Effect of Location and Extent of Glass Fiber Reinforcement on the Flexural Properties of Complete Denture

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Abstract-

Background- Breakage of complete dentures made of acrylic resins is one of the most unsolvable difficulties in prosthodontics. Reinforcement of complete dentures made of resins with metal wire has been done in the past to toughen them up and prevent them from breaking in clinical situations. Over the last two decades, glass fibres have been employed to enhance resin-based full dentures. During this time, there were few studies that looked at both glass fibre and metal reinforcement. However, till now there has been no study focussing on the effect of extent and location of fibres of glass for strengthening of the acrylic based complete dentures on the flexural properties of these dentures. This study was conducted with an objective of evaluating the effect of location and extent of the glass fibre reinforcement in the flexural properties of the complete dentures prepared from acrylic resin.

Materials and Methods- It was an in vitro study where evaluation was carried out for the effect of the extent and location of the reinforcement with twenty µm glass fibres in the dentures prepared with acrylic resins. The glass fibres were implanted in the complete denture base resin while it was in doughy phase. They were positioned in the four different locations. These locations were i) ridge lap region, ii) palate region in the anterior region, iii) middle region of the denture, iii) anterior and posterior locations of the palate in the denture. The extent of glass fibres reinforcement was studied at four extent of 12%, 16%, 21% and the 31%. This evaluation was carried out with the help of load testing machine (Tokyo,

Japan).The cross speed adjusted was 5.0 mm/ minute. There was ball attachment of diameter 25 mm to apply flexural load on each study specimen.
Results- It was observed that there was significant difference in reinforcement conditions when compared with condition of no reinforcement. But the difference was non significant when there was comparison among reinforcement at four different location and four different on evaluation of the flexural load corresponding to the proportional limit, efficiency of strengthening by the fibres of glass in comparison to the complete dentures having no reinforcement and flexural deflection found at the 100-N loading point
Conclusion- Within the limits of this study it was concluded that glass fibre reinforcement in the acrylic based complete dentures improves the flexural properties but effect of extent and location of glass reinforced fibres on the flexural properties were non significant.
Key words- Glass fibre reinforcement, complete denture, location, extent.

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INTRODUCTION

One of the most unsolved problems of Prosthodontics is the breakage of complete dentures prepared from acrylic resins. Conventionally reinforcement of the complete dentures based on resins with wire of metal has been carried out to toughen these dentures in order to avoid their fracture in clinical settings. Fibres of glass has been used during last twenty years for purpose of strengthening of the resin based complete dentures. During these years there was lack of studies to study both glass fibres reinforcement and metal reinforcement.[1,2]

It has been postulated that strengthening of the denture with fibres of glass can be carried out by two methods. First method involve the strengthening of the whole denture base with interlace of glass fibres. On the other hand second method involve the strengthening with fibres of glass only in the fragile portion. It has been advocated that second method is better option for strengthening of the denture during repairing of denture. This is because second method can be controlled in better manner than first method. Another reason may be role of second method in the avertion of recurring fractures in such dentures prepared from acrylic resins.[3,4] There are several factors which regulate the success of strengthening of dentures with fibres of glass. These factors include material of resin, length, quantity, orientation, shape and linkage properties of glass fibres. It has been advocated in several studies that inadequate interaction between the glass fibres and adjoining resins is the reason for failure in strengthening of the acrylic resins. This problem of inadequate interaction between glass fibres and adjoining resins can be managed by silanization of glass fibres before their embedment in the acrylic resins. Application of extra heat to these silanated fibres is also required.[5,6]

It has been advocated that commencement of fracture in the acrylic resin based dentures can be avoided by positioning of fibres of glass as close to the area of maximum tensile stress in the complete denture. These observations suggest the role of extent and location of the glass fibres in the flexural properties of the complete dentures. According to a scientific study several factors need to be emphasized in partial strengthening of the dentures with fibres of glass. It include accurate location of partial fibre reinforcement for the duration of mastication on the tensile surface, adjustment at a 90 degree angle to the probable line of fracture, length of the fibres of glass used, and precise laboratory methodology.[7,8]

It has been also studied that placement of glass fibres for partial strengthening of the acrylic resin based denture on the tensile surface ended in greater flexural properties like flexural modulas and flexural strength in comparison to the condition when the they were placed at the compressive surface. These findings has put forward a fact that extent and location of fibres of glass for strengthening of the denture prepared from acrylic resin can also play role in the flexural properties. But till now there has been no study focussing on the effect of extent and location of fibres of glass for strengthening of the acrylic based complete dentures on the flexural properties of these dentures.[9,10]

Hence this study was conducted with an objective of evaluating the effect of location and extent of the glass fibre reinforcement in the flexural properties of the complete dentures prepared from acrylic resin.

