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Sectioning Through Sectional Matricing Techniques: An In-Vivo Comparative Evaluation of Post-Operative Sensitivity

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Abstract
Aims and Objectives: *The aim of this study was to compare the post-operative sensitivity in Class 2 resin restorations after two different techniques using VAS.*
Materials and methods:*A total of 50 class 2 composite restorations were conducted on 46 patients during a period of 2 years. The sample was randomly divided into one of two groups and were restored. Group 1(n=25) was restored using injection moulding technique using bulk fill preheated composite(55ºC) and Palodent V3 sectional matrix system(Dentsply®) and Group 2(n=25) was restored using injection moulding technique using bulk fill pre heated composite(55º C) and the Biofit HD Posterior(Bioclear®) transparent sectional matrix and cured from the buccal, lingual and lastly occlusal aspect. The patients were assessed for post-operative sensitivity measured on a 10 cm VAS at regular time intervals(t=0, 24hrs, 1 week and 1 month). The obtained data was tabulated and subjected to statistical analysis. Normalcy of data was analysed using the Shapiro Wilkinson Test and difference in VAS scores was assessed using ONE WAY ANOVA followed by TUKEY'S HSD POSTHOC TEST, the level of significance was set to p<0.05.*
Results:*The results of the study showed thatthere was significant amount of post-operative sensitivity noted in Group 1 but there was no sensitivity seen in Group 2(VAS=0). The maximum sensitivity was noted at t=0 and was equal to that at t=24 hours. The VAS values were seen to decrease over time.*
Conclusion:*The use of a transparent sectional matrix along with the injection moulding technique showed a significant decrease in post-operative sensitivity. In patients who presented with sensitivity, there was a significant decrease in sensitivity over the period of 1 week.*
KEY WORDS*: bulk fill composites, injection moulding technique, Bioclear biofit HD, Palodent V3, Dentsply Sirona, post-operative sensitivity, class 2 composite restorations, sectional matrix*

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I. Introduction

Within the last decade, dental patients' expectations toward aesthetic restorations havegreatly increased. Different tooth-coloured materials such as ceramic and resin-basedcomposites have become very popular to restore teeth when aesthetic results are needed.Currently, resin-based composite is one of the most widely used materials in aestheticdentistry. Composite resins have the ability to strongly bond to both enamel anddentin. Theycan be applied with minimal thickness and be used to create ultraconservativerestorations while maintaining sound tooth structure.

Composite resin materials shrink volumetrically during polymerization. The amount ofshrinkage is dependent on the filler load and matrix composition of the material.[1] If thematerial polymerizes in unstrained conditions, minimal internal stress builds upbecause the material can flow and deform externally to compensate for the volumetricshrinkage.[2,3] Shrinkagestress occurring during polymerization can thus lead to a host of clinical complications such as cusp deflection,[4,5]fractureof enamel margins, debonding, micro-cracking of the shrinking composite,microleakage, and most importantly post-operative sensitivity.[6,7,8]

The market for restorative dental materials is driven by a demand for faster and easierprocedures. In an effort to meet this demand, manufacturers have introduced severalbulk-fill composite resins to the market.[9] Bulk-fill composite resins are recommendedto be placed and cured in bulk increments of 4-6 mm thickness. Manufacturers claiman increased depth of cure and lower shrinkage stress with these materials, comparedwith conventional composite resins, while eliminating the need for a sophisticatedlayering technique.[10]Mimicking their conventional counterparts, the bulk-fill materialscan be classified into high-viscosity and low-viscosity groups.The low-viscositymaterials are intended as bases, or dentin-replacement materials, which need to becovered with conventional composite resins for improved strength, wear resistance and aesthetics while the high-viscosity materials can make up the entire restoration.[11] Severalreformulations have been made in attempts to lower the shrinkage stress associated withbulk-fill composite resins. These include photoactive monomers, or "polymerizationmodulators" that prolong gelation time of the resin matrix, leading to greater stressrelief via internal flow during the pre-gel phase.[12,13]Other reformulations include pre-polymerized filler particles which lower the elastic modulus of the material. Other techniques include, handpieces that apply sonic energy to the material,lowering the viscosity temporarily which allows for increased particle motion in the pre-gel phase of the polymerization, leading to increased stress-relief via internalflow.Currently published in vitro studies, seeking to compare the polymerization shrinkage stress of bulk-fill composite resins to conventional composite resins, have limited similarity to clinical conditions. A symptom of polymerization stress is clinically perceived as post-operative sensitivity.[14]

