.

On the other hand, **Mohanapriya R et al** [41] evaluated the marginal adaptation of four different composite resins with or without preheating as an in vitro study and concluded that preheated composites showed poor internal marginal adaptation with increased frequency of gap formation. **Sabatini C** [42] concluded that pre-heating does not reduce polymerization stresses of resin composite restorations and found that gap formation at the gingival margin of Class II preparations was not improved relative to the preheating technique.

The **marginal discoloration** is the first clinical signs of the failure of composite resin restorations. For Group I all restorations record Alpha scores (100%) at base line, six, nine months. However, after twelve months of clinical service four restorations (20%) recorded Bravo score. The cavosurface marginal discoloration may be related to function of adhesive system composition and thickness at the tooth/restoration interface which may suffer degradation, consequently resulting in staining by oral fluid penetration over the past 12 months of evaluation, influencing these results [43] .The current cavo surface angles were all created as butt joint to obtain thick restoration at the margins. Concerning the effect of time, group I showed a significant difference between the different evaluation periods since p-value= 0.006.

Bayraktar Y et al [44] **and Atabek D et al** [45] found a slight degree of marginal discoloration was observed after for bulk-fill composite restorations .The explanation of this was that the adhesive degradation which occurs overtime.

For group II all restorations recorded Alpha scores (100%) at all evaluation periods. Comparing both groups at the end of follow up periods a significant difference was recorded since p-value= 0.035. The explanation of this may be due to the fact that preheating of composite resins increases the conversion rate. The conversion rate of the monomer affects the chemical stability of the substance. Non-converted dual carbon bonds are capable of making the material disposed to bond destruction, reducing color stability, increasing stain susceptibility and releasing materials such as methacrylic acid. It also facilitates the influence of solvents from the oral environment on the polymer network and destroys recently formed chains [46].

The results of the present study also confirmed with those of **Sousa SE et al** [47] who evaluated the influence of the preheating of bulkfill flowable composite resins on the color stability when exposed to drinking pigmented beverages. The preheating improved staining resistance of both flowable composites tested. **Darabi F et al** [48] investigated that preheating of the composite resin is effective in the reduction of color change after long time immersion in coffee solution. However, **Mundim FM et al**[49] reported that no significant difference in the color stability of the tested preheated composite resins as pre-heating does not promote changes in the optical and color stability properties.

Secondary caries can be associated with patients who have a high caries index and poor oral hygiene who were considered exclusion criteria in the present study. **Van Djikenand** and **Pallesen** [50] did not exclude patients with these conditions in their study and confirmed that restoration failure caused by secondary caries was associated with patients at high risk of caries. Also, the use of glass inomer cement in the present study as a liner beneath the composite resin restorations prevent secondary caries formation due to its fluoride release [51].

Surface texture is also an important factor in evaluating the longevity of composite restorations. The change in surface texture started at twelve months where in group I three restorations (15%) versus only one restoration in group II (5%) recorded Bravo score. There is no statistical significant difference found between the two groups using Chi-square test where (p-value =0.292).

The bravo scores recorded in both groups might be explained by the attitude of different patients, consuming different types of food, using different methods of brushing in addition to types of toothpaste and tooth brush which play an important role in the clinical changes of surface roughness. Another explanation might be due to organic matrix abrasion, , exposure of inorganic content and loss of smaller filler particles due to chewing and due to tooth brushing in their daily life [52].

In addition, concerning the evaluation of **postoperative hypersensitivity**, it was noted only at the base line of group I and II. 25% and 20% of cases recorded Bravo score for group I and II respectively. Overall, all groups exhibited excellent performance in terms of postoperative hypersensitivity, and no significant differences were observed between groups (p-value= 0.705) which indicated that preheating of composite resins did not affect the postoperative sensitivity.

That might be referred to self-etching adhesive used, the presence of liners (glass ionomer cement) in the current research might be the reason of the low rate of postoperative hypersensitivity observed. **Pazinatto FB et al** [53] found out that none of the patients reported postoperative sensitivity after 56 months of evaluation periods in Class I and II resin composite restorations as result of a using of glass-ionomer as a liner beneath the composite resin restorations.

Many studies indicated that up to 30% of the study populations reported postoperative sensitivity following the placement of a posterior resin restoration. They explained their findings by reporting this criterion to be less precisely quantified and might not be compared from case to case because of subjectivity of its measuring. Also, they concluded that this specifically is completely a patient dependent criterion [54].

However, **Gianordoli-Neto R et al** [55] revealed that 100% alpha score of postoperative sensitivity for bulk fill composite resin restorations at all evaluated periods was recorded in class I and II cavity preparations. All cavity margins had enamel present which increases significantly the restorative adhesive system sealing capacity, decreasing possibility of marginal microleakage, and its consequences such as postoperative sensitivity.

