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To Study Fracture Resistance of Interlig^{Tm} Glass Fiber Orientation and Placement on Large Class Ii Cavities in Maxillary Premolars: An *In Vitro* Study

SAMAR KHAN*, MUSKAN SITLANI, SUCHI PANDEY, SANTOSH KUMAR SINGH, PANKAJ MISHRA and ANU NARANG

Department of Conservative and Endodontics, Peoples College of Dental Science and Research Centre, Bhopal, M.P.

Abstract

To examine & assess how varied InterligTM glass fibre placement & orientation affect fracture resistance of large class II cavities in maxillary premolars -An In Vitro study. Class II (MOD) cavities were organized with uniform dimensions on 50 extracted human maxillary premolars, and samples were erratically distributed into 5 groups (n = 10 each) as follows: Group I contains composite materials, Group II contains composite + horizontal Interlig placement on the gingival & pulpal floors, Group III contains composite + horizontal Interlig placement only on the pulpal floors, Group IV contains composite + vertical Interlig placement on the gingival & pulpal floors, and Group V contains composite + Interlig chips. Fracture resistance of all samples was tested using universal testing machine following restorations and the thermocycling process. Under a stereomicroscope, the fracture modes were examined. One-way ANOVA & Tukey test were used to analyse data, with significance values of P 0.05. The fracture strength of control group was 736.8640 N while it was 1233.4480 N for group 2, 1223.2260 N for group 3, 1185.0440 N for group 4 and 797.5600 N for group 5. Fracture strength of group 5 was more than other groups except for group 1, there was no statistically substantial modifications. Fortification of composite with fiber does upsurge fracture resistance of wide Class II mesio-occluso-distal premolars cavities significantly.

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Keywords

Fracture Resistance of Large Class;
Fibre Placement and Orientation;
Interlig^{tm} Glass;
Reinforced Composite.

Introduction

One of challenging situations in field of operative dentistry is restoring a tooth that has suffered from significant caries. The challenge for dentist is to realm remaining tooth structure & rebuild it with material that has great strength & adequate

CONTACT Samar Khan khansamar1610@gmail.com Department of Conservative and Endodontics, Peoples College of Dental Science and Research Centre, Bhopal, M.P.

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clinical performance when both marginal ridges are affected by caries. The preparation of broad Class II mesio-occluso-distal (MOD) cavities reduces the teeth's ability to resist fracture due to the removal of marginal ridges and diminished strength. An optimal dental restoration can maintain a tooth's appearance and functionality, protect remaining tooth structure & prevent micro leakage.[1,2]

The dental structure has been strengthened significantly by modern adhesive techniques and composite resins. Higher clinical performance with lower polymerization shrinkage & enhanced resistance to withstand stresses of mastication has been made possible by the emergence of newer dental composites with improved qualities as a result of considerable research and molecular-level advancements.[2,3] While this, the composite resin lacks toughness rather than strength or stiffness despite being a rigid material. Toughness is interpreted as ability of material to captivate energy to rapid propagation of cracks.[4] Composites' polymerization shrinkage causes stress to build on surrounding tooth structure, which causes microcracks to form & predisposes tooth to fracture.[5]

Due to their anatomical design, maxillary premolars are more prone to fracture because their high cuspal inclines cause cuspal separation during mastication. Furthermore, worst case scenario in terms of fracture resistance is presented by the formation of MOD cavities in these teeth.