Efforts to combat this commonly encountered complication led to the development of a matrix system called the "*Bioclear Matrix System*". Dr David Clark, a practicing restorative dentist in Tacoma, USA, introduced this system in 2007, a system that has gained popularity in the recent years. This system makes use of well contoured transparent sectional matrix bands, enabling light curing of the composite from the buccal and palatal sides and then the occlusal side. The polymerization shrinkage stresses are hence deviated away from the cavity walls resulting in elimination or a decrease in post-operative complications such as post-operativepolymerization shrinkage and microleakage.[15]It has been recommended that the restorative technique of choice while using the *Bioclear* matrix system is the injection moulding technique.

The injection moulding technique tackles the challenges and short comings of the incremental technique. It involves the use of a bulk fill composite preheated in a composite warmer which is then injected into the prepared, etched and bonded cavity in one go. Basic characterization and anatomy are moulded into the composite and the entire bulk of material is light cured in one shot. The improved flow characteristics of the preheated composite and lowered viscosity ensures good flow (thixotropic flow), marginal adaptation, and density to the restoration.[16,17] The use of bulk fill composite ensures complete polymerization up to a depth of 4mm. Injection moulding of composite resin maximizes the material's propensity to flow once heated, then captures and pressurizes it within a containment. The combination of an excellent marginal adaptation along with a curing protocol thatdecreases polymerization shrinkage stresses could possibly reduce the most commonand extensive complaint that follows composite restorations, post-operative sensitivity.

This study aimed at assessing the post-operative sensitivity in class 2 composite restorations using two different resin restorative techniques using the Bioclear® posterior matrix system and the injection moulding technique with pre-heated bulk fill composite. The null hypothesis assumed is that there is no statistically significant difference in post-operative sensitivity seen between the two restorative techniques.

II. Materials And Methods

The sample size was estimated using the *GPower*software v. 3.1.9.2. Considering the effect size to be measured (f) at 42%, power of the study at 90% and the margin of the error at 5%, the total sample size needed was 50. Each group consisted of 25 samples.

A total of 46 consenting adults (50 teeth in total) between the ages of 18-50 years requiring class two composite restorations, satisfying the inclusion criteria were taken up for the study. The patients were briefed about the procedure of the restoration, the study purpose and design. An informed consent was taken from each patient. All restorations were performed by a single operator.

Inclusion Criteria

- Patients older than 18 years and younger than 40 years
- Tooth without any periapical or periodontal pathology
- Cavity to be restored was two surface
- Depth of the cavity not extending beyond half the depth of dentin
- Presence of adjacent tooth proximal to the side to be restored and antagonistic tooth in the opposite arch

Exclusion Criteria

- Deep cavities extending beyond half the depth of dentin

- Tooth to be filled is periodontally compromised
- Very wide cavities extending beyond 1/3rd the inter-cuspal distance and depth more than 4-5mm gingivally

Clinical procedure

A pre-operative IOPAR was taken to assess the extent of the lesion. The tooth of interest and the adjacent teeth on both the mesial and distal side were isolated under multiple tooth rubber dam isolation. Caries excavation was done using hand instruments followed using diamond abrasives and airotor. The cavities were prepared to receive a class two composite restoration. The sample was randomly divided into 2 groups (Group 1 and Group 2). In each group the cavities were restored using one of the two techniques.

Group 1:(n=25) and Group 2:(n=25)

The cavities were etched for 20 seconds using the Ivoclar N Etchant (using thetotal etch technique), washed and dried. A layer of bonding agent was applied using a micro brush applicator tip according to manufacturer's instructions and light cured. For teeth belonging to Group 1, a metal sectional matrix (Palodent V3) of the appropriate size was applied (Figure 1.) and for teeth of Group 2, a transparent sectional matrix (BioFit HD) was adapted (Figure 2.) on to the tooth. Bulk fill composite was preheated to pre-heated T=55^{o}C in a composite warmer. The composited was injection moulded into the cavity. The material was contoured to give basic anatomy. The material was light cured from the occlusal aspect for 60 seconds for Group 1 and for 20 seconds from each aspect-buccal, lingual and occlusal for Group 2.