Furthermore, the statistical analysis showed a positive significant relation between marginal adaptation and marginal discoloration in group I after twelve month of evaluation confirming that any marginal defects might lead to marginal discoloration. These findings came in agreement with **Almeida et al** [56] who stated that in most cases, stain accumulation is associated with a margin defect where creating a gap between the cut tooth and the restorative material which may be localized or generalized marginal discoloration. Color can be a collection of surface stain at the margin area or it can penetrate into the interface, demonstrating more of a shadow or undermining effect.

Long term follow up studies have demonstrated that a rough composite surface can compromise color and gloss, leading to increased plaque accumulation. Therefore, this lighted the idea of finding out a relation between surface texture and marginal discoloration currently. Performing statistical analysis using Spearman's correlation test, in the present research, a positive significant relation between surface texture, marginal adaptation and marginal discoloration was detected after 12 months of evaluation in group I which was confirming the results obtained by **Manabe et al** [57] who stated that the color stability was affected by the surface roughness and surface integrity. They explained their findings by the resin's affinity for stains which is modulated by its conversion rate and physicochemical characteristics with water sorption rate.

VI. Conclusions

Within the limitation of the present study, the following conclusions were observed:

1- Pre-heated bulk fill composite resin had superior clinical performance compared to unheated one by the end of the evaluation period.
2- Composite resins can be warmed to allow better adaptability to the cavity walls.
3- Time factor has no effect on the tested criteria for preheating technique.

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Tables:

Table (IV-1): Materials used in the study.

Materials	Figures	Chemical compositions	Manufactures	Website
X-tra fil Nano-Hybrid Bulk fill Composite compules Shade (universal)	**Fig (IV-2)**	Bis-GMA (bisphenol A-glycidyl methacrylate) , UDMA (urethane dimethacry late),TEG-DMA (tri ethyl eneglycol dimethacry late) 86 % by weight inorganic filler (70.1 % by volume) Barium glass, Mixed oxide, silicone dioxide Additives, stabilizers, catalyst, Pigments	Voco GmbH, Cuxhaven, Germany	www.voco.com
Futurabond M+ Universal Adhesive (Self-etch adhesive One step) PH (2)	**Fig (IV-3)**	Water, Ethanol, Silicium dioxide, Acid modified methacrylate (methacrylate ester), HEMA (2-hydroxyethyl methacrylate), Camphorquinone	Voco GmbH, Cuxhaven, Germany	www.voco.com
Riva Self Cure(Glass Ionomer Cement)	**Fig (IV-4)**	Powder bottle(15g): Fluoro-aluminosilicate glass Liquid bottle(6.9ml): Poly acrylic acid and tartaric acid	SDI, Victoria, Australia	www.sdi.com

Fig (IV-1): X-tra fil (bulk fill) composite resin

Fig (IV-2): Futurabond M+ universal adhesive

Fig (IV-3): Riva self-cure glass inomer cement

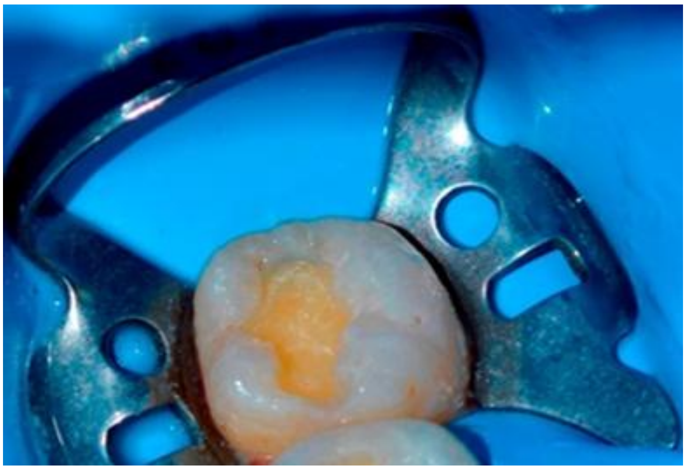
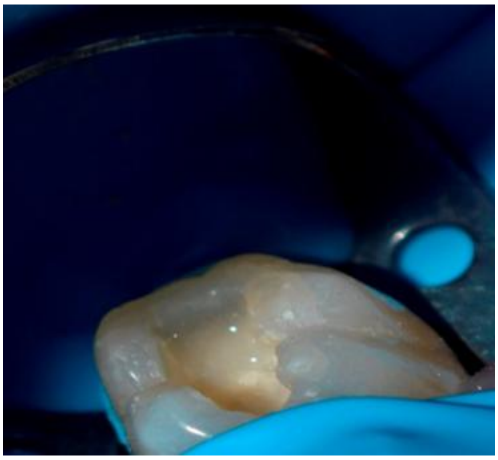
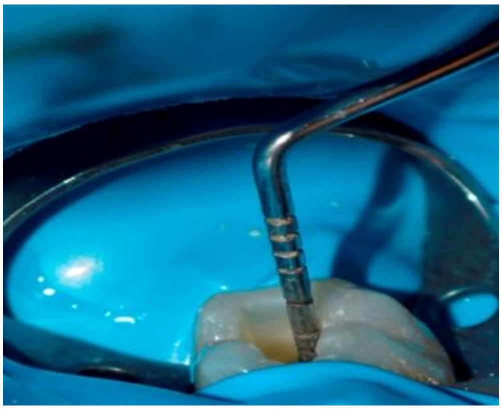