New studies have shown that adding fibres to composite reinforcement can boost the restoration's fracture strength since fibres have desired features like strong flexural strength, enhanced impregnation with resin, decent adhesion, & no mechanical retention. By dispersing and distributing stress within the composite resin, fibres reduce stress transmission to the remaining tooth structure.[7,8] Each fiber of Angelus Interlig Braided Glass Fiber is permeated with light-cured composite resin. As a consequence, single fibres act as crack plugs. Individual fibres function as fracture stoppers as a result by altering the direction of the stress, which finally causes the strain to dissipate. The crack shielding mechanism is reinforced when the Interlig fibres are carefully adapted to internal features of remaining tooth substrate. Interlig's braided structure aids in stress distribution over a larger area and hence offers multiple load routes. The distribution and management of polymerization shrinkage and occlusal load strains are improved. The Interlig fibres, when put directly against cavity walls, perform similarly to Dentino-enamel complex, which aids dentin & enamel in working together in strain harmony. This allows tooth substrate & restorative composite to work in harmony.[9]

In addition to the standard aesthetic, superior handling, & one-visit treatment features of composite restorations, fiber-reinforced composite (FRC) offers clinicians these additional benefits. Augmented fracture strength in these kinds of restorations might be the result of cuspal splinting together after applying fibre, and fibre treatment with plasma promotes stronger adhesion to the resin matrix. Although adding fibre can enhance the mechanical properties of composite & upsurge specimen fracture strength, this approach is only effective in certain directions, as using fibre in the mesiodistal and buccolingual regions can result in teeth surface splinting and be useful in boosting specimen fracture strength. Although fibre properties are well understood, little is known about how they affect composite restorations. Eakel disclosed that fiber composition, form, direction, volume percentage to resin, & strength of bond to resin affect fiber function in composite restorations.[10,11]

Therefore, objective of this study is to scrutinise & evaluate how varied Interlig™ glass fibre placement & orientation affect fracture resistance of large class II cavities in maxillary premolars -An In Vitro study.

Materials & Methods

For study, 50 extracted human maxillary premolars from orthodontic patients were used. Study only included fully erupted teeth with closed apices, healthy enamel & dentin free of caries, fractures, restorations, or developmental issues. Periodontal scalers were used to remove plaque, calculus, tissue fragments, and other deposits. These were kept in 10% formalin with phosphate buffers.

All of the specimens had Class II (MOD) cavities cut into them using airotor hand piece & straight fissure diamond bur (SF - 12C; Mani Da Burs). Gingival cavo surface edge was preserved 1.5 mm above CEJ, and all cavities were cut uniformly, preserving buccal & lingual wall thickness 2.5 0.2 mm from height of contour. Uniformity was assessed using UNC-15 periodontal probe. Except for axio-pulpal line angles, no bevel was specified. Four teeth were prepared with one bur. They were set in an acrylic resin block with a cold cure that is 1.5 mm apical to the CEJ. Light body elastomeric impression material was pragmatic over root surfaces to feign periodontal ligament.

Then, teeth were erratically distributed into five groups, with n = 10 in each group.

Group I (n = 10)
Composite

Group II (n = 10)
Horizontal glass fiber (Angelus Interlig Braided Glass Fiber) were inserted on gingival & pulpal floor + Composite

Group III (n = 10)
Horizontal glass fiber (Angelus Interlig Braided Glass Fiber) was inserted only on pulpal floor + Composite
Group IV (n = 10): Vertical glass fiber (Angelus Interlig Braided Glass Fiber) were inserted on gingival & pulpal floor + Composite

Group V (n = 20)
Glass fiber chips (Angelus Interlig Braided Glass Fiber) were inserted on gingival and pulpal floor + Composite

To support the restoration placement matrix band (Hahnenkratt, Benzstrasse, Germany) and-Tofflemire retainer (API, Schweinfurt, Germany) was used around each prepared tooth & low-fusing compound (DPI, Mumbai, India).