GROUP	MATRIX SYSTEM	RESTORATIVE MATERIAL
GROUP 1 ***(n=25)***	***Palodent V3®*** *(Ivoclar Vivadent)* Metal Sectional Matrix	**Tetric N Ceram BULKFILL Composite***(Ivoclar Vivadent)* *[PRE-HEATED T=55℃]*
GROUP 2 ***(n=25)***	***Bioclear®*** *Biofit Posterior HD* TransparentSectional Matrix	**Tetric N Ceram BULKFILL Composite***(Ivoclar Vivadent)* *[PRE-HEATED T=55℃]*

Finishing and polishing

The restoration was assessed for high points and premature contacts using articulating paper. High points were trimmed using a yellow band finishing bur under air water spray. The restoration was polished using *Soflex* polishing wheels(3M®).

Assessment of post-operative sensitivity

- Patients were asked to review their post-operative sensitivity on a 10cm visual analogue scale (0 indicated *"no pain"* and 10 indicated *"severe intolerable pain"*)
- The assessment was performed *at t=0, 24hrs, 1 week and 1 month* time intervals.
- The data acquired was then subjected to statistical analysis and the results were interpreted.

STATISTICAL ANALYSIS

The data was collected and statistical analysis was performed. One-way ANOVA followed by TUKEY'S HSD POSTHOC TEST was used to compare VAS scores at different time intervals withing each group as well as comparative assessment across groups at different time intervals.

III. Results

A total number of 46 patients were considered for the study and a total of 50 restorations were performed. The recorded VAS scores at different time intervals were tabulated in the form of a master chart and were subjected to statistical analysis. Data was analysed using the statistical package SPSS 22.0 (SPSS Inc., Chicago, IL) and level of significance was set at $p<0.05$.

Descriptive Analysis

- Descriptive statistics was performed to assess the mean and standard deviation of the respective groups.
- Normality of the data was assessed using *Shapiro Wilkinson test*. Normal distribution of data was observed.

Inferential Analysis

- *The one way ANOVA followed by TUKEY'S HSD POSTHOC TEST were used to analyse and compare VAS scores within each group at the different time intervals as well as across the different groups.*
- *The level of significance [P-Value] will be set at P<0.05*

COMPARISION OF VAS SCORES WITHIN EACH GROUP

Group 1

ANOVA TEST reported statistically significant result between the time intervals($p<0.05$). POSTHOC test by TUKEY'S HSD TEST showed the significant result present between 0 vs 1 WEEK, 0 vs 1 MONTH, 24 HRS vs 1 WEEK and 24 HRS vs 1 month. Significant result was not observed at 0 vs 24 HRS and 1 WEEK vs 1 MONTH intervals.(Table 1.)

Group 2

No Analysis has been performed as the mean values were zero at all time intervals. (Table 2.)

VAS TREND AT DIFFERENT TIME INTERVALS

The values of the VAS scores across both groups followed a similar trend. It was found that the values were relatively constant between *t=0* and *t=24* however, there was a downward trend noted between *t=24hrs* and *t=1 week*. It was also noted that there was no significant decrease in VAS values between *t=1 week* and *t=1 month*.

From the results of the study, the following are the key takeaways,

- Group 1 showed statistically significant values for post-operative sensitivity.
- Group 2 showed no post-operative sensitivity.
- There was a significant reduction of VAS scores across the time intervals.

The null hypothesis of the study was rejected.

IV. Discussion

The need for simpler and more predictable techniques have led to the advancement of various new materials – newer composite resins and matrix systems. The need to simplify the existing protocols for restorations and the emergence of newer technologies are resulting in a paradigm shift in the success rates of posterior composites.

This study was conducted to assess and compare post-operative sensitivity in patients receiving composite resin restorations using three different techniques. The use of preheated composite with both metal and transparent sectional matrix systems was compared.