Fig (IV-4): After removal of carious lesion and completing the cavity preparation

- 5): Cavity depth measured by periodontal probe (3-4mm)



): Glass inomer cement (Riva) used as a liner



V-7): Cavity depth measured by periodontal probe after application of liner ≥3mm

V- 8): Selective enamel etching with 37% phosphoric acid

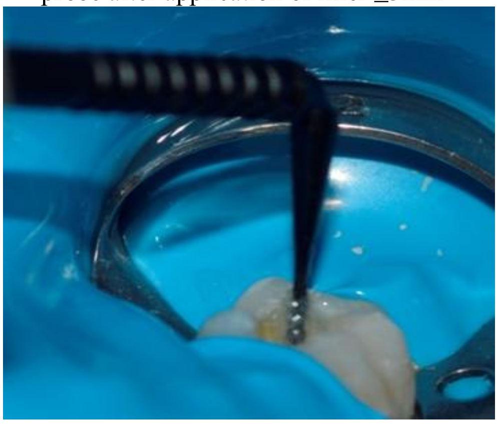


Fig (IV-9): Futrabond M+ application

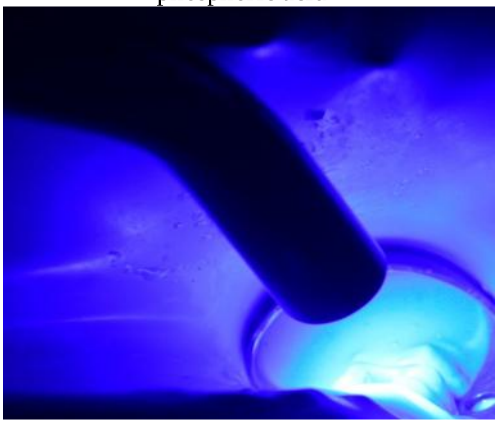
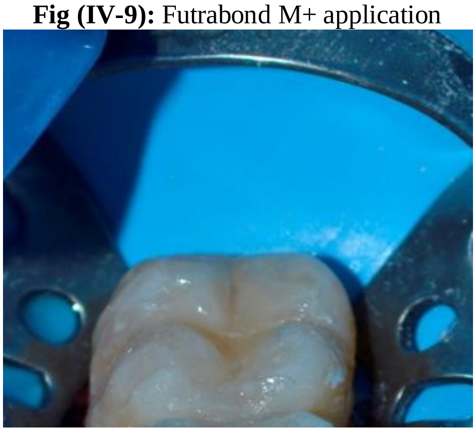
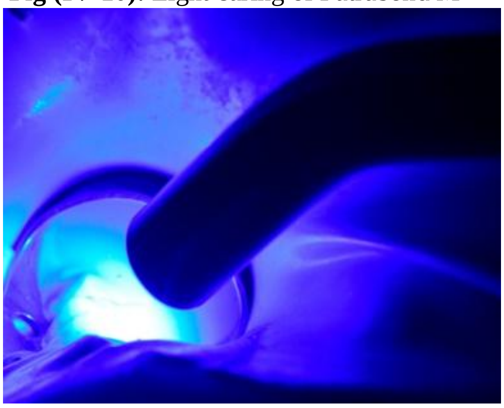


Fig (IV-10): Light curing of Futrabond M+



11): Xtra-fil composite placement for group I



-12): Light curing of Xtra-fil composite for group I

Fig (IV-13): Preheating of Xtra-fil compule in C-warmer device to 54^0C for group II