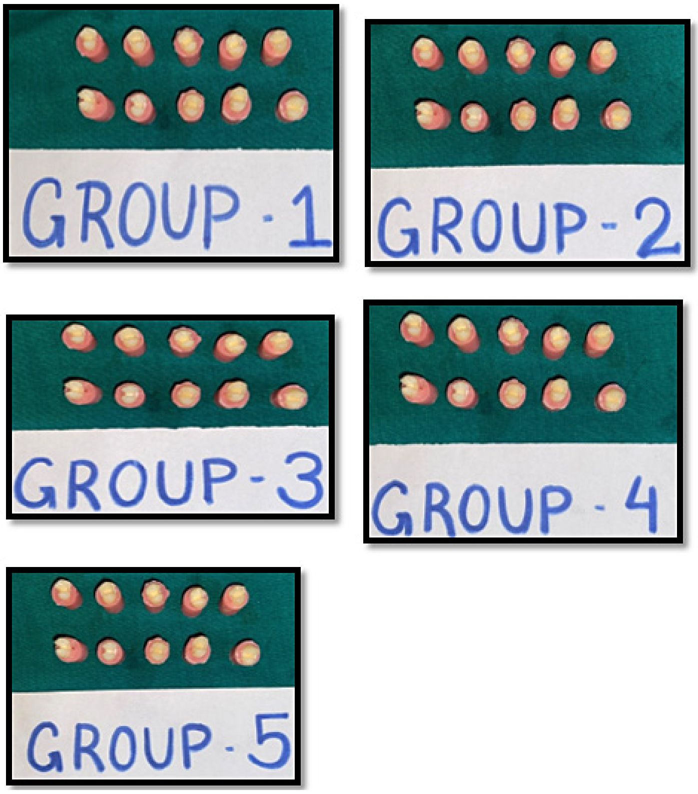


Fig. 1: sample divided into 5 groups

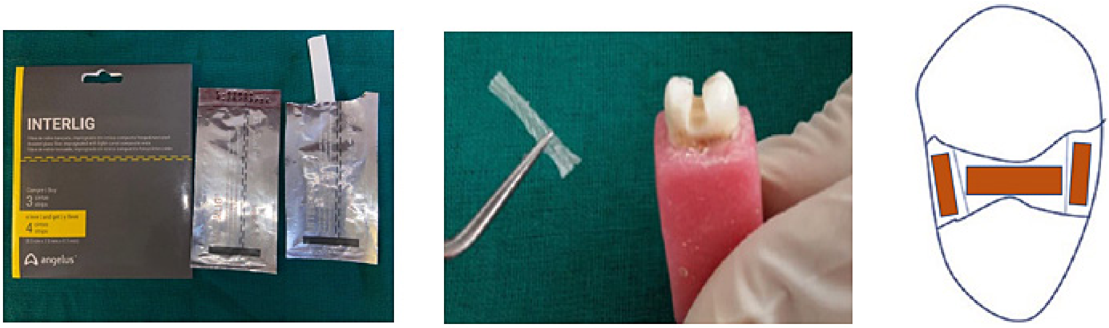
Group 1
Using Ivoclar Eco-Etch (Ivoclar Vivadent, Liechtenstein, Austria), teeth were etched and left for 20 seconds. Tooth surfaces were then gently dried for 1-2 seconds while being washed for 10 seconds to maintain the dentin's moist state. Following the manufacturer's recommendations, Ivoclar Vivadent Te-econom Bonding Agent (Ivoclar

Vivadent, Liechtenstein, Austria) was applied, and it was then cured using an Astralis 7 light-curing device for 10 seconds at 400 mW cm2 light intensity. Each tooth was surrounded by metal matrix held in place by retainer. A cavity was filled with Ivoclar Tetric N Ceram composite resin, which was applied using incremental layering method in 2 mm increments. Light curing was done for 40 s for each increment. Removing band, curing was again done from all sides for 40 s.

Fig. 2: etching of the samlpe

Fig. 3: application of bonding agent

Fig. 4: composite filling by layering technique



(a) (b) (c)

Fig. 5: a & b Interlig glass fiber

Fig. 5: (c) horizontal insertion on gingival and pulpal floor

Group 2

Etching and bonding is done as group 1. The interlig glass fibre (Angelus Interlig Braided Glass Fiber) was then placed horizontally inside the cavity using 0.1 mm thick flowable composite resin on gingival & pulpal floor & light-cured for 40 s. The pieces of interlig glass fibre were then cut to almost 1 mm less than bucco-lingual dimension. After that, Ivoclar Tetric N Ceram composite was added in 2-mm increments to the remaining cut cavity, just like Group 1.

