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RESEARCH ARTICLE

COMPARISON OF CUSPAL DEFLECTION & MICROLEAKAGE IN CLASS II RESTORATION WITH DIFFERENT MATERIALS: AN INVITRO STUDY

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Cuspal Deflection Due to Adhesive Restoration Leads to Microleakage Around Restoration So Clinician Has to Use Method of Restoration in Such Way That it Will Reduce Cuspal Deflection and There by Prevent Leakage Around Restoration

Abstract

Aim & objective: To compare the cuspal deflection and microleakage in class II restoration with Nanocomposite,Bulkfill composite resin & new hybrid GIC cement.

Materials and Methods: Freshly extracted human maxillary 1st premolar teeth were collected ((n=30).Samples were embedded 3mm beneath the CEJ in selfcure acrylic resin block.Small glass beads were fixed with X-Flow resin on the cusps as reference point.Buccopalatal width was measured with a Digital Micrometer Gauge before prepartion.Standardized Class II MOD cavities prepared on all the samples in dimensions:2mm width x 2mm axial depth x 2mm depth. Samples were divided into groups according to restoration done:GroupA: Nanocomposite(Filtek Z350 XT),Group B:Bulk fill composite(FiltekBulkfill), Group C:Hybird GIC cement.Bucco palatal width were measured after restoration and after thermal cycling(500cycle) to measure cuspal deflection then immersed in 2 % methylene blue dye for 24 hours.The samples were sectioned vertically(mesiodistally) and dye penetration were recorded under a stereomicroscope(20X) using a scoring system.

Results: The mean Bucco-Palatal width of cusp decreased after restoration and after thermocycling as compared to before restoration in group A&C but in Group B increases after restoration & after thermal cyclinig.The mean dye penetration of Group-A (1.90±1.10) followed by Group-C (1.80±0.79) were higher than that of Group-B (1.60±0.70) but one-way analysis of variance (ANOVA) showed that there was no significant difference between them.

Conclusion: Nanocomposite, bulkfill composite and GIC hybrid cement causes cuspal deflection and microleakage on the MOD cavities, though not statistically significant.

Introduction:-

With the increase in demand for aesthetic restorations, advancements have been made in recent times in tooth-coloured adhesive materials.[1] With the advent of composite resin restorative material, patients' demand in tooth coloured filling materials have upsurged. Recent studies shows the use of composite resins in occlusal and occluso-proximal cavities of posterior teeth.[2]However, stress due to polymerization shrinkage is still a limitation of composite restoration which leads to its failure at times.[3]Polymerization

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stress affects composite resin restorations by different way likeprovoking cracks in enamel and dentin, post-operative sensitivity, cuspal deflection, disturb marginal adaptation, micro-leakage, cusp fracture. Among these microleakage and cuspal deflection are the most common[4]

Microleakage is an undetectable passage of bacteria, ions and liquid through the tooth-restoration interface occurs mainly due to polymerization of resin.[5]On the other hand, if the bond between tooth and composite resin is strong and remains intact, stress is applied to tooth structure and would cause cuspal deflection or even tooth fracture.[6]Cuspaldeflection occurs when the adhesive strength exceeds the contraction stress, the restoration maintains an internal tension that pulls the cavity walls together, reducing the inter-cuspal distance. The magnitude of this inward cuspal movement depends mainly on the cavity size, type tooth, and the type of material used.

Cuspal deflection occurs due to the interaction between the polymerization shrinkage stress of the resin composite, the adhesive interface, and the compliance of the cavity wall.[7]Mean cuspal deflections of up to 50 mm were recorded using the range of techniques highlighted, dimensional changes have been reported to range from 4 to 25 m most commonly.[8]The size and configuration (C-factor) of the cavity influence the amount of cuspal deflection and the highest deflection values have been recorded for mesio-occluso-distal (MOD) cavities.[9]

Advancement of restorative materials leads to introduction of variety of composite resin or high strength GIC cement with various types of filler and adhesiveness. Conventional composite resin filled with the incremental layering (each increments of 1.5-2.0 mm). But the use of these materials has certain drawbacks such as increased polymerization stress, time consuming procedure, technique sensitive, chances of voids. Different methods are available to decrease polymerization shrinkage as well as polymerization stress. Methods like incremental application of composite resin, ramp curing, stage curing,[10] increasing the percentage of fillers or changing the structure or chemical formulation of monomer with low shrinkage are few methods which are commonly used in clinical practice.[11]