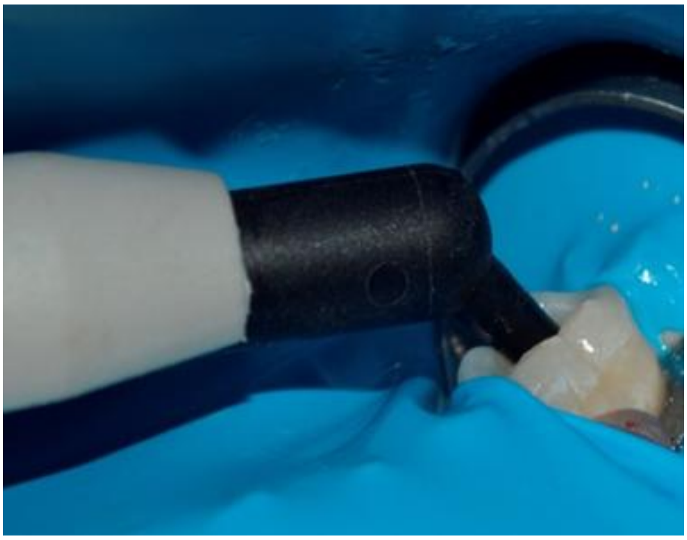


Fig (IV-14): Xtra-fil composite placement for group II

15): Final restorations of lower right first and second molar after its finishing and polishing for group I

V-16): Final restorations of lower left first and second molar after its finishing and polishing for group II

Table (IV-2): Intra- oral random distribution of restorations.

Distribution of restorations	Teeth locations				Total number = 40
	Lower first molars	Lower second molars	Upper first molar	Upper second molar	
Group I	16	2	1	1	20
Group II	14	2	2	2	20

Table (IV-3): Modified USPHS criteria.

Category	Scores	Criteria
Retention	Alpha	Retained.
	Charlie	Mobile or missing : clinically unacceptable
Marginal discoloration	Alpha	No discoloration at the margins.
	Bravo	Shallow discoloration at the margins (localized or generalized) clinically acceptable.
	Charlie	Deep discoloration (localized or generalized) clinically unacceptable.
Marginal adaptation	Alpha	Closely adapted, no detectable margin

	Bravo	Visible evidence of crevice along the margins, dentine not exposed: clinically acceptable.
	Charlie	Explorer penetrates into crevice along the margins, dentine is exposed: clinically unacceptable.
Secondary caries	Alpha	No caries present.
	Charlie	Caries present.
Surface texture	Alpha	Smooth to finely granular.
	Bravo	Coarse, gritty: clinically acceptable.
	Charlie	Pitted: clinically unacceptable.
Postoperative hypersensitivity	Alpha	Not present
	Bravo	Sensitive but diminished in intensity
	Charlie	Constant sensitivity, not diminished in intensity

Table (V-1): Scores, number and percent of the retention rate of the restorative tested groups at different follow up periods

Retention		**Baseline**		**After 6 months**		**After 9 months**		**After 12 months**	
Groups	**Score**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Group I (Unheated)	**Alpha**	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**
	Charlie	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Group II (Preheated)	**Alpha**	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**
	Charlie	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

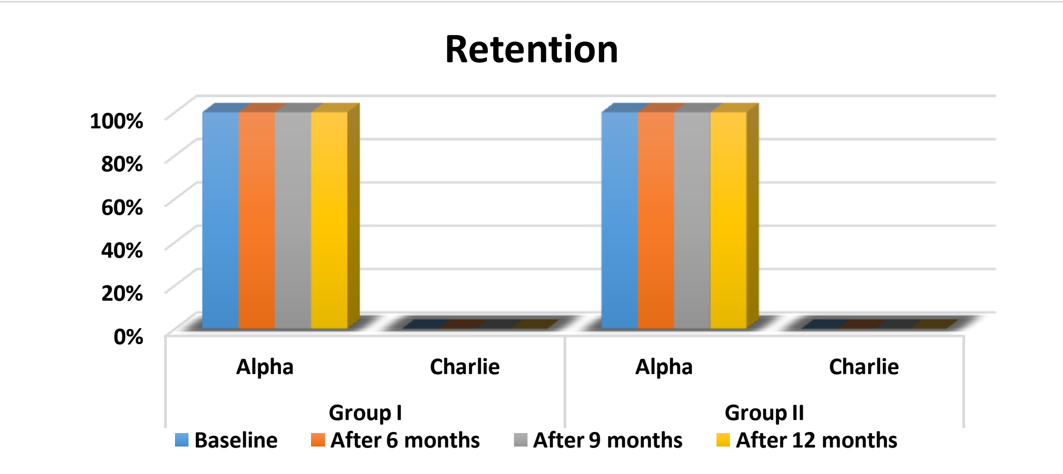


Fig (V-1): Bar graph showing scoring % of the retention rate of groups I and II at different follow up periods.

