Short Communication

Mechanical Strength of an Acrylic Resin Palatal Denture Base Reinforced with a Mesh or Bundle of Glass Fibers

Wieslaw Hedzelek, Prof Dr Med Dent[a]/Przemyslaw Gajdus, DDS, PhD[b]

The aim of this pilot study was to evaluate the mechanical strength of an acrylic resin palatal denture base reinforced with a mesh or bundle of glass fibers. Silicon and stone casts of an edentulous maxilla (Frasaco) were used to manufacture palatal denture bases (n = 20) using heat-polymerized acrylic resin (SR Triplex Hot). The denture bases were reinforced with either 1 or 3 layers of glass-fiber mesh (Stick Net) or with a bundle of unidirectional glass fibers (Stick). Denture bases without reinforcement served as the control group. Fracture tests were carried out on a universal testing machine to determine each material's mechanical strength. The highest mean fracture values of 919 N were obtained in samples with 3 layers of Stick Net, with mean values of 677 N in the control samples. The differences between these 2 groups were statistically significant ($P < .05$). The applied glass-fiber reinforcement increased the mechanical strength of the acrylic resin palatal denture bases. *Int J Prosthodont 2007;20:311–312.*

Steps to enhance the mechanical strength of materials used to fabricate removable prostheses are undertaken by material manufacturers, dental clinicians during clinical work, and dental technicians during laboratory preparation. Nonetheless, fissures or fractures in acrylic resin materials may still occur. A common laboratory method to increase the fracture resistance of acrylic resin dentures is the inclusion of high-resistance synthetic fibers in the processing protocol. Percentage of fiber volume, adequate adhesion, and appropriate color and biocompatibility of the employed materials are important determinants of the properties of the definitive prosthesis. Glass fibers have been reported to fulfill these requirements.[1]

The aim of this study was to compare the mechanical strength of an acrylic resin palatal denture base reinforced with either a mesh or bundle of glass fibers in a fracture test.

[a]*Professor and Head, Department of Prosthetic Dentistry, University of Medical Sciences of Poznan, Poland.*
[b]*Assistant Lecturer, Department of Prosthetic Dentistry, University of Medical Sciences of Poznan, Poland.*

Correspondence to: *Prof Wieslaw Hedzelek, Department of Prosthetic Dentistry, University of Medical Sciences of Poznan, Bukowska 70 str, 60-812 Poznan, Poland. E-mail: hedzelek@amu.edu.pl*

This study was presented at the 26th Annual Conference of the European Prosthodontic Association, Dubrovnik, Croatia, September 26–28, 2002.

Materials and Methods

Silicon and stone casts (Frasaco) of an edentulous maxilla were used to fabricate the test samples. A 1.5-mm-thick base plate was extruded from thermoforming foils using the Erkoform RVE apparatus (Erkodent). This permitted the fabrication of 20 specimens of consistent thickness through a compression-molded process, which were subsequently processed in a polymerization flask. Each sample was made from a heat-polymerized acrylic resin (SR Triplex Hot, Ivoclar Vivadent).

The samples included 10 specimens reinforced with a glass-fiber mesh (Stick Net, Stick Tech), in which 1 layer (5 samples) or 3 layers (5 samples) of the mesh were positioned in relation to each other at a 45-degree angle and placed in acrylic resin in a polymerization flask. In the remaining 5 samples, bundles of unidirectional glass fibers (Stick, Stick Tech) were used. Each bundle was 3 mm wide and 75 mm long and was placed into the acrylic resin overlying the alveolar ridge area. Five acrylic resin palatal denture bases without reinforcement comprised the control group.

Prior to testing, the 20 denture bases were stored in water at room temperature for 2 weeks. The fracture tests were carried out on a universal testing machine (Rauenstein FM 250, VEG) at a crosshead speed of 30 mm/min. A force of 1,000 N was applied via a specially profiled acrylic resin block adjacent to the posterior part of the palatal denture base at the midline. The recorded results were statistically analyzed (Tables 1 to 3).