Material and methods

It was an in vitro study where evaluation was carried out for the effect of the extent and location of the reinforcement with twenty µm glass fibres in the dentures prepared with acrylic resins. In this study denture base resin, dimethacrylate resin and silanized glass fibres were used for preparation of the study specimens. 1: 1 ratio was used for mixing of TEGDMA and UDMA. Camphorquinone 0.7 % by weight was utilized at ratio of 1:2. All the study specimens were dentures in which strengthening with fibres of glass was carried out. There were control which were complete dentures with no added strengthening.

The glass fibres were implanted in the complete denture base resin while it was in doughy phase. They were positioned in the four different locations. These locations were i) ridge lap region,ii) palate region in the anterior region, iii) middle region of the denture, iii) anterior and posterior locations of the palate in the denture. The extent of glass fibres reinforcement was studied at four extent of 12%, 16%, 21% and the 31%.

In each group fifteen study specimens were studied. All the study specimens were placed in the distilled water at a temperature of 37˚C for a duration of fifty hour before testing process is started.Firstly there was evaluation of the flexural load corresponding to the proportional limit complete denture prepared from acrylic resin at different locations and efficiency of strengthening by the fibres of glass in comparison to the complete dentures having no reinforcement. Then there was evaluation of the flexural load corresponding to the proportional limit in complete denture prepared from acrylic resin with different extent of reinforcement and efficiency of strengthening by the fibres of glass in comparison to the complete dentures having no reinforcement. (Figure 1and Figure 2)

Figure 1- Representative image showing impregnation of glass fibers

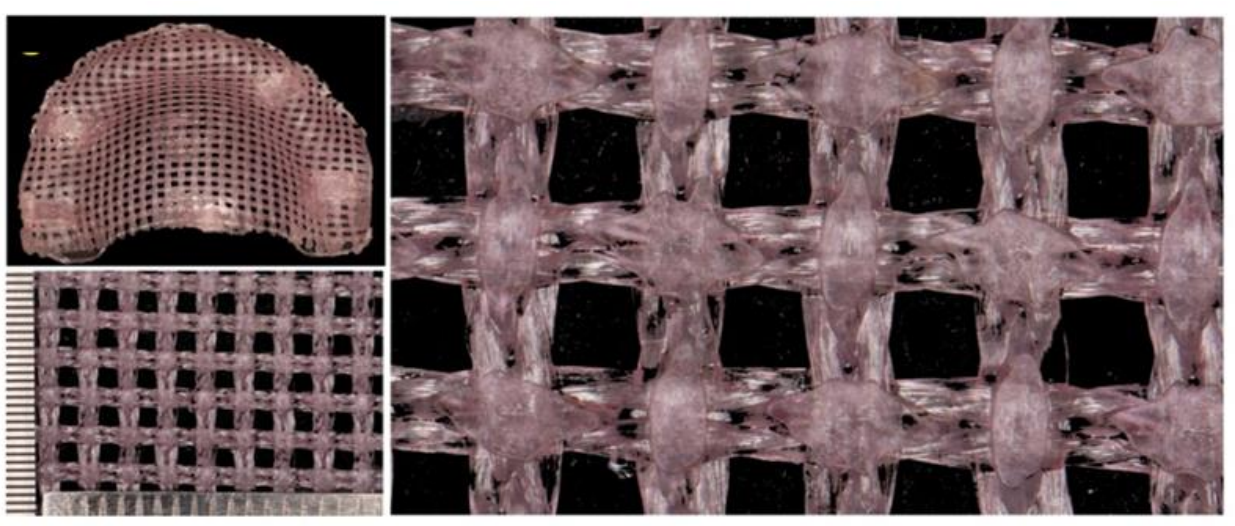

Figure 2- Microscopic structure of Glass fibers

There was evaluation of flexural deflection found at the 100-N loading point in complete denture prepared from acrylic resins with strengthening through fibres of glass at different locations. The same evaluation was carried out for different extent of reinforcement. When there was evaluation for evaluation of different modes of fracture at different locations of strengthening. These evaluation was carried out with the help of load testing machine (Tokyo, Japan).The cross speed adjusted was 5.0 mm/ minute. There was ball attachment of diameter 25 mm to apply flexural load on each study specimen.

The failure of the complete denture was analysed in three patterns. The three patterns were i) Fracture at complete midline, ii) partial fracture at midline and iii) fracture along the reinforcement.

Statistical Analysis

All the collected data were collected and put in the MS excel sheet. Then there was statistical analysis with the help of SPSS software of most recent version. The tests used for statistical analysis was carried out with the help of one way ANOVA and chi square test. The statistically significant criteria were adjusted at $p \leq 0.05$.

