ISSN (O) : 2582-3271
PubMed-National Library of Medicine - ID: 101766917

International Journal of Dental Science and Clinical Research (IJDSCR)

Dr. Angel Vaidic Publication

Available Online at: http://www.ijdscr.org

Volume - 8, Issue – 2, April - 2026, Page No. : 01 – 10

Comparative Evaluation of Load Bearing Capacity of Inter Rim Fixed Partial Dentures Reinforced With E-Glass Fibers and Polypropylene Fibers: An In Vitro Study

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Citation of this Article: Dr. Madhusudhan Amudalapalli, Dr. Ch. Siddesh Kumar, Dr. K. Jagadish, Dr. L. Srikanth, Dr. M. Vasavi, Dr. B. Rajasekhar, "Comparative Evaluation of Load Bearing Capacity of Inter Rim Fixed Partial Dentures Reinforced With E-Glass Fibers and Polypropylene Fibers: An In Vitro Study'' IJDSCR – April – 2026, Vol. – 8, Issue - 2, Page No. 01-10.

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Type of Publication: Original Research Article

Conflicts of Interest: Nil

ABSTRACT

Background

Inter-rim fixed partial dentures (FPDs) used as interim restorations are subjected to occlusal forces that may lead to fracture. Fiber reinforcement is recommended to enhance their mechanical strength, but comparative evidence between different fiber types remains limited.

Aim

To compare the load-bearing capacity of inter-rim FPDs reinforced with E-glass fibers and polypropylene fibers.

Materials and Methods

Forty-three-unit interim FPD specimens were fabricated and divided into four groups (n=10) based on pontic design (hygienic and modified ridge lap) and type of fiber reinforcement (E-glass or polypropylene). Load-bearing capacity was evaluated using a universal testing machine (Autograph AG-IS 50 KN, Shimadzu Corporation) at a crosshead speed of 2.5 mm/min. The maximum fracture load was recorded in Newtons and analyzed using one-way ANOVA (α=0.05).

Results

The overall mean fracture load was 1344 N. The hygienic pontic reinforced with polypropylene fibers showed the highest mean value (1518 N), whereas the modified ridge lap pontic reinforced with polypropylene fibers demonstrated the lowest mean value (1077 N). No statistically significant difference was observed among the groups ($p>0.05$).

Conclusion

Both E-glass and polypropylene fibers improved the load-bearing capacity of interim inter-rim FPDs. Within the limitations of this in vitro study, both fiber types can be considered clinically acceptable reinforcement options.

INTRODUCTION

Restoration of partially edentulous arches using fixed partial dentures remains a key component of prosthodontic treatment. Inter-rim fixed partial dentures are commonly used as interim restorations but are often subjected to significant occlusal forces[1,2]. Inadequate strength may lead to fracture and failure of these prostheses. Fiber-reinforced composite materials have been introduced to enhance the mechanical properties of such restorations[3,4]. Among available fibers, E-glass fibers offer high tensile strength and rigidity, while polypropylene fibers provide toughness and resistance to crack propagation[5,6]. Reinforcement with these fibers improves stress distribution within the prosthesis. However, limited evidence exists comparing their load-bearing capacity in inter-rim fixed partial dentures[7]. A comparative evaluation is therefore necessary.

AIM

To comparatively evaluate the load-bearing capacity of inter-rim fixed partial dentures reinforced with E-glass fibers and polypropylene fibers.

OBJECTIVE OF THE STUDY

To comparatively evaluate the load-bearing capacity of inter-rim fixed partial dentures reinforced with E-glass fibers and polypropylene fibers.

NEED OF THE STUDY

Inter-rim fixed partial dentures are commonly used as interim restorations but are prone to fracture under occlusal forces.Fiber reinforcement can improve their mechanical strength.However, limited data exist comparing different fiber types.E-glass and polypropylene fibers differ in their properties and stress distribution.This study aims to identify the most effective fiber for enhancing prosthesis durability.