Recent advances introduced the application of thicker increments in the tooth cavity, such as 4 to 5 mm, which was possible when bulk-fill resin composite was used. There was an increase in the translucency of the material or an incorporation of new photo-initiators for effective polymerization. The chemical composition also had modifications to reduce the volumetric shrinkage arising from the polymerization of the material.[12]

Advanced Glass Hybrid Technology has led to the development of next generation high strength self-adhesive Glass Ionomer cement for restoration of posterior non stress bearing areas. This has certain advantages like: high mechanical strength, better esthetics, more translucency, good adhesion, fluoride release, high moisture tolerance.

Thus, the present study was conducted to compare the cuspal deflection and microleakage in Class II restoration using Nanocomposite (Filtek Z 350 XT,3M), Bulkfill composite resin (Filtek Bulkfill,3M) and new high strength hybrid glass ionomer cement(GC-FUJI ,Japan) .

Materials And Method:-

Freshly extracted maxillary first premolar for orthodontic reason were collected, teeth were non carious and not have any previous restorations were included. Teeth with any morphologic variations or any decalcification or hypoplasia or any resoptive defects or any preexisted cervical lesion were excluded.

Sample Size Determination

Required sample size was calculated using G*Power software(G* Power for Windows, Version 3.1.9.7, University Duesseldorf, Germany). Based on the outcome, a minimum total sample size of 30

(N=32) with 10 samples per group (n=10) will be required to achieve a power of 81.3% at 95% confidence level

30(n=30) freshly extracted maxillary first premolar were collected. Teeth were cleaned of organic remnants using ultrasonic scaler,disinfected using 3% sodium hypochlorite for 10 minutes and rinsed with distilled water according to OSHA guideline & were stored in 0.9% normal saline until ready for use . Samples were embedded 3 mm beneath the cemento-enamel junction (CEJ) in a self-cure resin (DPI RR Cold cure ,Acrylic repair material). Fabrication of reference point for Buccopalatal,width measurement was done . With a measurement of 2mm X 2mm area of Buccal and palatal surface were etched with 37% phosphoric acid followed by bonding agent applied and light cured.Two rounded mold filled with composite resin of 2 mm diameter and 2 mm height placed over the prepared surface and light cured . Bucco Palatal Width(BPH) [t0]was recorded with a digital micrometer gauge (Safeseed) before cavity preparation .

Standardized large mesio-occluso-distal (MOD) cavity prepared and cavity measurement done. The measurement was 2mm width X 2mm axial depth X 2mm depth and the Gingival margin was placed 1 mm above the CEJ. All walls of the cavity were also prepared parallel to each other.

The samples were then divided into three groups:
GROUP A: SAMPLES WERE RESTORED WITH NANOCOMPOSITE
GROUP B : SAMPLES WERE RESTORED WITH BULK FILL COMPOSITE
GROUP C : SAMPLES RESTORED WITH HIGH STREGNTH GIC

In Group A (n=10) samples were restored with Nanocomposite (Filtek Z 350 XT,3M), Group B(n=10) samples were restored with Bulk fill composite (Filtek Bulkfill,3M) and Group C (n=10) samples were restored with hybrid Glass ionomer cement . Samples were etched with 37% phosphoric acid (Ultra-Etch, Ultradent) followed by rinsed for 20 sec and air dried .Bonding agent (Te Econo Bond,Ivoclar) was applied for 10sec . Light cured for 10 sec with a LED lamp (Bluephase NM,Ivoclar). Restoration done by corresponding composites and BPW measured [t1].Samples were immersed in storage in Ringer’s solution for 24 hours and 5,00 thermocycles (5 ± 2°C/55 ± 2°C, dwell time 30 seconds, transfer time 3 seconds) done in water bath. Buccopalatal width of all the samples were measured [t2]after thermocycling . The thermocycled teeth were immersed in 2% Methylene blue dye for 24 hours.Samples were then rinsed under running water, air dried. Samples were then sectioned mesiodistally into two halves in a vertical plane parallel to long axis of the tooth using diamond disc in mesio-distal direction.The sections were examined under a stereomicroscope at 20X magnification to evaluate the degree of dye penetration along with capturing of photographs using digital camera (10X Zoom, 18 MegaPixel)

