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RESEARCH ARTICLE

FEM ANALYSIS TO EVALUATE THE STRESSES INDUCED BY TWO DIFFERENT FIBER REINFORCED COMPOSITE BRIDGES

Swetha Kannamparambil, *Dr. Roseline Meshramkar, Dr. Lekha K. and Dr. Ramesh K. Nadiger

Department of Prosthodontics, SDM College of Dental Sciences and Hospital, Dharwad – 580 009, India

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**Corresponding author:*
Dr. Roseline Meshramkar,

ABSTRACT

Aim: The purpose of this study was to examine and compare the stress distribution on simulated anterior FPD models by using a fiber reinforced composite framework, modified with 2 types of fibers – polyethylene and glass fiber reinforced – and of standardized thickness. ***Materials and Methods:*** A three-unit FPD replacing the maxillary lateral incisor was constructed using finite element analysis software. A fiber framework of the pontic was designed with three variations: with the main framework curved labially (FRC1), located in the center (FRC2), or curved lingually (FRC3). Each framework was compared with a hybrid composite FPD without any fiber reinforcement. A lateral load was applied to the three different loading points of the pontic 0mm, 3mm, and 6mm from the incisal edge, each representing loading conditions 1, 2, and 3, respectively. Stress analysis was by using two dimensional finite element method. ***Results:*** Maximum principle stresses developed in both the crown as well as the dentin of glass fiber reinforced composite anterior FPD was seen to be lesser than that developed in the same of polyethylene reinforced composite anterior FPD for all three loading conditions. ***Conclusion:*** Tensile stresses in the crown of glass fiber reinforced composite is less than that observed in the crown of polyethylene reinforced composite. Hence glass reinforced composite has more strength against masticatory forces.

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INTRODUCTION

Prosthodontic dentistry deals with a variety of different clinical situations. Amongst the many cases seen in the field of prosthodontics, a common case is that of a single missing anterior tooth. It could be due to many reasons like congenitally missing teeth, accidents, caries, cases of abuse or fights, etc. Some of the treatment plans for such a case are treatment partial dentures, implant dentures, conventional bridges, resin bonded fixed partial dentures and fiber reinforced composite bridges. When considering a case of a single missing anterior tooth, esthetics is a major concern. Hence, treatment partial dentures, though economic, do not meet the esthetic demand of many patients.Implant dentures on the other hand are highly esthetic. However they are expensive and highly invasive. The replacement can also be made via conventional porcelain-fused-metal bridges or resin bonded FPDs. The former is the most invasive treatment in terms of tooth reduction and could be esthetically compromised with gingival contour modifications. The latter is less invasive, but the non-esthetic aspect of the metal framework, necessity of dental reduction or preparation, challenging long-lasting bonding of metal to tooth, and lack of longevity could limit its use (Amir Chafaie *et al.,* 2004). Fiber reinforced composite (FRC) bridges represent an interesting alternative to conventional metal bridges (Vallittu *et al.,* 2004).

Oral restorations using minimal amount of metal are in high demand due to an increasing interest in esthetics and biocompatibility (Wataha *et al.,* 2002; Al-Hiyasat *et al.,* 2003; Aoyagi *et al.,* 2004). The new generation of composite resins with dentin and enamel shades provides very good esthetic results by reproducing the natural aspect of the tooth, mainly in the incisal third of anterior teeth (Vanini *et al.,* 1996). The use of unreinforced composite resins as the structural material for bridges often result in fracture (Amir Chafaie *et al.,* 2004). The fracture resistance of these composites can be effectively increased by reinforcing them with fibers. Fiber-reinforcement has been introduced to increase both flexural strength and modulus of these materials. FRC prostheses offer the potential advantages of optimized esthetics, low wear of the opposing dentition and the ability to bond the prosthesis to the abutment teeth, thereby compensating for less-than-optimal abutment tooth retention and resistance form. They have good rigidity against masticatory forces, low weight and are economically feasible restorations. It has been said that the strength of FRC and veneering composite laminates can be increased by placing the FRC layer as a substructure which will be subjected to tensile stress (Ellakwa *et al.,* 2001). Hence, if the FRC is placed at the bottom of the pontic to sustain tensile stress produced during mastication, stress that will apply to the veneering composite may be decreased to reduce the risk of fracture (Takashi Nakamura *et al.,* 2005). This study was conducted to examine stress distribution on simulated anterior FPD models by using a FRC framework. Simulated FPDs was modified with 2 types of fibers – polyethylene and glass fiber reinforced – and standardized thickness. Different methods can be used for analyzing stress distribution. Some of the popular methods are photo elasticity stress analysis, strain gauge, pressure transducer and finite element (FE) analysis. Stress analysis for this study was done by using 2 dimensional finite element method.