Group 3

Etching and bonding is done as group 1. The interlig glass fibre (Angelus Interlig Braided Glass Fiber) was then placed inside the cavity using 0.1 mm thick flowable composite resin on the pulpal floor only, & light-cured for 40 seconds. Interlig glass fibre was then cut into pieces that were almost 1 mm smaller than bucco-lingual dimension. Ivoclar Tetric N Ceram composite was then placed into rest of cut cavity in 2-mm increments similar to Group 1.

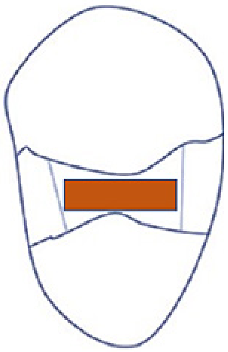


Fig. 6: horizontal insertion on pulpal floor

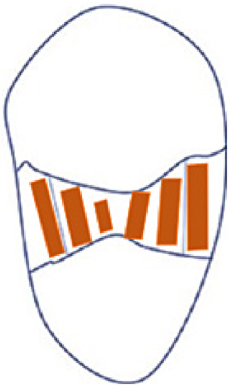


Fig. 7: vertical insertion on gingival and pulpal floor

Group 4

Etching and bonding is done as group 1. The interlig glass fibre (Angelus Interlig Braided Glass Fiber) was then placed vertically inside the cavity using 0.1 mm thick flowable composite resin on gingival & pulpal floor & light-cured for 40 s. The pieces of interlig glass fibre were then cut to almost 1 mm less than bucco-lingual dimension. Ivoclar Tetric N Ceram composite was then placed into rest of cut cavity in 2-mm increments similar to Group 1.

Group 5

Etching & bonding is done as group 1. Interlig glass fibre (Angelus Interlig Braided Glass Fiber) pieces were then divided into little chips rather than an insert & placed on pulpal & gingival floors. Utilizing flowable composite resin that is 0.1 mm thick on gingival & pulpal floor & light-cured for 40 s inside the cavity After that, Ivoclar Tetric N Ceram composite was added in 2-mm increments to the remaining cut cavity, just like Group 1.

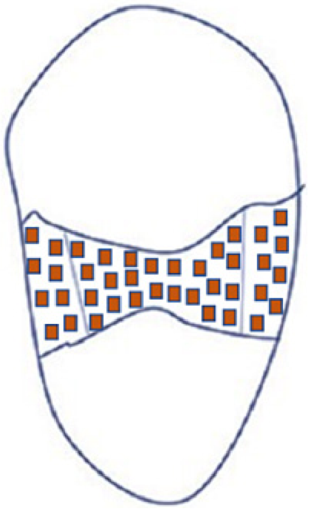


Fig.8: chips dispersed on gingival and pulpal floor

Restorations were done using graded succession of aluminium oxide discs (Sof-Lex TM, 3M ESPE). Thermocycling was then performed on all teeth in accordance with ISO standard 11405 for 500 cycles at 5 to 55 degrees Celsius with 30-second dwell period. following a 24-hour incubation period at 37°C in an incubator.

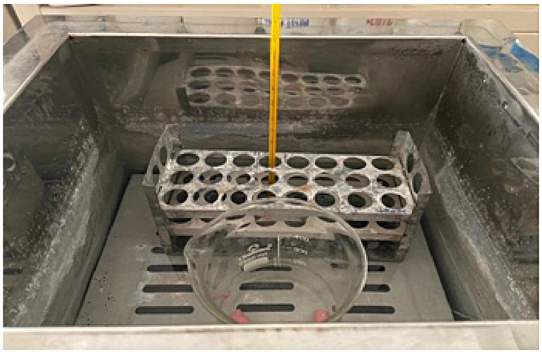


Fig. 9: thermocycling of the samples

To Measure the Fracture Strength

Instron universal testing equipment (TINIUS OLSEN/ H50KL, India Pvt. Ltd., Uttar Pradesh), 2 mm diameter round bar was used to apply compressive force at strain rate of 0.5 mm/min while positioned centrally over occlusal surface of teeth & parallel to their long axes. Each tooth's fracturing forces were measured in Newtons (N).