Measurement of Microleakage [Chuang SF et al., 2004]
- No dye penetration.
- Superficial penetration not beyond the dentinoenamel junction (DEJ).
- Penetration beyond the DEJ but limited to two-thirds of the gingival wall length.
- Penetration beyond two-thirds of the gingival wall length

Statistic analysis:
The collected data were tabulated in a spreadsheet using Microsoft Excel 2021 and then statistical analysis was carried out using GraphPad Prism for Windows, Version 10.0.0 (GraphPad Software, La Jolla California USA). A Shapiro-Wilk's test and a visual inspection of the histograms, normal Q-Q plots, and box plots showed that the collected data were approximately normally distributed for the bucco-palatal width, however, the microleakage scores were ordinal. A two-way analysis of variance (ANOVA) was used to compare the effect of the procedure and materials on the bucco-palatal cuspal width and the

Kruskal-Wallis test was used to compare the amount of dye penetration to assess microleakage between the study groups. The *P* value of 0.05 was considered as the level of significance.

Results:-

The mean bucco-palatal cuspal width of the various groups at various testing phases is listed in Table 1 and illustrated in Figure 1.

In all the groups, the mean cuspal width showed a decrease after restoration with a slight increase after thermocycling. Analysis of the results demonstrated that only the phases of testing affected the. bucco-palatal cuspal width (*P*=0.0031) and that the latter did not depend on the materials tested (*P*>0.05). It is worth mentioning that at baseline, all the specimens of the three groups had near similar cuspal widths, thus nullifying any bias (*P*=0.21).

Post-hoc Tukey analysis revealed that in group A, there was no significant change in the cuspal width at various time points(*P*=0.06). however, in both group B, the cuspal width after thermocycling was significantly higher than recorded after restoration (*P*=0.02), and in group C, the cuspal width after restoration was found to be significantly higher than before restoration (*P*=0.012) All other comparisons were found to be non-significant(*P*> 0.05).

Regarding the dye penetration scores, although group C demonstrated higher scores (Mdn:2; IQR:1-2.25) than group A (Mdn:1.5; IQR:1-3) and group B (Mdn:1.5; IQR:1-2) respectively, the difference was only indicative and not statistically significant (*P*=0.83). The distribution alongwith the median of scores have been tabulated in Table 1 and the percentage distribution of scores has been illustrated in Figure 2.

Tables

Table 1:- Mean bucco-palatal cuspal width and standard deviations (in mm) as a function of procedural stage and treatment groups.

Phases	Group A (*n*=10)	Group B(*n*=10)	Group C(*n*=10)	*P* value[§]
Before restoration	11.89±0.41 ^{a,A}	12.07±0.36 ^{ab,A}	12.16±0.27 ^{a,A}	0.06ns
After restoration	11.7±0.4 ^{a,A}	11.98±0.47 ^{a,A}	12.1±0.23 ^{b,A}	
After thermocycling	11.86±0.43 ^{a,A}	12.15±0.39 ^{b,A}	12.14±0.23 ^{ab,A}	
***P* value**[‡]	0.0031*			

n:sample size per group
§:Effect of study materials; ‡: Effect of phases
ns:not statistically significant (*P*>0.05),*: statistically significant (*P*≤0.05)
The same lowercase letters imply no statistically significant difference between cells in a column.
The same UPPERCASE letters imply no statistically significant difference between cells in a row.

Table 2:- Descriptive statistics of microleakage scores of the three study groups.

Groups/Scores	Frequency(%)				Median(IQR)	*P* value[a]
	1	2	3	4		
Group A(***n*=10)**	5(35.7%)	2(20%)	2(40%)	1(100%)	1.5(1-3)	0.83ns
Group B(***n*=10)**	5(35.7%)	4(40%)	1(20%)	0(0%)	1.5(1-2)	
Group C(***n*=10)**	4(28.6%)	4(40%)	2(40%)	0(0%)	2(1-2.25)	

n:sample size per group
ns:not statistically significant (*P*>0.05)
IQR:inter quartile range
a:analyzed by Krusal-Wallis test

Figure 1:- Bar Graph showing the mean cuspal width(in mm) of the study groups and the significant comparisons between them.

Figure 2:- Stacked Bar Graph showing the distribution of microleakage scores between the study groups.