Table (V-2): Scores, number and percent of the marginal adaptation of restorations of the tested groups at different follow up periods

Marginal adaptation		**Baseline**		**After 6 months**		**After 9 months**		**After 12 months**		**χ^2 p-value**
Groups	**Score**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
Group I (Unheated)	**Alpha**	**20**	**100**	**20**	**100**	**20**	**100**	**15**	**75**	**16.000 0.001***
	Bravo	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**25**	
	Charlie	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	

Group II (Preheated)	**Alpha**	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	------
	Bravo	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
	Charlie	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
χ^2 (p-value)		------		------		------		**5.714 0.017***		------

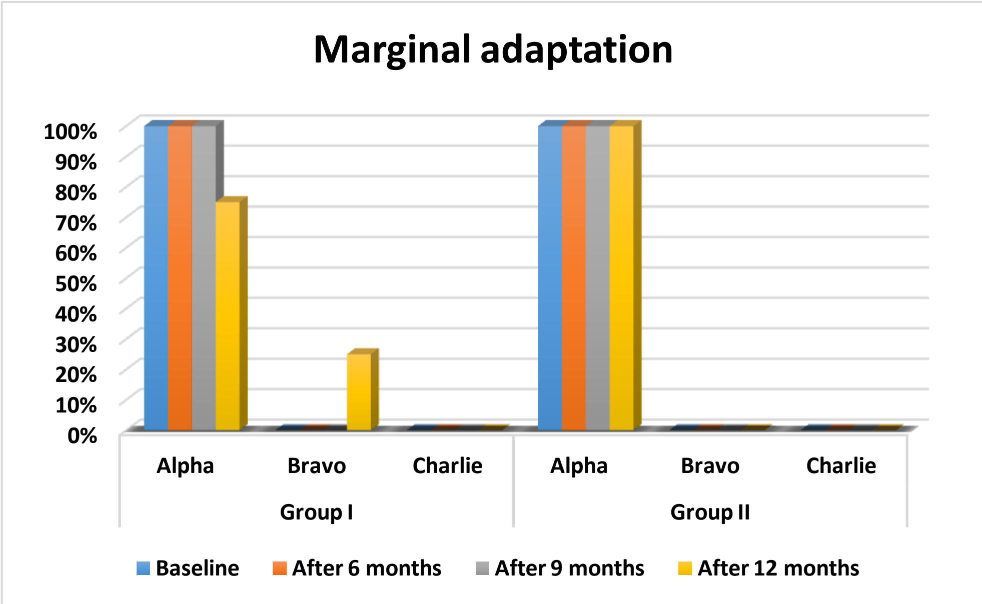


Fig (V-2): Bar graph showing scoring % of marginal adaptation of groups I and II at different follow up periods.

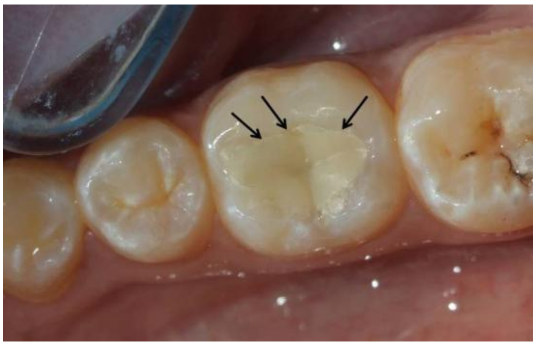


Fig (V-3): Clinical photo represents Bravo score (visible evidence of crevice along the margins, dentine not exposed) (arrows) of marginal adaptation of lower right first molar (group I) restored with un-heated Xtra-fil composite resin at 12 months follow up.

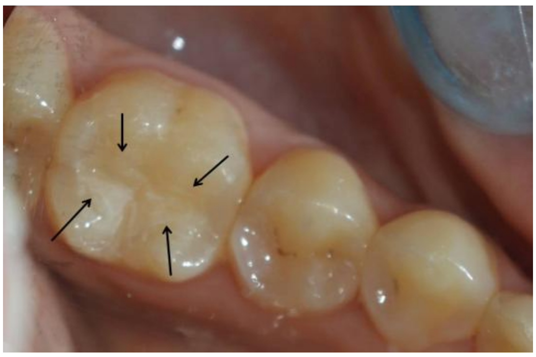


Fig (V-4): Clinical photo represents Alpha score (Closely adapted, no detectable margin) (arrows) of marginal adaptation of lower left first molar (group II) restored with pre-heated Xtra-fil composite resin at 12 months follow up.