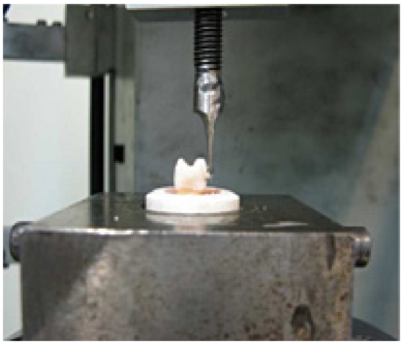


Fig.10: sample on universal testing machine

Favourable Fracture

(a)

(b)

(c)

Fig.11: a,b&c sample with favourable fracture of group

Unfavourable Fracture

(d)

(e)

Fig.12: d&e sample with unfavourable fracture of group

Following measurement of force, each specimen was visually scrutinized to regulate kind of fracture mode. According to Sáry *et al.,*[11] a distinction was made between repairable fractures (fractures above CEJ) and nonrepairable fractures (fractures below CEJ) under stereomicroscope.

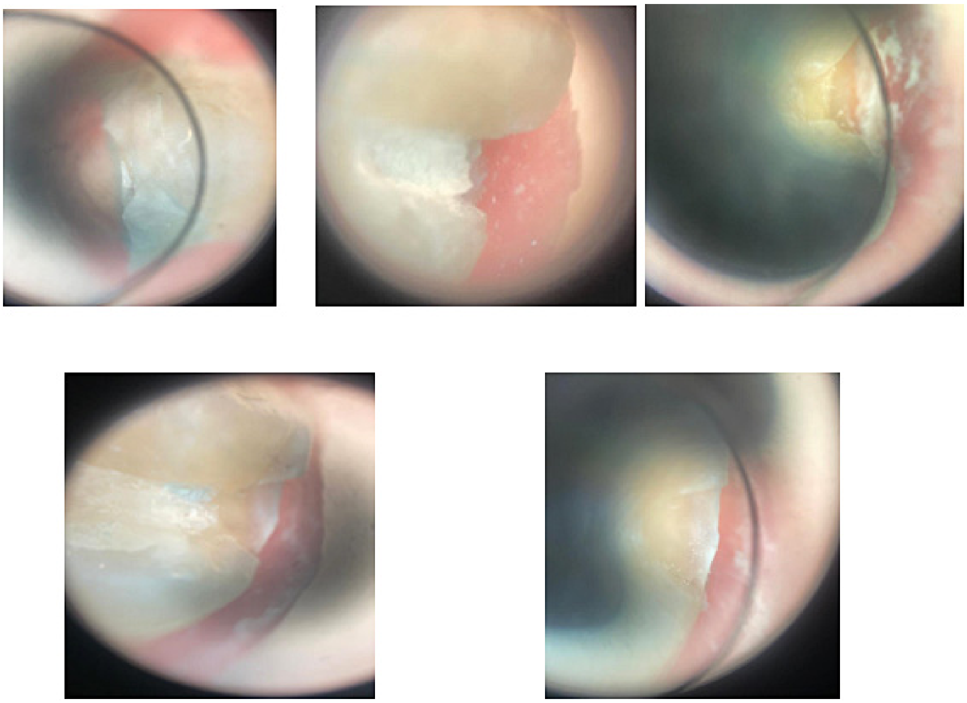


Fig.13: Images of stereomicroscope displaying repairable (fracture above CEJ) or nonrepairable fractures (Fracture below CEJ) from group 1-5

Table 1: Mean & Statistical Significant Differences between groups using one way ANOVA n =50

Groups	Sample Size N	Range	Minimum	Maximum	Mean	SE	SD	P
Group-1	10	996.91	422.50	1419.41	736.8640	118.76653	375.57276	<0.001*
Group-2	10	581.89	921.96	1503.85	1233.4480	63.39029	200.45768	
Group-3	10	723.99	903.74	1627.73	1223.2260	77.77256	245.93844	
Group-4	10	540.97	982.96	1523.93	1185.0440	60.56194	191.51368	
Group-5	10	1312.42	381.71	1694.13	797.5600	158.30856	500.61562	

SE- Standard Error
SD- Standard Deviation
*. Correlation is noteworthy at 0.05 level (2-tailed).