The null hypothesis assumed that there was no statistical difference in sensitivity between the two groups. A total of 50Class 2 composite restorations were performed in 46 patients in total. All the patients were assessed for post-operative sensitivity at four time intervals(t=0, 24hrs, 1 day and 1 month). The post-operative sensitivity was assessed using the 10cm VAS(Visual Analogue Scale, ranging from 0 indicating *"no pain"* and 10 indicating *"severe intolerable pain"*).

The visual analogue scale is a widely used tool in the field of medicine to assess pain owing to its ease of use for both patients and clinicians. This scale ranging from 10cm to 100cm is used extensively to measure clinical pain or pain relief in analgesic assays or in experimental pain.The 10 cm VAS scale was chosen as it was easy to hold for the patients, easy to read and interpret.

The materials used for the study were standardized across the groups in order to attain accurate results. The *Tetric N Ceram* series by Ivoclar Vivadent® was used in this study as this range of products had both the packable composites as well as bulkfill composite. Another reason for choosing this particular material for the study was the presence of Ivoclar's patented photo-initiator "*Ivocerin*"(ensuring better polymerization of bulkfill composites at greater depths). The corresponding etchant and bonding agent were used according to manufacturer's instructions. For the etching procedure, a total etch technique was used for simplicity and standardization across all three groups. The studies by Balkaya et. al., and Kasraeis et. al., evaluated the clinical performance of bulkfill composites and incremental placement of packable composite.[17,18,19] It was found that there was significant difference between the two groups after 36 months with the bulkfill group showing better clinical performance in terms of marginal leakage and post-operative sensitivity.

In this study, the age group of patients selected was between 18-45 years as, the incidence of sensitivity increases after the age of 18, peaks during 28-34 years and gradually begins to decrease after the age of 40.[19,20,21] This is attributed to the age related wear of the enamel and exposure of dentin in the early stages. As age progresses, the deposition of sclerotic dentin and occlusion of the dentinal tubules inhibits fluid movement within the tubules and hence reduces sensitivity. Thus selection of patients outside this age group would have led to inaccurate readings of post-operative sensitivity due to the higher tolerance.[22]

Patients with proximal caries in premolars and molars were included in the study. The carious lesion was not to extend beyond 0.5mm into the dentin, assessed by appropriate clinical and radiographic examination. Lesions that extended beyond the defined limit were eliminated as the *direct bonding between the composite*

and tooth material without the use of a base or liner was essential to assess sensitivity caused by the composite resin.

The patients who agreed to take part in the study were further educated about the risks, benefits and alternatives before being taken up for the study and were asked to sign a written consent form. In this study, a total of 50 teeth were restored across 46 patients. The patients were randomly allocated to one of the two groups and assessed for post-operative sensitivity. This in-vivo study was conducted over a period of 24 months.

All clinical procedures were performed by a single operator to ensure standardization of treatment. The procedure began with isolation of the operating field using multiple teeth rubber dam isolation technique including the mesial and distal adjacent teeth. This ensured adequate access to the proximal aspect of the decay as well as adequate space to accommodate the rubber dam clamp and the twin ring of the matrix. The cavity preparation began with the excavation of caries first with hand instruments followed by rotary diamond abrsives (round and diamond points). The cavity design followed the principles of minimally invasive dentistry where excess removal of tooth structure was avoided. The walls of the prepared cavity rested on sound enamel or dentin to ensure adequate bonding and prevention of development secondary caries.

The teeth were then etched using total etch protocol, rinsed and dried using a three way syringe after which a bonding agent was rubbed and light cured onto the tooth using an applicator tip according to manufacturer's instructions. The adjacent tooth was protected using *Teflon* tape during the etching and bonding procedure. After this the appropriate matrix was adapted according to the group allocation of the patient and the appropriate technique of restoration was performed.