MATERIALS AND METHODS

Finite element method was used to create 2-dimensional models of a 3-unit FPD for a missing maxillary lateral incisor. Each model consisted of 2905 nodes and 5559 elements. 2-dimensional triangular elements were used (Figure 1). The crown thickness was 1.5mm at the incisal surface and 1mm at the margins. Shoulder margin design was used. For the fiber – reinforced composite (FRC) of the framework, an experimental BR-100 (Kuraray) was used. Two types of FRCs were used – glass reinforced and polyethylene reinforced. The FRC was placed in such a manner that it interlocked the retainer and pontic. A thickness of 0.8mm was placed at the bottom of the pontic (Figure 2).

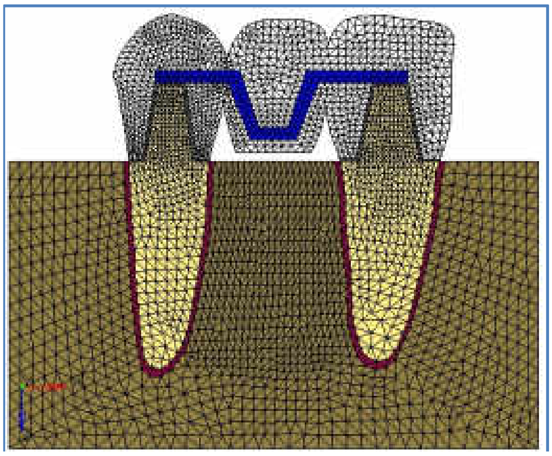


Figure 1. 2-dimensional triangular elements were used

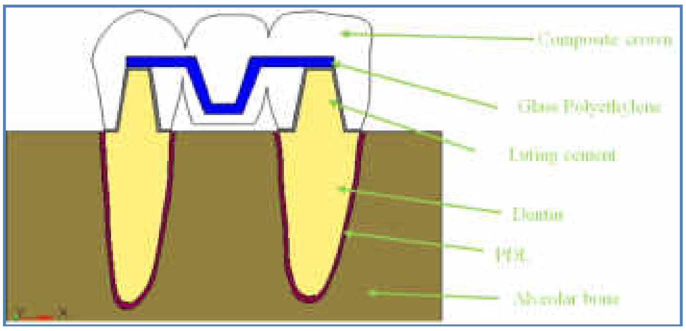
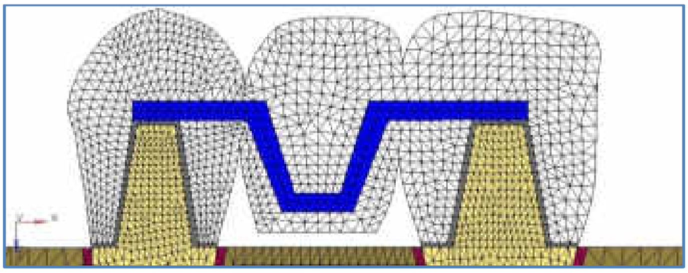


Figure 2. Two types of FRCs were used – glass reinforced and polyethylene reinforced. The FRC was placed in such a manner that it interlocked the retainer and pontic. A thickness of 0.8mm was placed at the bottom of the pontic

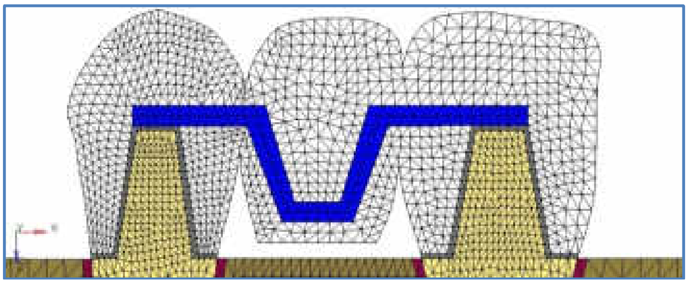
Since BR-100 had anisotropy its material constants were measured in both longitudinal and transverse directions and were used for analysis. In (Table 1), the materials used with their respective elastic modulus and poisson's ratio were listed. Bottom portion of the bone was fixed in all directions. Load of 50N simulating masticatory forces was applied in 3 different directions.

Table 1.