Table (V-3): Scores, number and percent of the marginal discoloration of restorations of the tested groups at different follow up periods

Marginal discoloration		Baseline		After 6 months		After 9 months		After 12 months		χ^2 p-value
Groups	Score	N	%	N	%	N	%	N	%	
Group I (Unheated)	Alpha	20	100	20	100	20	100	16	80	12.632 0.006*
	Bravo	0	0	0	0	0	0	4	20	
	Charlie	0	0	0	0	0	0	0	0	
Group II (Preheated)	Alpha	20	100	20	100	20	100	20	100	------
	Bravo	0	0	0	0	0	0	0	0	
	Charlie	0	0	0	0	0	0	0	0	
χ^2 (p-value)		------		------		------		4.444 0.035*		------

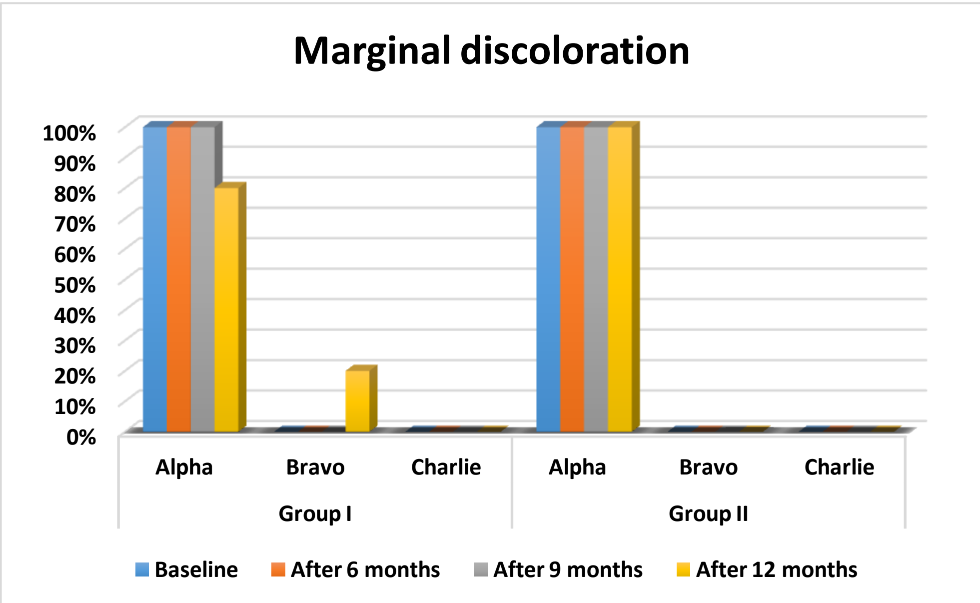


Fig (V-5): Bar graph showing scoring % of marginal discoloration of groups I and II at different follow up periods.

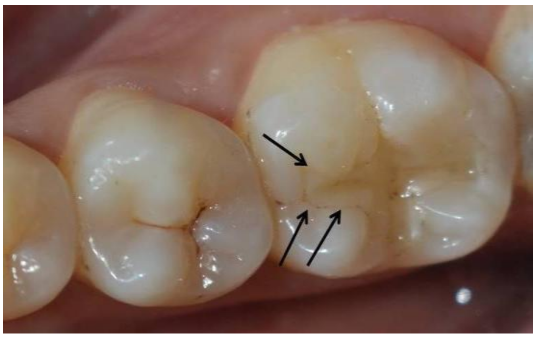


Fig (V-6): Clinical photo represents Bravo score (shallow discoloration at the margins) (arrows) of marginal discoloration of lower right first molar (group I) restored with un-heated Xtra-fil composite resin at 12 months follow up.

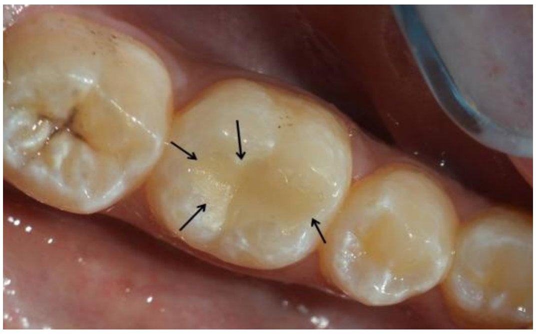


Fig (V-7): Clinical photo represents Alpha score (no discoloration at the margins) (arrows) of marginal discoloration of lower left first molar (group II) restored with pre-heated Xtra-fil composite resin at 12 months follow up.

Table (V-4): Scores, number and percent of secondary caries of the tested groups at different follow up periods.

