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RESEARCH ARTICLE

Effect of glass fiber non-dental's length and position on the flexural strength of FRC

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ABSTRACT

Glass fiber non-dental has a similar composition to E-glass fiber dental that commonly used as fiber reinforced composite (FRC) materials in resin bonded prosthesis. Fiber effectiveness can be determined by the length and the position. The aim of this study was to examine the effect of glass fiber non dental's length and position on the flexural strength of FRC in resin bonded prosthesis. This study has been done used 36 FRC samples with beam shaped (15 mm x 2 mm x 2 mm). Fiber reinforced composite samples were consisted of 9 groups (a combination between length: 4 mm, 6 mm, and 12 mm and position: compression, neutral, tension zone). The flexural strength was tested by universal testing machine and statistically analyzed using two-way ANOVA ($p<0.05$). The result showed that the lowest (compression, 4 mm) and the highest (tension, 12 mm) flexural strength were 104.30 ± 13.90 MPa and 166.18 ± 8.59 MPa. The two-way ANOVA test showed that variation of position, length, and interaction between placement-length had a significant effect on the flexural strength ($p<0.05$). The conclusion of this study was fiber position on compression zone with 4 mm length had the lowest flexural strength. In addition, fiber position on tension zone with 12 mm length had the highest flexural strength.

Keywords: flexural strength; FRC; glass fiber non-dental; length; position

INTRODUCTION

Tooth loss leads to the decreased alveolar bone and tooth migration. These disadvantages can be resolved by making a denture.[1] The percentage of fixed denture used in 2016 at Prof. Soedomo Dental Hospital, Yogyakarta, Indonesia is 30.64%.[2] The most common material used in the fixed denture are porcelain fused to metal (PFM). Fixed denture with PFM needs much preparation on abutment tooth, but it can be overcome by using a fixed denture with fiber-reinforced composite (FRC) materials, which has a minimal preparation on abutment tooth.[1,3,4]

The type of fiber that widely used in dentistry is E-glass fiber dental. E-glass fiber dental has a chemical composition of SiO_2 54.5%; Al_2O_3 14.5%; CaO 17%; MgO 4.5%; B_2O_3 8.5%; and Na_2O 0.5%. The availability of E-glass fiber dental is still rare in Indonesia.[5] Currently, Indonesia has so many glass fiber non-dental that can be used as an alternative material in dentistry. Glass fiber non-dental are used in the field of engineering as reinforcing materials in the manufacture of gypsum panels, sculptures, automotive components, and building industries.[6] The composition and strength of glass fiber non-dental have resembled dental fibers and are not cytotoxic to fibroblast cells.[7,8]

The length and position of fiber can determine the flexural strength of FRC. The length of fiber correlates with span length. Span length in fixed denture with FRC is between 8-10 mm.[9] Span length exceeding 15 mm can lead to high deflection and failure.[10] Span length must be at least following critical fiber length.[11] Critical fiber length from 2 mm can provide good reinforcement properties on FRC.[12] In clinical conditions with mastication occurring within the oral cavity, a fixed denture with FRC will receive flexural strength in the form of compressive, tensile, and shear strength.[13] The right position of fiber can affect FRC when receiving flexural strength with the load on the tension side

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and compression side.[14] This study aimed to examine the effect of length and position of glass fiber non-dental on the flexural strength of FRC in resin bonded prosthesis.

MATERIALS AND METHODS

The procedures in this study obtained approval from the ethics committee of Faculty Dentistry Universitas Gadjah Mada (001301/KKEP/FKG-UGM/EC/2018). The research started with the Scanning Electron Microscope-Energy Dispersive X-Ray Spectroscopy (JSM-651, Jeol, Japan) test to examine the composition of glass fiber non-dental, then the samples were tested by a universal testing machine. The materials used in this study were flowable composite (Charmfil flow, Denkist, Korea), glass fiber non-dental, and silane coupling agent (Monobond-S, Ivoclar Vivadent, USA). This study has been done using 36 FRC samples with beam shaped (15 mm x 2 mm x 2 mm). Fiber reinforced composite samples consisted of 9 groups (a combination between length: 4 mm, 6 mm, and 12 mm and position: compression, neutral and tension).

Glass fiber non-dental were cut to size 12 mm x 2 mm and weighed using a digital scale, then the results was 0.006 g. Glass fiber non-dental was silanated with 1 drop silane coupling agent 7.5 μl on each side using microbrush. Fiber was placed in the sample mold with compression, neutral, and tension position. The sample mold was placed on top of the glass plate. Flowable composite resin was filled, then left 0.5 mm thickness from the top surface of the sample mold (compression), 1 mm (neutral), and 1,5 mm (tension). Glass fiber non-dental was placed on the top sample mold, filled with flowable composite resin, covered with celluloid strips, then polymerized with light curing unit. Samples FRC were stored in incubator at 37 °C for 24 hours and further testing of flexural strength using universal testing machine.