Table 1 Mechanical Strength (N) of the Tested Materials

Sample	Control	Stick	Stick Net (3 layers)	Stick Net (1 layer)
1	787	560	888	469
2	687	910	980	1,020
3	752	566	890	693
4	607	760	901	722
5	552	609	936	651
Total	3,385	3,405	4,595	3,555
Average	677	681	919	711
SD	97.91	151.43	39.16	198.80

Table 2 Analysis of Variance for the Mechanical Strength Results

Sum of squares	*df*	Mean square	F	*P*
200,680	3	66,893.3333	3.6366	.0357

Table 3 Duncan Multiple Range Test of the Tested Materials

	Control	Stick	Stick Net (3 layers)	Stick Net (1 layer)
Control		.96350	.01835*	.71287
Stick	.96350		.01732*	.73123
Stick Net (3 layers)	.01835*	.01732*		.02765*
Stick Net (1 layer)	.71287	.73123	.02765*	

*Statistically significant ($P < .05$).

Results

The highest mean fracture values (919 N) were obtained in samples with 3 layers of Stick Net, while the lowest mean fracture values (677 N) were seen in the control samples. The difference between these 2 groups was statistically significant ($P < .05$). The difference between samples reinforced with 3 layers of Stick Net and samples reinforced with Stick was also statistically significant. Mean fracture values of acrylic resin denture bases reinforced with Stick (681 N) were statistically different from those recorded for denture bases with 1 layer of Stick Net (711 N), although large standard deviations were observed.

The following material fracture locations were noted: samples with 1 or 3 layers of Stick Net fractured separately at the midline, but samples reinforced with Stick broke at the symmetry axis without breaking up into fragments. The applied glass-fiber reinforcement limited the amount of broken fragments (from 4 to 2) compared to the control samples.

Discussion

Numerous in vitro laboratory studies have investigated the mechanical properties of glass-fiber reinforcement in acrylic resin samples. A study by Karacaer et al[2] indicated that increasing the percentage of glass fiber to about 20% caused problems with the compatibility between fiber and polymer, while the use of silane treatment increased the number of voids in the material. To improve mechanical properties of acrylic base material, the authors suggested gamma rays as a curing method. Ionizing radiation penetrates the material without increasing the local temperature, decreases the number of voids by converting monomer into polymer, and helps in the bonding between graft fiber and polymethyl methacrylate.[2]

The improved mechanical properties of glass-fiber reinforced acrylic resins used in removable prosthodontics have been reported. The measurement of the mechanical properties of complete dentures processed in this manner would, however, yield more valuable information if a clinically simulated protocol were used. In spite of the clear limitations of the study design, the use of Stick fibers as reinforcement for palatal denture bases is in agreement with the study by Vallittu et al,[3] who showed that dynamic fatigue tests of complete dentures reinforced with a bundle of 5-mm-diameter glass fibers did not result in denture fracture. In another study, acrylic resin partial dentures reinforced with a bundle of glass fibers fractured after 1.2 million cycles[4]; and in turn, Kim and Watts[5] showed that the impact strength of dentures reinforced with Stick Net increased 224% at crack initiation and 290% at complete fracture.

In this pilot study limited to 1 type of acrylic resin, and within the limitations of the specific fracture testing protocol, palatal denture bases with glass-fiber reinforcement showed an increase of 5% in mechanical strength when a single layer of Stick Net was used. This number increased to 35% when 3 layers of Stick Net were used.

Conclusions

Glass-fiber reinforcement appears to increase the mechanical strength of the studied acrylic resin palatal denture base material, particularly when reinforced with 3 layers of the Stick Net, as tested under the selected loading condition.

References

1. Jagger DC, Harrison A, Jandt KD. The reinforcement of dentures. J Oral Rehabil 1999;26:185–194.
2. Karacaer O, Dogan A, Dogan OM, Usanmaz A. Dynamic mechanical properties of dental base material reinforced with glass fiber. J Appl Polymer Sci 2002;85:1683–1697.
3. Vallittu PK, Lassila VP, Lappalainen R. Transverse strength and fatigue of denture acrylic-glass fiber composite. Dent Mater 1994;10:116–121.
4. Vallittu PK. Comparison of the in vitro fatigue resistance of an acrylic resin removable partial denture reinforced with continuous glass fibers or metal wires. J Prosthodont 1996;5:115–121.
5. Kim SH, Watts DC. The effect of reinforcement with woven E-glass fibers on the impact strength of complete dentures fabricated with high-impact acrylic resin. J Prosthet Dent 2004;91:274–280.