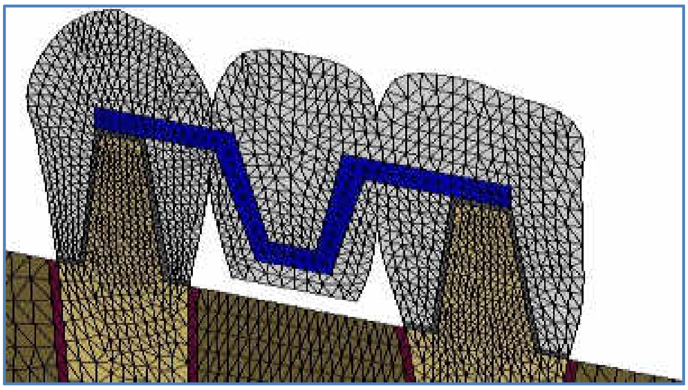
Material	Elastic modulus (GPA)	Poisson's ratio
Glass fiber reinforced comoposite -		
Longitudinal	39	0.35
Transverse	12	0.11
Polyethylene reinforced composite	0.5	0.46
Veneering composite	21	0.27
Luting cement	18	0.30
Dentin	14	0.15
Pulp	0.01	0.49
PDL	0.01	0.49
Alveolar bone	12	0.15



Load case 1 => vertical (Figure 3)



Load case 2 => oblique (45degree) (Figure 4)



Load case 3 => horizontal (Figure 5)

The element coordinate system was used considering the anisotropy of the FRC. Tensile stress was examined using a finite element structural analysis software since the fracture of brittle materials such as composites was chiefly due to tensile stress. The maximum tensile stresses in the crown and dentin, on different loading conditions, of the two types of FRCs were analyzed and compared.

RESULTS

For glass reinforced composite anterior FPD

- Max tensile stress - vertical loading is around 55 MPa
- Max tensile stress - oblique loading is around 21.3 MPa
- Max tensile stress - horizontal loading is around 35.6 MPa

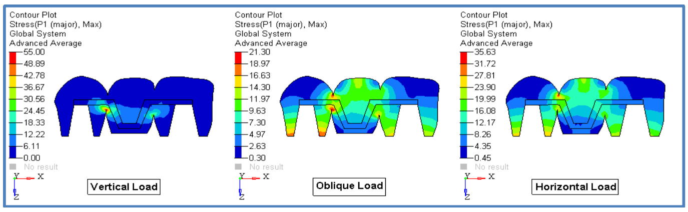


Figure 6. Max principle Stresses in Crown

- Max tensile stress - vertical loading is around 5.11 MPa
- Max tensile stress - oblique loading is around 22.5 MPa
- Max tensile stress - horizontal loading is around 32.2 MPa

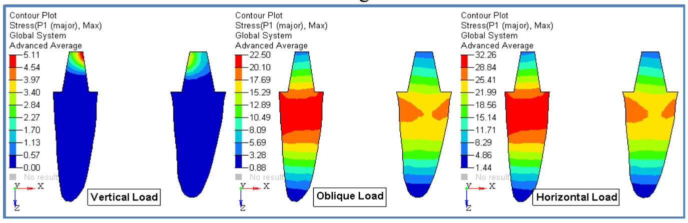


Figure 7. Max principle Stresses in Dentin

For polyethylene reinforced composite anterior FPD

- Max tensile stress - vertical loading is around 24.06 MPa
- Max tensile stress - oblique loading is around 33.52 MPa
- Max tensile stress - horizontal loading is around 48.21 MPa

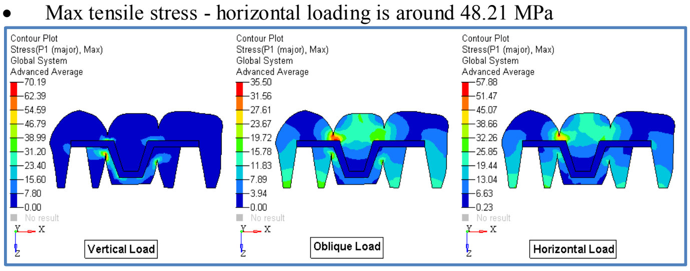


Figure 8. Max principle Stresses in Crown

- Max tensile stress - vertical loading is around 70.19 MPa
- Max tensile stress - oblique loading is around 35.5 MPa
- Max tensile stress - horizontal loading is around 57.88 MPa