Secondary caries		Baseline		After 6 months		After 9 months		After 12 months	
Groups	Score	N	%	N	%	N	%	N	%
Group I (Unheated)	Alpha	20	100	20	100	20	100	20	100
	Charlie	0	0	0	0	0	0	0	0
Group II (Preheated)	Alpha	20	100	20	100	20	100	20	100
	Charlie	0	0	0	0	0	0	0	0

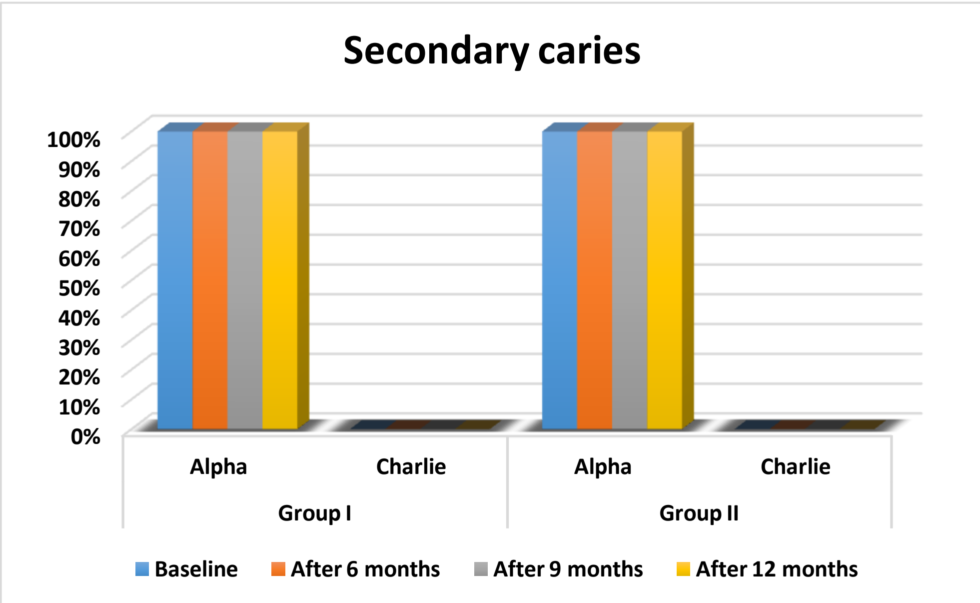


Fig (V-8): Bar graph showing scoring % of secondary caries of groups I and II at different follow up periods.

Table (V-5): Scores, number and percent of surface texture of restorations of the tested groups at different follow up periods.

Surface texture		Baseline		After 6 months		After 9 months		After 12 months		χ^2 p-value
Groups	Score	N	%	N	%	N	%	N	%	
Group I (Unheated)	Alpha	20	100	20	100	20	100	17	85	9.351 0.025*
	Bravo	0	0	0	0	0	0	3	15	
	Charlie	0	0	0	0	0	0	0	0	

Group II (Preheated)	**Alpha**	**20**	**100**	**20**	**100**	**20**	**100**	**19**	**95**	**3.038 0.386**
	Bravo	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**5**	
	Charlie	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
χ^2 **(p-value)**		**------**		**------**		**------**		**1.111 0.292**		**------**

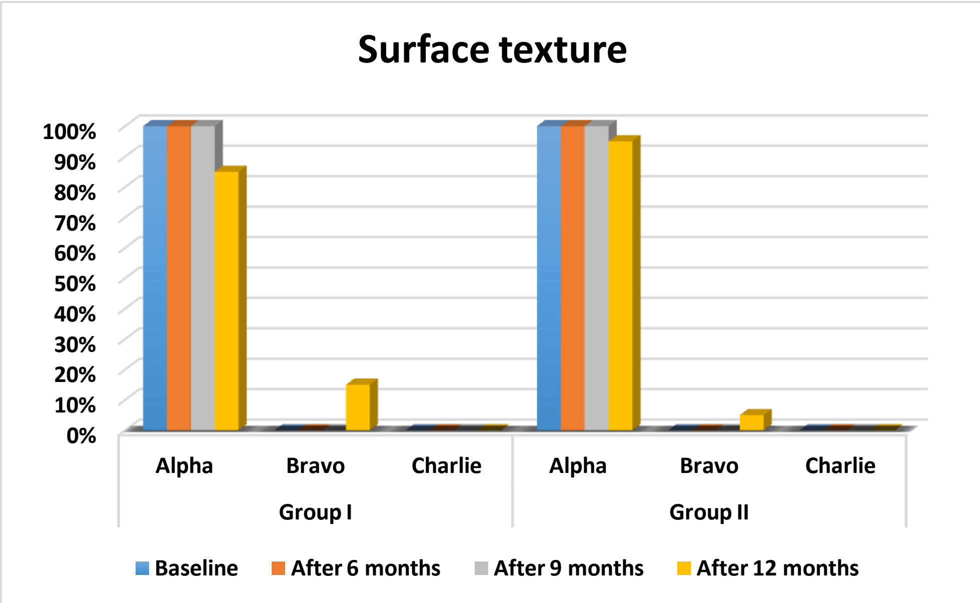


Fig (V-9): Bar graph showing scoring % of surface texture of groups I and II at different follow up period.