In Group 1, the composite was preheated to a temperature of 55^{o}C. Wegner et. al., proposed that the ideal temperature to preheat composite to is 54.4^{o}C.[14]The advantages of pre-heating composite prior to placement are as follows – reduced viscosity and increased flow characteristics, improved marginal adaptation to cavity wall, improved conversion rate, increased polymerization, increased compressive strength and lesser polymerization shrinkage stresses.[14] This group showed a statistically significant post-operative sensitivity (p=0.0001). These results are in correspondence with a study conducted by Opdam et. al., which showed significant post-operative sensitivity with the use of bulk fill composite and a metal sectional matrix.[23] In another study by Kimyai et. al., that assessed the marginal adaptation of bulk fill composites, it was inferred that polymerization shrinkage stresses generated during one step curing bulk fill increments 4-6mm in depth may be concerning.[24,25] In a study conducted by Sergio et. al., it was stated that polymerization shrinkage occurring towards the light can result in gap formations at the restoration-dentin interface.[9,13] The reason for the significant post-operative sensitivity occurring in the patients of group 1 may be attributed to these gap formations and the incomplete polymerization occurring due to the metal matrix being impervious to light.

Group 2 was restored with the Bioclear Biofit HD Posterior Matrix System and, the injection moulding technique with pre-heated bulk fill composite. These transparent matrices are pre-contoured and adapt very anatomically in the proximal aspect. The pre-heated bulkfill composite was injection moulded into the cavity and bulk cured. The depth of cure of bulkfill composites is 4mm unlike the conventional packable composites which is 2mm. Thus the need for incremental layering is eliminated. The curing protocol with transparent sectional matrices was first described by Maximiliano Sergio et. al. In the study it was suggested that the use of a transparent sectional matrix would make it possible to control the direction of polymerization shrinkage of the material.[20,24] It is known that polymerization shrinkage occurs towards the light source. Curing from the cavity wall sides, i.e., from the buccal and lingual sides first, followed by the occlusal side could result in polymerization shrinkage occurring towards the cavity walls there by reducing the polymerization shrinkage stresses at the level of the restoration-dentin interface. It was found that in Group 2, none of the patients presented with any sensitivity after restoring the tooth. The baseline VAS score was 0 in all of the cases. The results could be attributed to this.

The inter group comparison of the recorded immediate postoperative sensitivity was done. It was found that there was a statistically significant difference in the VAS scores among the two groups at baseline(p=0.0001). The highest VAS scores were noted in Group 1(mean=1.76,SD=1.030 and the least was noted in Group 2(mean=0, SD=0). Intergroup analysis showed a significant difference between Group 1 and Group 2(p=0.0001).

It was noted that the general trend across all three groups was that the mean VAS values showed a gradual regression. In a similar study conducted by Campbell, et. al., the time intervals at which VAS was analysed showed a similar trend.[15] It was noted that post-operative sensitivity significantly reduces from 24 hours after placement to that recorded at 2 weeks and 1 month later. Opdam et. al., in a study to assess the general trend of post-operative sensitivity stated that there is a transient post-operative sensitivity occurring due to the newly formed polymerization shrinkage stresses during the process of polymerization.[27] These stresses get released as the polymerization tends to continue even after light curing. This effect is known as delayed curing and the decrease in sensitivity over time can be attributed to this factor.[28,29]

The most common and challenging aspect of posterior composite restorations is the occurrence of failures. In a study conducted by *Opdam et. al*., on the marginal integrity and post-operative sensitivity it was noted that majority of the failures occur at the level of the gingival marginal seat.[22,23,24] In an invitro study conducted by *Narayana et. al*., assessing microleakage in the gingival seat area of Class 2 composite restorations, it was stated that the *higher organic component, tubular structure, fluid pressure, and permeability along with lower surface energy of dentin make bonding of the composite to dentin more difficult than to enamel.*[25] This may also affect the marginal adaptation, having an negative effect on the bonding of composite resin at the tooth-restoration interface.