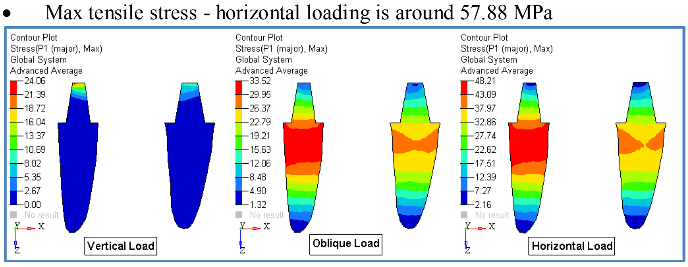
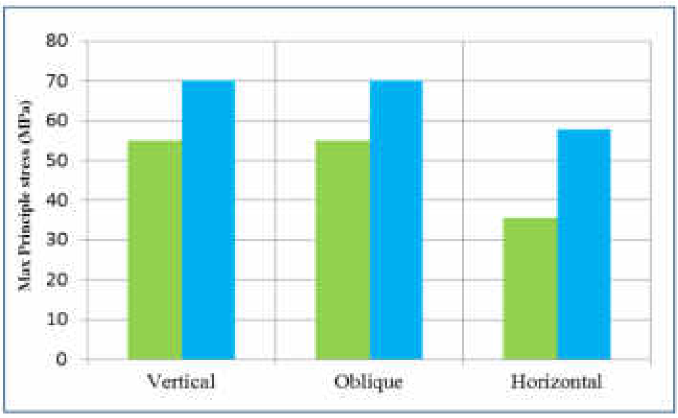


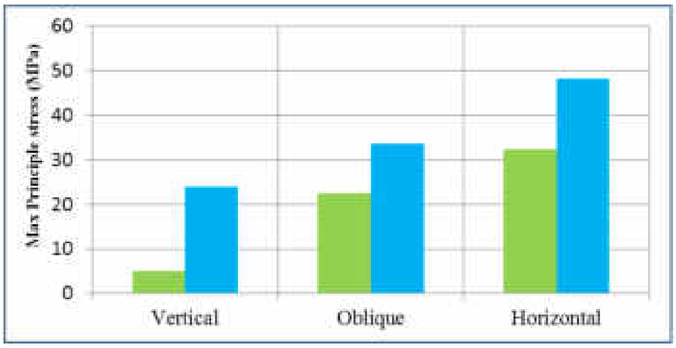
Figure 9. Max principle Stresses in Dentin

In [Graph 1], the stresses produced in the crowns of the two types of FPDs were compared for each loading condition.



Graph 1. Stress comparison in crown

In (Graph 2), the stresses produced in the dentin of the two types of FPDs were compared for each loading condition.



Graph 2.

DISCUSSION

While considering the various therapeutic options for the replacement of a congenitally or traumatically missing permanent anterior tooth, FRC bridges represent an interesting alternative to the commonly opted conventional metal bridges. They could be made directly or indirectly using an artificial plastic tooth or the avulsed tooth (Aoyagi *et al.,* 2004; Belli and Ozer, 2000) or by adirect build up composite resin tooth with (Feinman and Smidt, 1997; Miller, 1993) or without (Van Wijlen, 2000) porcelain veneering. FRC bridges involve little or no tooth reduction thereby making them no-invasive or minimally invasive procedures. They are relatively easy to fabricate and repair with impressive bondability. In order to reduce the risk of fracture, the FRC layer is placed at the bottom of the pontic. The layer sustains the tensile stress produced during mastication, reducing the stress applied to the veneering composite (Takashi Nakamura *et al.,* 2005). On finite element analysis, the stresses induced in polyethylene and glass fiber reinforced composites were studied and on subsequent comparison, it was observed that higher stresses were induced in polyethylene. Chong K H demonstrated in 2003 that when glass fiber-reinforced composite materials were used in an FPD, those consisting of unidirectional fibers are employed for the inner part of the appliance because they have a greater strength than composite materials reinforced with woven fibers (Chong and Chai, 2003). Loose et al reported that FPDs reinforced with FRC showed a higher strength than all-ceramic FPDs (Loose *et al.,* 1998). However, in actual clinical situations, fiber-reinforced composite FPDs often pose a problem of poor strength in the veneering composite area (Behr *et al.,* 2003). In 2003, Li *et al.* (2004) did a finite element (FE)study on FRC bridges. The FE model adopted was constructed from computer tomography images of a physical bridge specimen. The peak stresses and their variations with the different bridge designs were evaluated. The analysis showed stress concentration at the pontic-abutment interface, which results in failure at the interface. The numerical analysis of the bridge structure reveals that a high stress concentration occurs around the incisal portion of the adhesive interfaces between the pontic and abutment. Shinya *et al.* in 2008 studied the stress distribution in anterior FPDs and at tooth/framework interface. The design of FPD consists of retainers in maxillary central and canine and pontic lateral incisor. Two different materials were compared: Isotropic Au-Pd alloy and anisotropic continuous unidirectional E-glass FRC. A 3-D FE model of 3 U FPD with 153N loading was analyzed to determine the stress distribution at FPD and adhesive interface. The general observation was that the FRC-FPD provided more even stress distribution from the loading contact point to cement interface than did metal-FPD.