Results

Results indicated that Group 2 had highest mean fracture resistance, followed by Groups 3, 4, & 5. Lowermost mean fracture resistance was seen in Group 1 (Non-fiber group). In a one-way ANOVA, statistically substantial difference (P 0.001) was discovered between each group [Table 1]. For intergroup comparisons, Tukey's honestly significant difference test was applied, and the findings [Table 2] revealed that several of the groups exhibited statistically substantial differences. Mean difference in fracture resistances between groups 1 & 2 is statistically & ominously higher, & it is followed by mean difference between groups 2 & 5, which is also confirmed to be statistically substantial. Mean difference in fracture resistance between Groups 1 & 2 is also shown in this table & remaining groups are extremely statistically substantial at 1% level of connotation. Same is true for Group 2, that is, mean difference in fracture resistance between Group 2 & remaining groups is similarly highly substantial at 1% level of significance. While mean differences in fracture resistance for Groups 3, 4, & 5 are statistically & substantially different from Groups 1 & 2 alone, mean differences in fracture resistance for other groups are inconsequential.

Table 2: Intergroup Multiple comparisions of means and intergroup significant level

Group I	Group J	Mean difference (I-J)	SE	Sig. P	95% Confidence Interval	
					Lower	Upper
Group-1	Group-2	-496.58400	103.50806	.149	-730.73549	-262.43251
	Group-3	-486.36200	180.09624	.036*	-893.76800	-78.95600
	Group-4	-448.18000	140.57505	.703	-766.18286	-130.17714
	Group-5	-60.69600	206.29536	.804	-527.36854	405.97654
Group-2	Group-3	10.22200	113.43188	.427	-246.37875	266.82275
	Group-4	48.40400	86.99711	.967	-148.39714	245.20514
	Group-5	435.88800	183.76203	.516	20.18940	851.58660
Group-3	Group-4	38.18200	117.19691	.219	-226.93583	303.29983
	Group-5	425.66600	199.42181	.319	-25.45748	876.78948
Group-4	Group-5	387.48400	104.43873	.000*	151.22717	623.74083

**. Correlation is substantial at 0.01 level (2-tailed).

*. Correlation is substantial at 0.05 level (2-tailed).

Integration of fibres in various orientations & places has affected ratio of repairable to nonrepairable fractures in terms of fracture mode. The highest proportion of repairable fractures (70%) was found in Group II (horizontal fibres both on gingival & pulpal floor), followed by Group III (horizontal fibres on the pulpal floor) and Group IV (vertical insertion on gingival and pulpal floor) with a ratio of 60%, and the lowest proportion (40%) was found in Group I (Composite alone).

Table 3: Outcomes of Failure Mode in Number (%)

S.no	Favourable Fracture	Unfavourable Fracture
GROUP-1	4	6
GROUP-2	7	3
GROUP-3	6	4
GROUP-4	6	4
GROUP-5	5	5

Discussion

A major challenge the clinician faces is to restoring the class II cavity. The restoration's goal is to strengthen, restore, and repair the tooth. With adhesive restorations, functional stresses can be transferred and distributed across bonding contact to tooth structure more effectively. Since nanocomposites have dense filler loadings, they function better. The fillers' lower sizes enable them to have both outstanding mechanical and great optical qualities.[12,13] Composite resins are not often used for large repairs because of their fragility, despite breakthroughs in material sciences. Fibre reinforcement has been demonstrated to give composite resins strength and toughness. With fibre reinforcement, it has been reported that both direct and indirect composite resins' flexural strength greatly increases.[14,15]