MATERIALS AND METHODS:

The materials used included dental die stone, dental plaster, and cold mould seal for model preparation and processing.A micromotor handpiece, airotor, TC burs, mandrel bur, cotton buff bur, and Super Endo tooth preparation bur kit were used for tooth preparation and finishing.E-glass fibers and polypropylene fibers were used as reinforcement materials.DPI tooth moulding powder,Zeta Plus putty by Zhermack, typodont teeth set, porcelain jar, and dispenser were also utilized.(Figure 1)

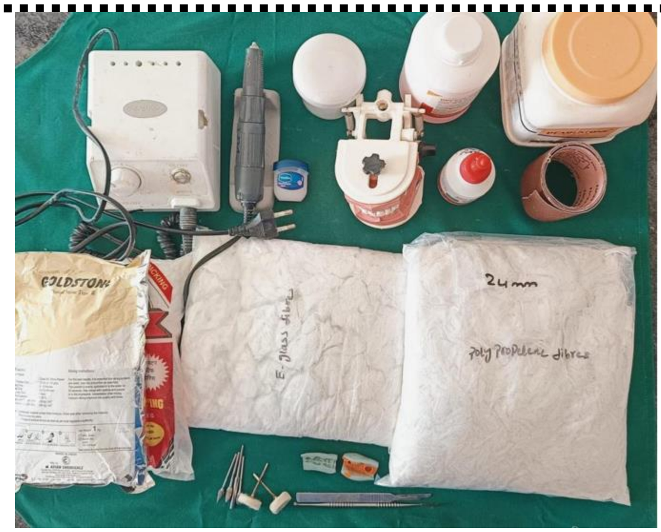


Figure No 1: Armamentarium for interim fixed partial denture using E- glass and Polypropylene fibers.

PREPARATION OF TEETH FOR THREE UNIT BRIDGE

Tooth preparations for porcelain fused metal (PFM)-FPDs on typodont teeth were done. For three-unit bridge, 35 and 37 were prepared using diamond points. Once prepared, impressions were made with the addition of silicone putty and light body India) with wax-shaped according to the two types of pontics (modified ridge lap and hygienic) placed in the pontic area of the typodont. Impressions, each was made for three unit bridge with the type of pontic design needed.(Figure 2&3)

Figure No 2: Three-unit preparation on typodont jaw set

Figure No 3: Three-unit preparation on typodont teeth

A die for unprepared three-unit was made out of die stone (type IV) with the help of a putty index of the typodont teeth before preparation. Modeling wax was added to the dies for increasing its height and width by 10 cm each for making a base. Putty index of these two were made to pour in all the 40 dies in the exact dimension of plaster base. (Figure 4)

Figure No 4: 40 die samples preparation with plaster base

PREPARATION OF REINFORCED INTERIM RESTORATIONS

Die was coated with a layer of petroleum jelly as a separating medium. The glass fibers were placed at each die in its position and DPI Tooth moulding temporary material was dispensed into the putty index. The index was placed over the die till the material was set. Once set, the temporary bridge was removed from the die. The fibers were embedded into the DPI Temporary tooth moulding interim bridge.(Figure 5&6)

Figure 5: Putty index of unprepared teeth (Left 3-unit FPD 35 TO 37)

Figure No 6: Preparation of three unit bridge

Standardized inter-rim fixed partial denture specimens were fabricated and divided into four groups based on fiber reinforcement.

Table 1: Groups included in the study

Group-1	Three-unit F.P.D With Hygienic pontic reinforced with E-glass fibre
Group-2	Three-unit F.P.D With Hygienic pontic reinforced with Polypropylene fibre
Group-3	Three-unit F.P.D With modified ridge lap pontic reinforced with E-glass fibre
Group-4	Three-unit F.P.D With modified ridge lap pontic reinforced with Polypropylene fibre

All specimens were tested for load-bearing capacity using a universal testing machine until fracture, and the maximum fracture load was recorded and statistically analyzed.

TESTING OF SAMPLES

The load-bearing capacity was evaluated using a Autograph AG-IS 50 kN Universal Testing Machine (Shimadzu Corporation, Japan). The machine had a maximum load capacity of 50 kN and was operated at a crosshead speed of 2.5 mm/min.