RESULTS

In this study there was analysis of extent and location of glass fibre reinforcement in denture prepared from acrylic resin. Four locations were studied ridge lap region, anterior region, middle region both anterior and posterior region. Effect of extent of strengthening was studied for four different extents of 12%, 16%, 21% and 31%. Firstly there was evaluation of the flexural load corresponding to the proportional limit complete denture prepared from acrylic resin at different locations and efficiency of strengthening by the fibres of glass in comparison to the complete dentures having no reinforcement. It was observed that there was significant difference in reinforcement conditions when compared with condition of no reinforcement. But the difference was non-significant when there was comparison among reinforcement at four different location. (Table 1).

Table I. Evaluation of the flexural load corresponding to the proportional limit in complete denture prepared from acrylic resin at different locations and efficiency of strengthening by the fibres of glass in comparison to the complete dentures having no reinforcement (n = 15).

Location at which strengthening with glass fibres carried out	Flexural load corresponding to the proportional limit (N); Calculated mean (Standard deviation)	Efficiency of strengthening	P value
No reinforcement	119.6 (205.7)	1.00	0.07
Location of ridge lap region	2553.9 (234.3)	x1.68	0.01
Location of anterior region	1589.9 (219.0)	x1.86	0.03
Location of middle region	1396.9 (148.9)	x1.65	0.04
Location of anterior and posterior regions	1496.6 (64.9)	x1.76	0.02

Then there was evaluation of the flexural load corresponding to the proportional limit in complete denture prepared from acrylic resin with different extent of reinforcement and efficiency of strengthening by the fibres of glass in comparison to the complete dentures having no reinforcement. It was observed that there was significant difference in reinforcement conditions when compared with condition of no reinforcement. But the difference was non-significant when there was comparison among reinforcement at four different extents. (Table 2).

Table 2: Evaluation of the flexural load corresponding to the proportional limitin complete denture prepared from acrylic resin with different extent of reinforcement and efficiency of strengthening by the fibres of glass in comparison to the complete dentures having no reinforcement (n = 15).

Extent of reinforcement with glass fibres carried out	Flexural load corresponding to the proportional limit (N); Calculated mean (Standard deviation)	Efficiency of strengthening	P value
No reinforcement	219.6 (205.7)	1.00	0.08
12%	3553.9 (234.3)	x1.68	0.02
16%	2589.9 (219.0)	x1.86	0.04
21%	2396.9 (148.9)	x1.65	0.04
31%	2496.6 (64.9)	x1.76	0.04

When there was evaluation of flexural deflection found at the 100-N loading point in complete denture prepared from acrylic resins with strengthening through fibres of glass at different locations then it was found that there was significant difference in reinforcement conditions when compared with condition of no reinforcement. But the difference was non- significant when there was comparison among reinforcement at four different location. (Table 3).

Table 3: Evaluation of Flexural deflection found at the 100-N loading point of complete denture prepared from acrylic resins with strengthening through fibres of glass at different locations (n = 15).

Location at which strengthening with glass fibres carried out	Calculated flexural deflection in mm; calculated mean (Standard Deviation)	P value
No reinforcement	0.245 (0.025)	0.07
Location of ridge lap region	0.014 (0.015)	0.04
Location of anterior region	0.121 (0.007)	0.03
Location of middle region	0.213 (0.008)	0.01
Location of anterior and posterior regions	0.112 (0.009)	0.04

When the same evaluation was carried out for different extent of reinforcement then there was significant difference in reinforcement conditions when compared with condition of no reinforcement. But the difference was non significant when there was comparison among reinforcement at four different extent of reinforcement. (Table 4).

Table 4: Evaluation of flexural deflection found at the 100-N loading point of complete denture prepared from acrylic resins with strengthening through fibres of glass at different locations (n = 15).

Extent of reinforcement with glass fibres	Calculated flexural deflection in mm; calculated mean (Standard Deviation)	P value
No reinforcement	0.245 (0.025)	0.02
12%	0.089 (0.015)	0.08
16%	0.132 (0.007)	0.09
21%	0.121 (0.008)	0.08
31%	0.087 (0.009)	0.07

When there was evaluation for evaluation of different modes of fracture at different locations of strengthening then it was observed that fracture along the entire midline was most common pattern of fracture in dentures without any added strengthening. The most common pattern of fracture was fracture at zone corresponding to reinforcement in the dentures where strengthening was carried out in the anterior and anterior with posterior region. The most common pattern of fracture was partial fracture along the midline in dentures having location of reinforcement in the middle one third.(Table 5).