Premolar teeth were included for this research since they are more likely than molars to be imperilled to lateral stresses that are added destructive in nature. When repairing upper premolars, aesthetic standards should be fulfilled given their location in the aesthetic zone. Clinically, the average biting force for the maxillary premolar area is 222-445 N (average 322.5 N), and during clenching, occlusal force can reach 520-800 N. (average 660 N).[16,17]

The fibres used in this study, Interlig™ (Group B), are made of glass fibres that have been braided together and pre-impregnated with light-curable composite resin. As done by Vineet et al., fibres were positioned differently on the gingival and pupal floor in this study.[2] In totalling, fracture resistance upsurges when fibres are placed close to point where force is exerted as it leads to a shorter working arm according to levers principle.[18,19]

In a study conducted by Jafari Navimipour *et al.*[6] over and under the restoration with glass fibre greatly boosts fracture resistance. In their investigation, the application of occlusal & circumferential fibres resulted in fracture resistance that was higher than that of circumferential fibre alone, but not ominously higher than that of occlusal fibre group. Other research by Kolbeck *et al.,*[20] Sharafeddin *et al.,*[21] & Kamble *et al.*[22] revealed that glass fibres have a stronger reinforcing effect than polyethylene fibres. These findings were at odds with those of Oskoee *et al.,*[18] who discovered that polyethylene fibre had higher fracture resistance than glass fibre. Cause for variance in outcomes could be due to abridged adhesion between polyethylene fibres & resin matrix as previous studies have used untreated polyethylene fibres.

Outcomes of present study revealed that glass fiber in gingival and pulpal floor group had highest mean fracture resistance. Among experimental groups, Group 2 had uppermost mean fracture resistance (1233.4480 N) followed by Group 3 (1223.2260 N), Group 4 (1185.0440N), and Group 5 (797.5600 N) while no fiber group have least fracture resistance of 736.8640 N

One-Way ANOVA test done in existing study discovered statistically substantial difference (P = 0.001) between all groups [Table 1].

The results for Group 2 (fibre placed horizontally on both pulpal & gingival floor) showed better fracture resistance, which may be related to the following factors,

1. Horizontal fibre placement covers a wider surface area (pulpal and gingival), increasing its ability to withstand stresses and distributing them evenly over the broad surface area.
2. Because the structure of the Interlig™ fibre is preserved and not chopped (as in Group 5), there may be an enhancement in fracture resistance.
3. Increase fiber quantity, properly adapt to gingival floor, & lessen shrinkage stress during composite resin polymerization
4. If longitudinal axis of fibres is perpendicular to compressive forces, fibres improve strength of restoration, however, if longitudinal axis of fibres is parallel to compressive forces, matrix fails & strength is not increased.[2]

According to position of fracture line in respect to cementoenamel junction, which is helpful in envisaging prognosis of restored tooth in case of failure, failure modes were categorised as favorable & unfavorable. No-fibre group with only composite restoration has relatively low fracture resistance, & majority of failures (60%) were adverse, according to findings [TABLE-3]. For group 2, application of fibres improved fracture resistance (70% were favourable in nature). Groups 3 and 4 display a favourable fracture of 60%.

Since the tooth can still be treated by using techniques like post and core followed by a full crown, clinicians may find this to be very beneficial. Furthermore, Reeh et al[23] study's demonstrated relative loss of stiffness of 5% as a result of endodontic procedures and a 63% decrease in MOD cavity preparation, whereas current study discovered relatively smaller reduction of 30-40% in fracture resistance of MOD cavity preparation reinstated with nanocomposites or nanocomposites restored with diverse fibres.

Conclusions

Within confines of study, it can be clinched that.

1. Glass fibre inserts considerably increase the fracture resistance of Class II composite restorations.
2. The maximum fracture resistance in maxillary premolars is provided by broad class II MOD cavities with horizontally oriented fibre on both the pulpal and gingival floor.

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Conflict of Interest

No

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