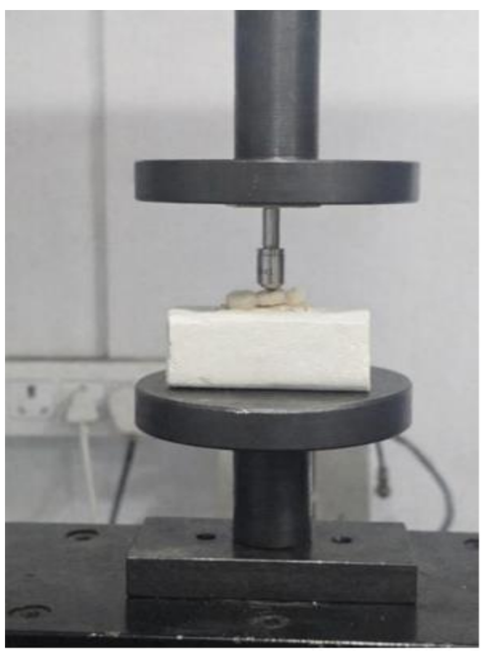


Figure no 7: Load bearing capacity tested by Universal testing machine

A stainless-steel ball indenter of 6 mm diameter was used to apply the load. The force was applied at the center of the pontic region corresponding to tooth 36 in the three-unit fixed partial denture specimens, and this loading position was standardized for all samples.

The load was applied continuously until fracture of the interim restoration occurred. The maximum load at fracture was recorded in Newtons (N) using the inbuilt software of the testing machine. The collected data were collated, tabulated, and subjected to statistical analysis.

RESULTS

Table 2: Descriptives of Load bearing (N) across study groups

Group	Material	Mean	Std. Error	Std. Dev	Median	Min	Max
Group-1	Hygienic Pontic + E-glass	1342	204.23	645.85	1630	500	2140
Group-2	Hygienic Pontic + Polypropylene	1518	47.39	149.87	1540	1280	1730
Group-3	Modified Ridge Lap + E-glass	1439	222.50	703.61	1700	580	2450
Group-4	Modified Ridge Lap + Polypropylene	1077	137.64	435.27	1150	520	1820
OVERALL (Avg)		1344	152.94	483.65	1505	720	2035

Table 3: Inter-group comparison of Load bearing (N) across all the study groups

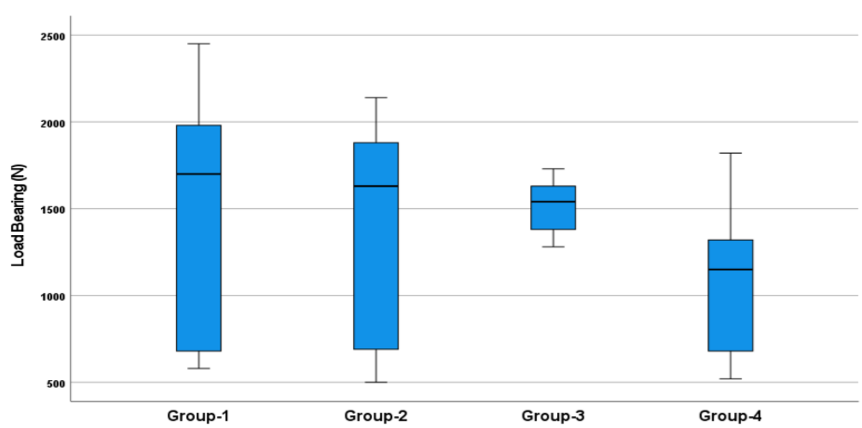
	Sum of Squares	df	Mean Square	F	p-Value
Between Groups	1105940	3	368646.667	1.312	0.286
Within Groups	10117220	36	281033.889		
Total	11223160	39			