CLINICAL SIGNIFICANCE OF THE STUDY

The complete elimination of polymerization shrinkage stresses is unrealistic. However,attempts to experiment with these four factors by using different materials in combination with the different techniques may help reduce the amount polymerization shrinkage stresses.Several clinical studies have reported that nearly 30% of the patient present with post-operative sensitivity after placement of resin composites in posterior teeth. Post-operative sensitivity is a result of accumulation of polymerization shrinkage stresses in the restoration-dentin interface and is a significant negative prognostic factor. Pre-heating and injection moulding as a technique is an excellent method to ensure an adequate marginal seal. The one-shot curing protocol significantly decreases the procedural time. The use of a transparent sectional matrix enables adequate light to penetrate and cure the composite along the walls there by reducing the polymerization shrinkage stresses and hence the post-operative sensitivity. The use of this technique in day to day practice can largely benefit the patient and the operator.

V. Conclusion

Within the limitations of this in-vivo study the following points can be concluded –

- There was a significant difference in post-operative sensitivity noted between the three groups.
- There was a time dependent downward trend noticed with a decrease in post-operative sensitivity that occurred between 24 hours to 1 week and plateaued between 1 week to 1 month.
- The use of a metal sectional matrix with the injection moulding technique resulted in significant post-operative sensitivity.
- The use of a transparent sectional matrix along with the injection moulding technique displayed no occurrence of post-operative sensitivity.

This study however was limited by its sample size. Further studies need to be conducted in order to verify the obtained results as well as to corroborate the results. The use of the injection moulding technique in conjunction with the transparent sectional matrix is a simple and promising technique for more predictable Class 2 composite resin restorations.

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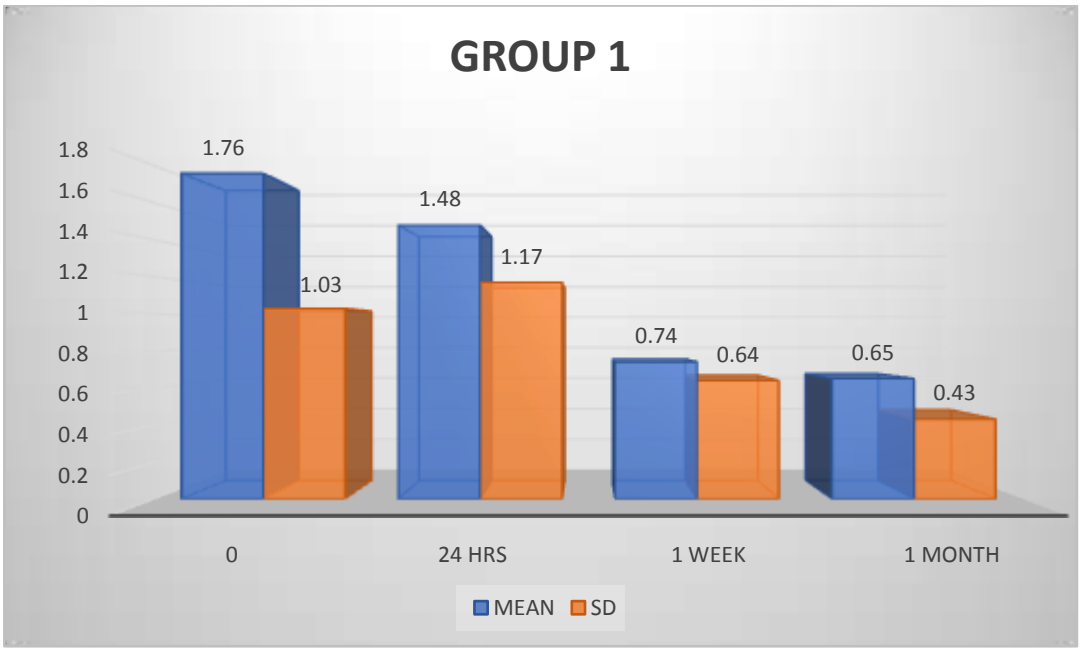
TABLES and FIGURES

TABLE 1

VAS SCALE	N	MEAN	SD
0	25	1.76	1.03
24 HRS	25	1.48	1.17
1 WEEK	25	0.74	0.64
1 MONTH	25	0.65	0.43
F VALUE	9.9073		
P VALUE (ANOVA)	0.0001*		
POSTHOC TEST (TUKEY'S HSD TEST)	PAIR GROUP	P VALUIE	
	0 vs 24 HRS	0.66	
	0 vs 1 WEEK	0.004*	
	0 vs 1 MONTH	0.001*	
	24 HRS vs 1 WEEK	0.017*	
	24 HRS vs 1 month	0.005*	
	1 WEEK vs 1 MONTH	0.98	