Table 1. Sample Group

Group	Fiber position	Fiber fragment and length
I	Compression	3 fragments; 4 mm; n=4
II		2 fragments; 6 mm; n=4
III		1 fragment; 12 mm; n=4
IV	Neutral	3 fragments; 4 mm; n=4
V		2 fragments; 6 mm; n=4
VI		1 fragment; 12 mm; n=4
VII	Tension	3 fragments; 4 mm; n=4
VIII		2 fragments; 6 mm; n=4
IX		1 fragment; 12 mm; n=4

RESULTS

The result of SEM-EDX test (Table 2) shows the composition of glass fiber non dental. The amount of SiO_2 glass fiber non-dental is relatively higher than the amount of SiO_2 in E-glass fiber dental[5] and other glass fiber non-dental.[7]

Mean and standard deviation of flexural strength FRC in compression, neutral, and tension position with 4, 6, and 12 mm could be seen in Table 3. The lowest flexural strength was in group I (compression, 4 mm), while the highest flexural strength was in group IX (tension, 12 mm). The two-way ANOVA test (Table 4) showed that position variation, length variation, and interaction between non-dental glass fiber position variable had significant influence on flexural strength FRC ($p<0.05$).

Table 2. Composition of glass fiber non-dental

No	Component	Glass fiber non-dental (%)	E-glass fiber (%)	Glass fiber non-dental (LT, China) (%)	Glass fiber non-dental (CMAX, China) (%)	Glass fiber non- dental (HJ, China) (%)
1	SiO_2	63.46	54.5	56.88	52.56	55.86
2	CaO	12.62	17	16.24	10.03	18.71
3	Al_2O_3	5.16	14.5	5.56	2.45	5.51
4	Na_2O	8.83	0.5	12.91	-	18.71
5	MgO	3.29	4.5	4.86	0.11	5.11

Table 3. Mean and standard deviation (SD) of flexural strength FRC with position and length variation

Group	Position	Length	Mean ± SD (MPa)
I	Compression	4 mm	104.30 ± 13.90
II		6 mm	109.23 ± 12.22
III		12 mm	128.77 ± 10.18
IV	Neutral	4 mm	114.27 ± 7.28
V		6 mm	115.64 ± 15.93
VI		12 mm	162.53 ± 4.63
VII	Tension	4 mm	121.91 ± 9.05
VIII		6 mm	149.02 ± 5.66
IX		12 mm	166.18 ± 8.59

Table 4. Two-way ANOVA test with variable position and length of glass fiber non-dental

Group	Flexural strength	
	F	p
Position of glass fiber non-dental	27.984	0.000
Length of glass fiber non-dental	45.173	0.000
Interaction between position-length of glass fiber non-dental	3.918	0.012

DISCUSSION

Glass fiber non-dental in this research was the type of E-glass fiber, because it had 63.46% SiO_2. SiO2 is the main component in glass fiber and become a determinant in glass fiber classification and its properties.[15] The amount of 60-65% SiO_2 is classified into E-glass fiber type, which has excellent strength properties, also better resistance to corrosion and thermal.[16]

The two-way ANOVA test showed that position variation, length variation, and interaction between non-dental glass fiber position variable have a significant influence on flexural strength FRC ($p<0.05$). Fiber position, fiber length, and interaction between fiber-length had an essential role in distributing the pressure received by FRC.

The aspect of glass fiber non-dental position can be explained by the surface dimensional change in FRC. When a load is applied, the compression position will shorten the surface dimensions, resulting in a decrease in the surface area. On the reduction of surface area, the load received will be higher, resulting in a lower flexural strength. When a load is applied, the tension position will have an elongation of dimensional surface, resulting in an increase of surface area. On increasing surface area, the load received will be smaller, resulting in a high flexural strength.[17,18]

The aspect of glass fiber non-dental length can be explained based on changes in surface dimensions and length/diameter (L/D) ratio theory. Differences in fiber length and L/D ratio can produce different flexural strengths. The larger the length of fiber and L/D ratio, the higher the flexural strength value.[11,19]

The combination of fiber in the form of a compression position with a 4 mm fiber length lead to interaction between compression positions that shorten the surface dimensions and 4 mm fiber lengths which receive the pressure divided into 3 (smallest force), resulting in a low flexural strength value. The combination of fiber in the form of tension position with 12 mm fiber length resulted in interaction between tension position with elongation of surface dimension and 12 mm fiber length which received pressure divided 1 (largest force), resulting in high flexural strength value. The combination of fiber in the form of a neutral position with a length of 6 mm fiber will produce flexural strength with a large value between the compression position with a length of 4 mm and a neutral position with a length of 6 mm. The interaction between the position and length of the fiber showed that the larger the dimensions of surface and fiber length, resulting in high flexural strength; while the smaller the dimensions of surface and fiber length, resulting in a lower flexural strength. The interaction is in accordance with the theory of L/D ratio. The smaller L/D ratio will result in a high maximum load and low flexural strength; while the greater L/D ratio, will result in a low maximum load and a high flexural strength.[18,19]

CONCLUSION

Length and position of glass fiber non-dental effected on the flexural strength of FRC in resin bonded prosthesis. Glass fiber non-dental with 4 mm length and compression position had the lowest flexural strength; while glass fiber non-dental with 12 mm length and tension position had the highest flexural strength.

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