Fig (V-10): Clinical photo represents Bravo score (Coarse, gritty: clinically acceptable) (arrows) of surface texture of lower right first molar (group I) restored with un-heated Xtra-fil composite resin at 12 months follow up.

Fig (V-11): Clinical photo represents Alpha score (smooth to finely granular) (arrows) of surface texture of lower left first molar (group II) restored with pre-heated Xtra-fil composite resin at 12 months follow up.

Fig (V-12): Clinical photo represents Bravo score (Coarse, gritty: clinically acceptable) (arrows) of surface texture of lower left first molar (group II) restored with pre-heated Xtra-fil composite resin at 12 months follow up.

Table (V-6): Scores, number and percent of postoperative hypersensitivity of the tested groups at different follow up periods.

Postoperative hypersensitivity		Baseline		After 6 months		After 9 months		After 12 months		χ^2 p-value
Groups	Score	N	%	N	%	N	%	N	%	
Group I (Unheated)	Alpha	15	75	20	100	20	100	20	100	16.000 0.001*
	Bravo	5	25	0	0	0	0	0	0	
	Charlie	0	0	0	0	0	0	0	0	
Group II (Preheated)	Alpha	16	80	20	100	20	100	20	100	12.632 0.006*
	Bravo	4	20	0	0	0	0	0	0	
	Charlie	0	0	0	0	0	0	0	0	
χ^2 (p-value)		0.143 0.705		------		------		------		------

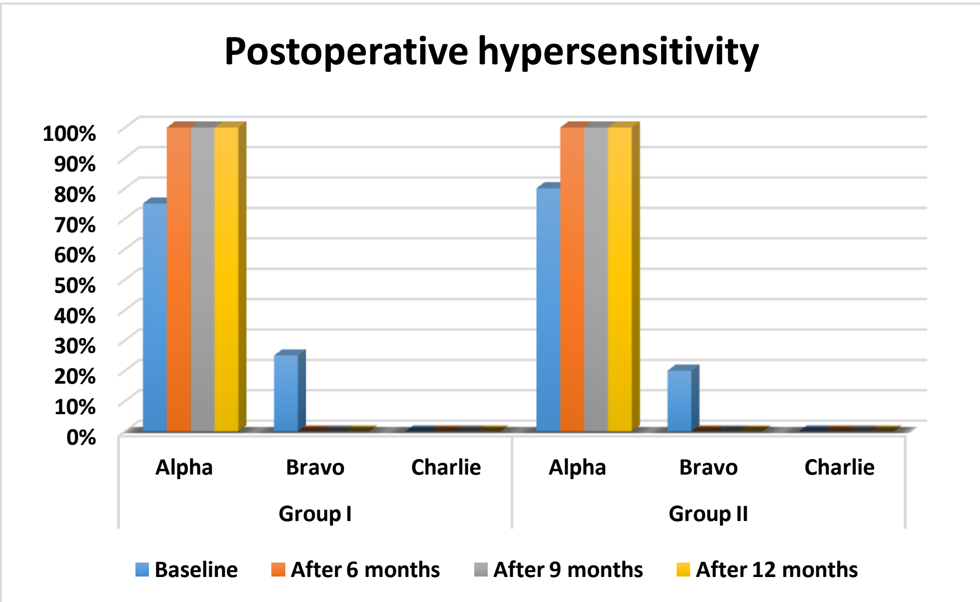


Fig (V-13): Bar graph showing scoring % of postoperative hypersensitivity of groups I and II at different follow up period.

Table (V-7): Relationship between marginal adaptation versus marginal discoloration of the group I at twelve months follow up period.

Relation between Marginal adaptation and Marginal discoloration		
Groups	**12 Months**	
	ρ	**p-value**
Group I (Unheated)	**0.866**	**0.000****

Table (V-8): Relationship between surface texture and marginal discoloration of the group I at twelve months follow up period.

Relation between Surface texture and Marginal discoloration		
Groups	**12 Months**	
	ρ	**p-value**
Group I (Unheated)	**0.728**	**0.000****

Table (V- 9): Relationship between surface texture and marginal adaptation of the group I at twelve months follow up period.

Relation between Surface texture and Marginal adaptation		
Groups	**12 Months**	
	ρ	**p-value**
Group I (Unheated)	**0.840**	**0.000****

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