TABLE 1. Shows the VAS score comparison within GROUP2. ANOVA TEST reported statistically significant result between the time intervals($p<0.05$). Posthoc test by TUKEY'S HSD TEST showed the significant result present between 0 vs 1 WEEK, 0 vs 1 MONTH, 24 HRS vs 1 WEEK and 24 HRS vs 1 month. Significant result was not observed at 0 vs 24 HRS and 1 WEEK vs 1 MONTH intervals**.**

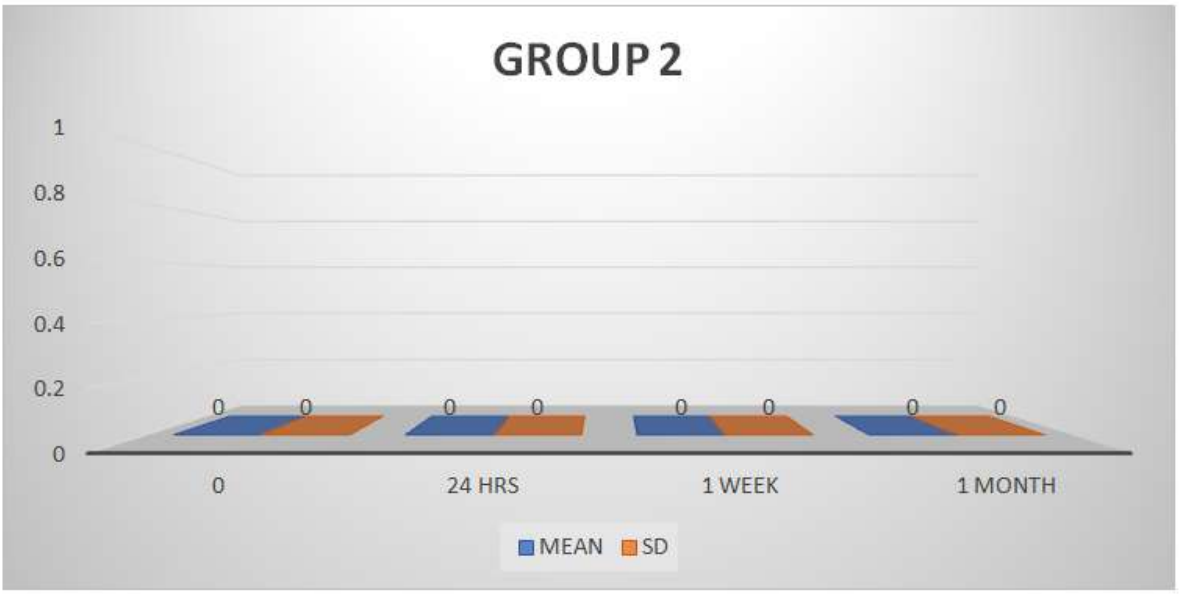


GRAPH 1: Graphical representation of Group 1 VAS scores recorded during different time intervals.

TABLE 2

VAS SCALE	N	MEAN	SD
0	25	0	0
24 HRS	25	0	0
1 WEEK	25	0	0
1 MONTH	25	0	0
F VALUE	-		
P VALUE (ANOVA)	-		
POSTHOC TEST (TUKEY'S HSD TEST)	PAIR GROUP	P VALUIE	
	0 vs 24 HRS	-	
	0 vs 1 WEEK	-	
	0 vs 1 MONTH	-	
	24 HRS vs 1 WEEK	-	
	24 HRS vs 1 month	-	
	1 WEEK vs 1 MONTH	-	

Table 2. Shows mean VAS values of GROUP 3. No Analysis has been performed as the mean values were zero at all time intervals.



Graph 2. Graphical representation of Group 2 VAS scores obtained during different time intervals

XXXXXXX, et. al. "Sectioning Through Sectional Matricing Techniques: An In-Vivo Comparative Evaluation of Post-Operative Sensitivity."*IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 21(04), 2022, pp. 50-57