Table 5: Different patterns of fractures in different locations

Locations at which strengthening with glass fibres carried out	Fracture along entire midline	Fracture along some part of midline
No reinforcement	11	
Location of ridge lap region	3	
Location of anterior region		
Location of middle region		11
Location of anterior and posterior regions		

Fracture along the entire midline was most common pattern of fracture in dentures without any added strengthening when analysis for pattern of fracture in dentures with different extents of strengthening. The most common pattern of fracture was fracture at zone corresponding to reinforcement in the dentures where strengthening was carried out in the extent of 16% and 32%. The most common pattern of fracture was partial fracture along the midline in dentures having extent of 21% .(Table 6).

Table 6: Different patterns of fractures in different extent.

Extent of reinforcement with glass fibres	Fracture along entire midline	Fracture along some part of midline	Fracture all along the reinforcement
No reinforcement	12		
12%	4		10
16%			12
21%		12	
31%			12

DISCUSSION

Breakage of complete dentures made of acrylic resins is one of the most unsolvable difficulties in prosthodontics. Reinforcement of complete dentures made of resins with metal wire has been done in the past to toughen them up and prevent them from breaking in clinical situations. Over the last two decades, glass fibres have been employed to enhance resin-based full dentures. During this time, there were few studies that looked at both glass fibre and metal reinforcement.[11,12,25]

It has been proposed that denture strengthening with glass fibres can be accomplished in two ways. The first method entails interlacing glass fibres throughout the whole denture foundation. The second method, on the other hand, entails just strengthening the delicate area with glass fibres. It has been suggested that the second approach is a preferable alternative for denture strengthening during denture repair. This is because the second way can be regulated more effectively than the first. Another factor could be the role of the second approach in the prevention of repeated fractures in acrylic resin dentures.[13,14.26]

The placement of glass fibres as close to the location of maximal tensile stress in the complete denture has been proposed as a way to avoid the onset of fracture in acrylic resin based dentures. These findings imply that the extent and position of the glass fibres play a role in the entire dentures' flexural capabilities. According to a scientific study, various variables should be stressed when using glass fibres to partially strengthen dentures. It includes precise placement of partial fibre reinforcement on the tensile surface for the period of mastication, adjustment at a 90 degree angle to the likely line of fracture, and the length of the glass fibres utilised.[15,16.27]

In this study there was analysis of extent and location of glass fibre reinforcement in denture prepared from acrylic resin. Four locations were studied ridge lap region, anterior region, middle region both anterior and posterior region. Effect of extent of strengthening was studied for four different extents of 12%, 16%, 21% and 31% .

First, the flexural load corresponding to the proportional limit complete denture manufactured from acrylic resin was evaluated at various sites, as well as the efficacy of strengthening by glass fibres in comparison to full dentures without reinforcement. When comparing the reinforcement circumstances to the no-reinforcement condition, it was discovered that there was a considerable difference. When comparing reinforcement at four different locations, however, the effect was not significant. Then there was a test to see how much reinforcement was needed.It was observed that there was significant difference in reinforcement conditions when compared with condition of no reinforcement. But the difference was non significant when there was comparison among reinforcement at four different extents.In earlier studies there were some studies which were found to have similar findings of this study while some had different findings from our study.[16,17,28]

When flexural deflection was measured at the 100-N loading point in complete dentures made of acrylic resins with glass fibre reinforcement at various sites, it was discovered that there was a considerable difference in reinforcement

conditions when compared to no reinforcement. When comparing reinforcement at four different locations, however, the effect was not significant. When the same evaluation was done for different levels of reinforcement, there was a substantial difference between the reinforcement conditions and the no-reinforcement condition. But the difference was non-significant when there was comparison among reinforcement at four different extent of reinforcement. In previous studies there were some studies which were found to have similar findings of this study while some had different findings from our study.[18,19,29,30]

A study was carried out by Yoshida K et al concluded that the location of strengthening with fibres of glass in dentures is significantly correlated with the flexural properties of the dentures. They also found that added strengthening in the anterior region and antero-posterior region provide better flexural properties in dentures. The results of this study are not similar to the present study because in our study it was found that there is no significant correlation between the location of added strengthening with glass fibres. This difference can be attributed to the difference in the stiffness of the study specimens.[21-23]

Fracture along the entire midline was most common pattern of fracture in dentures without any added strengthening when analysis for pattern of fracture in dentures with different extents of strengthening. The most common pattern of fracture was fracture at zone corresponding to reinforcement in the dentures where strengthening was carried out in the extent of 16% and 32%. The most common pattern of fracture was partial fracture along the midline in dentures having extent of 21%. The results of this study were similar to the findings of the previous study by Yoshida K et al.[24,25,31]

CONCLUSION

Within the limits of this study it was concluded that glassfibre reinforcement in the acrylic based complete dentures improves the flexural properties but effect of extent and location of glass reinforced fibres on the flexural properties were non-significant.

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