Conclusion

Through this study it is observed that the tensile stresses in the crown of glass fiber reinforced composite is less than that observed in the crown of polyethylene reinforced composite. Hence glass reinforced composite has more strength against masticatory forces. The study was performed under static loading conditions. In actual clinical settings, bite force is repeatedly applied and the appliance needs to withstand such a severe conditions. Further research can be done to observe the longevity of the FRC-FPD in a clinical study.

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REFERENCES

Al-Hiyasat AS, Bashabsheh OM, Darmani H. 2003. An investigation of the cytotoxic effects of dental casting alloys. *Int. J Prosthodont.,* 16:8-12.

Amir Chafaie, Richard Portier, 2004. Anterior fiber-reinforced composite resin bridge: A case report. *Pediatric Dent.,* 26:530-534.

Aoyagi H, Katagiri M. 2004. Long-term effects of Ag-containing alloys on mucous tissue present in biopsy samples. *Dent Mater J.,* 23:30-347.

Behr M, Rosentritt M, Leibrock A, Behr M, Handel G. 2003. Fiber-reinforced composite crowns and FPDs: A clinical report. *Int J Prosthodont.,* 16:239-243.

Belli S, Ozer F. 2000. A simple method for single anterior tooth replacement. *J Adhes Dent.,* 2:6-70.

Chong KH, Chai J. 2003. Strength and mode of failure of unidirectional bi-directional glass fiber-reinforce composite materials. *Int J Prosthodont,* 16:161-166.

Ellakwa AE, Shortall AC, Shehata MK, Marquis PM. 2001. The influence of fiber placement and position on the efficiency of reinforcement of fiber reinforced composite bridgework. *J Oral Rehabil.,* 28:785-791.

Feinman RA, Smidt A. 1997. A combination porcelain/fiber-reinforcedcomposite bridge: A case report. *Pract Periodontics Aesthet Dent.,* 9:925-929.

Li W, Swain MV, Li Q, Ironside J, Steven GP. Fiber reinforced composite dental bridge. Part II: Experimental investigation. *Biomaterials*, 25:4995-5001.

Loose M, Rosentritt M, Leibrock A, Behr M, Handel G. 1998. In vitro study of fracture strength and marginal adaptation of fiber-reinforced-composite versus all-ceramic fixed partial dentures. *Eur J Prosthodont Restor Dent.,* 6:55-62.

Miller MB. 1993. Aesthetic anterior reconstruction using a combined periodontal/restorative approach. *Pract Periodontics Aesthet Dent.,* 5:33-40.

Shinya A, Yokoyama D, Lassila LV, Shinya A, Vallittu PK. 2008. Three-dimensional finite element analysis of metal and FRC adhesive fixed dental prostheses. *J Adhes Dent,* 10:365-371.

Takashi Nakamura, Tatsuo Waki, Tomonori Waki, Soichiro Kinuta, Kazumichi Wakabayashi, Naoki Takano, Hirofumi Yatani, 2005. Finite element analysis of fiber-reinforced fixed partial dentures. *Dental Materials Journal,* 24(2):275-279.

Vallittu PK. 2004. Survival rates of resin-bonded, glass fiber-reinforced composite fixed partial denture with a mean follow-up of 42 months: A pilot study. *J Prosthet Dent.,* 3:241-246.

Van Wijlen P. 2000. A modified technique for direct, fiber-reinforced, resin-bonded bridges: Clinical case reports. *J Can Dent Assoc.,* 66:367-371.

Vanini L. 1996. Light and color in anterior composite restorations. *Pract Periodontics Aesthet Dent.,* 8:673-682.

Wataha JC, Lockwood PE, Noda M, Nelson SK, Mettenburg DJ. 2002. Effects of toothbrushing on the toxicity of casting alloys. *J Prosthet Dent.,* 87:94-98.

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