One way ANOVA test: p-Value >0.05-non-significant

Table 4: Pairwise comparison of Load bearing (N) across all the study groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-Value	95% CI Lower Bound	95% CI Upper Bound
Modified Ridge Lap + E-glass	Hygienic Pontic + E-glass	97	237.08	1.0	-564.92	758.92
	Hygienic Pontic + Polypropylene	-79	237.08	1.0	-740.92	582.92
	Modified Ridge Lap + Polypropylene	362	237.08	0.813	-299.92	1023.92
Hygienic Pontic + E-glass	Modified Ridge Lap + E-glass	-97	237.08	1.0	-758.92	564.92
	Hygienic Pontic + Polypropylene	-176	237.08	1.0	-837.92	485.92
	Modified Ridge Lap + Polypropylene	265	237.08	1.0	-396.92	926.92
Hygienic Pontic + Polypropylene	Modified Ridge Lap + E-glass	79	237.08	1.0	-582.92	740.92
	Hygienic Pontic + E-glass	176	237.08	1.0	-485.92	837.92
	Modified Ridge Lap + Polypropylene	441	237.08	0.426	-220.92	1102.92
Modified Ridge Lap + Polypropylene	Modified Ridge Lap + E-glass	-362	237.08	0.813	-1023.92	299.92
	Hygienic Pontic + E-glass	-265	237.08	1.0	-926.92	396.92
	Hygienic Pontic + Polypropylene	-441	237.08	0.426	-1102.92	220.92

Graph -1: Load bearing (N) across study groups



The overall mean load-bearing capacity was 1344 N (SD 483.65 N; range 720–2035 N).

Among the study groups, Hygienic Pontic + Polypropylene (Group-2) showed the highest mean value (1518 N) with the least variability (SD 149.87 N), indicating more consistent performance. Modified Ridge Lap + Polypropylene (Group-4) demonstrated the lowest mean load-bearing capacity (1077 N). The greatest variability was observed in Modified Ridge Lap + E-glass (Group-3) (SD 703.61 N).

One-way ANOVA revealed no statistically significant difference in load-bearing capacity among the four groups ($F = 1.312$; $p = 0.286$).

Post-hoc Bonferroni analysis confirmed the absence of significant pairwise differences, with all comparisons showing $p > 0.05$ and 95% confidence intervals crossing zero. The largest observed mean difference (441 N between Group-2 and Group-4) was also non-significant ($p = 0.426$).

DISCUSSION

Interim fixed partial dentures are subjected to functional occlusal forces, particularly in the posterior region, making reinforcement essential to prevent fracture[8,9]. In this in vitro study, the overall mean load-bearing capacity (1344 N) exceeded average physiological masticatory forces, indicating that fiber-reinforced inter-rim FPDs can withstand functional loading[10,11].

Among the groups, the hygienic pontic reinforced with polypropylene fibers demonstrated the highest mean load-bearing capacity and the most consistent performance[12,13]. This may be attributed to the toughness and crack-arresting ability of polypropylene fibers, along with favorable stress distribution in the hygienic pontic design[14,15]. The modified ridge lap pontic reinforced with E-glass fibers also showed high mean values but greater variability, possibly due to differences in fiber orientation and bonding within the resin matrix[16,17,18]. The lowest mean load was observed in the modified ridge lap pontic reinforced with polypropylene fibers, suggesting that pontic design may influence stress concentration and fracture behavior[19,20].

However, statistical analysis (ANOVA and Bonferroni post-hoc test) revealed no significant difference among the groups ($p > 0.05$). Within the limitations of static loading and in vitro conditions, both E-glass and polypropylene fibers provided comparable reinforcement[21,22]. Therefore, either fiber type may be considered suitable for strengthening interim inter-rim fixed partial dentures[23,24].

CONCLUSION

Within the limitations of this study, both E-glass and polypropylene fiber reinforcements improved the load-bearing capacity of inter-rim fixed partial dentures. Although polypropylene fibers in hygienic pontic design showed the highest mean fracture resistance, no statistically significant difference was found between groups. Therefore, both fiber types can be considered viable reinforcement options for interim fixed partial dentures.

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