Discussion:-

A common biomechanical occurrence in teeth restored with composites is cuspal deflection, which is caused by the interaction between the cavity wall's conformity and the composite's polymerization shrinkage stress.It is unable to fully capture the issue of shrinkage stress.It has been reported that Following cavity preparation, the residual cusp supports the occlusal stress as cantilever beams. Mechanically speaking, the cusp deflection is inversely related to the thickness of the cantilever cubed and proportional to the cubed cantilever length.[1] According to the dye penetration results, the shrinkage stress of the composite resin moves to the bonding system and eventually the tooth, where it will either be released through microleakage or cracks in the enamel.

None of the groups demonstrated reduced microleakage in the evaluation of MOD restoration.Group A exhibited the highest median dye-penetration, suggesting a higher microleakage than Group B & C, but the difference was not statistically significant. Group A also had the highest dye penetration score (score 4). This result was consistent with the findings of Fleming et al. (2005) and Garapati et al. (2014), who found no discernible variation in dye penetration between the materials.When compared to bulk-filling technique, Versluis et al. (1996) found that incremental layering procedure significantly increased the generation of polymerization stress.Campodonico et al (2017) suggested that if various factors like cavity design, size, thickness of remaining tooth are standardized, the cuspal deflection is a reasonable way to quantify the shrinkage stress.The detrimental consequences of polymerization shrinkage in vivo are still caused by the stress that develops at the tooth-restoration interface, which can only be caused by a combination of material characteristics, restoration geometry, and the interfacial adhesive quality of the tooth and filling material.[4]According to Campodonico et al. (2017), the cuspal deflection is a reasonable way to quantify the shrinkage stress if various factors like cavity design, size, and thickness of remaining tooth are standardized.According to the findings of Ebrahim Yarmohamadi et al.'s (2018) study, marginal microleakage did not differ significantly between the two bulk fill posterior restorative materials and the conventional composite, with the ormocer-based composite exhibiting the lowest cuspal deflection. which is comparable to our outcome.It has also been proposed that lowering the C-factor will lessen cure shrinkage by allowing unhindered material "flow" in the unbonded surface layer.[3]

Khaled Mohamed et al. (2020) came to the conclusion that using fiber-reinforced composite inserts can significantly lessen the issue of cuspal deflection and microleakage in complex cavities prepared in premolars.The primary factor causing cusp deflection during composite curing is the shrinkage caused by polymerization. The degree of polymerization shrinkage, the total volume of composite in a cavity, and the elastic modulus of the cured composite all affect the cuspal deformation. The composite flow and the C-factoralso have an impact on the polymerization shrinkage force.(2)In adhesive dentistry, cuspal flexure during the curing of resin composite restorative materials can result in major issues such microleakage, postoperative discomfort, debonding of the restoration-tooth contact, microcracks inside the tooth structure, and marginal discoloration.

Method to reduce cuspal deflection and microleakage:include preferable to use a nanofilled composite,Use of bulk fill composite above Nanaofilled composite ,use of incremental filling technique,Use of delayed curing option,Using the option of delayed curing,Utilizing composite inserts reinforced with fibers,Restoration using indirect composite inlay

Image 2:- Composite Restoration.

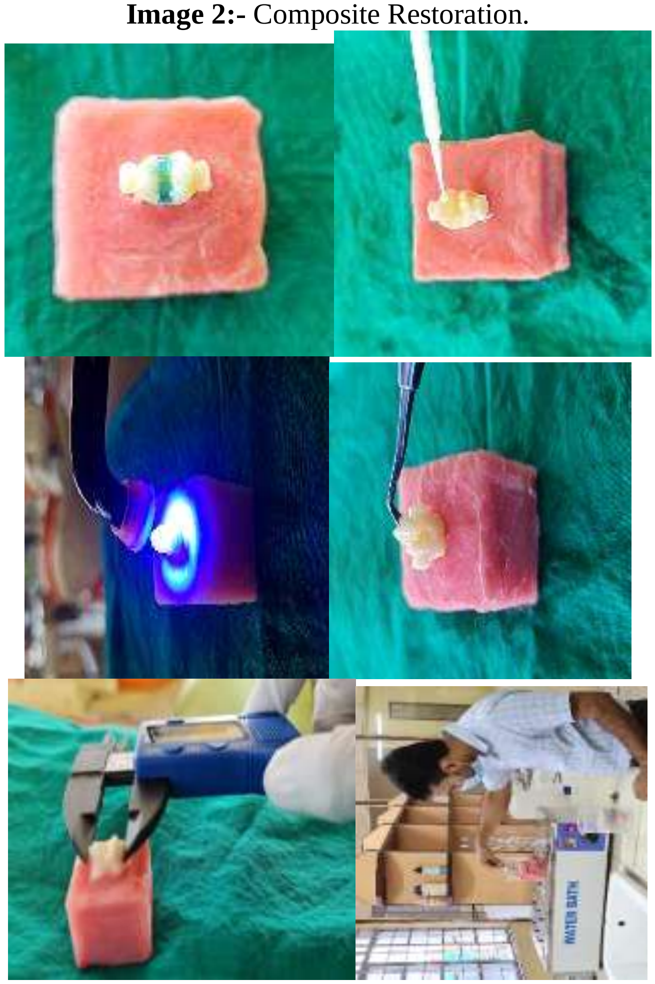

Image 4:- Microleakge Analysis.

	GROUP-A			GROUP -B			GROUP - C		
Bucco-Palatal width of cusp (in mm) Sample no.	Before restoration	After restoration	After thermo cycling	Before restoration	After restoration	After thermo cycling	Before restoration	After restoration	After thermo cycling
1	12.3	12.4	12.2	11.6	11.5	11.5	12.2	12.1	12.2
2	11.6	11.7	11.5	11.8	11.7	12	11.9	11.9	12.0
3	12.1	11.9	11.6	12	12	12.2	12.6	12.5	12.4
4	11.8	11.6	11.9	12.6	12.5	12.7	12.2	12.1	12.3
5	11.5	11.6	11.6	12.3	12.3	12.3	11.9	11.9	11.8
6	11.8	11.5	11.6	12	11.8	12	12.2	12.1	12.2
7	11.5	11.3	11.4	11.9	11.8	12	11.9	11.9	12.0
8	12.5	12.1	12.6	12.4	12.3	12.5	11.9	11.9	11.8
9	11.4	11.0	11.7	12.5	12.7	12.6	12.6	12.5	12.4
10	12.4	11.9	12.5	11.6	11.2	11.7	12.2	12.1	12.3

GROUP A		GROUP B	GROUP C
Sample No	Dye penetration Score	Dye penetration Score	Dye penetration Score
1	1	2	2
2	1	2	1
3	1	3	1
4	2	1	3
5	4	1	2
6	3	2	2
7	1	1	1
8	2	1	2
9	3	2	1
10	1	1	3

Bucco-Palatal width of cusp (in mm)	**Before restoration**	**After restoration**	**After thermocycling**
Mean ± s.d.	11.89±0.41	11.70±0.40	11.86±0.43
Median	11.8	11.65	11.65
Range	11.4 - 12.5	11.0 - 12.4	11.4 - 12.6

Bucco-Palatal width of cusp (in mm) of Group-A

Bucco-Palatal width of cusp (in mm)	Before restoration	After restoration	After thermocycling
Mean ± s.d.	12.07±0.36	11.98±0.47	12.15±0.39
Median	12.0	11.9	12.1
Range	11.6 - 12.6	11.2 - 12.7	11.5 - 12.7

Bucco-Palatal width of cusp (in mm) of Group-B

Bucco-Palatal width of cusp (in mm)	**Before restoration**	**After restoration**	**After thermocycling**
Mean ± s.d.	12.16±0.27	12.10±0.23	12.14±0.23
Median	12.2	12.1	12.2
Range	11.9 - 12.6	11.9 - 12.5	11.8 - 12.4

Bucco-Palatal width of cusp (in mm) of Group-C

Dye penetration	Group-A	Group-B	Group-C
Mean ± s.d.	1.90±1.10	1.60±0.70	1.80±0.79
Median	1.5	1.5	2.0
Range	1 - 4	1 - 3	1 - 3

Dye penetration of three groups

Conclusion:-

Although it was not statistically significant, it can be concluded within the confines of this in vitro study that on the large MOD cavities, Nano composite and hybrid glass ionomer had higher cuspal deflection and microleakage than Bulk fill composites.Additional in vitro and clinical research is required to validate the results of the laboratory.

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