Fiber-Reinforced Composites: Effect of Fiber Position, Fiber Framework, and Wetting Agent on Flexural Strength

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Purpose: Polymer matrix composites are frequently used in dentistry. Fiber-reinforced composites (FRC) are relatively new to dentistry, but their characteristics have found application in a number of other areas. While FRCs demonstrate improved mechanical characteristics, they fail to achieve general clinical acceptance because of insufficient enhancement of properties. Fiber placement into resins has frequently resulted from intuitive procedures, with a resultant unreliable improvement in mechanical properties. The hypothesis in the present investigation was based on the fact that the physical properties of composite materials depend on the type of matrix, type of fiber, fiber distribution, framework, fiber:matrix ratio, diameter and length of the fibers, and quality of the fiber-matrix coupling.[1]

Materials and Methods: Three denture base resins were used: conventional heat-cured resin, autopolymerized resin, and microwave-polymerized resin; control groups of specimens were left unreinforced. The specimens in the experimental groups were reinforced with two fiber reinforcement types (woven or roving). The fibers were treated or not treated with coupling agent (γMPS; Silquest A 174, Crompton) and placed approximately in the middle or at the compressive/tensile side of the specimen (Fig 1). The specimens were evaluated according to ISO 1567:1999 for flexural strength. Thermogravimetric analysis was used to observe the effectiveness of the cleaning process and the amount of coupling agent on the fiber in different situations. The fracture surfaces were examined with scanning electron microscopy (SEM). Micrographs were also taken to observe the adhesion of the glass fiber to the polymethyl methacrylate (PMMA). One-way analysis of variance was used to determine statistical differences ($P < .05$). The Tukey test was used to determine differences among groups.

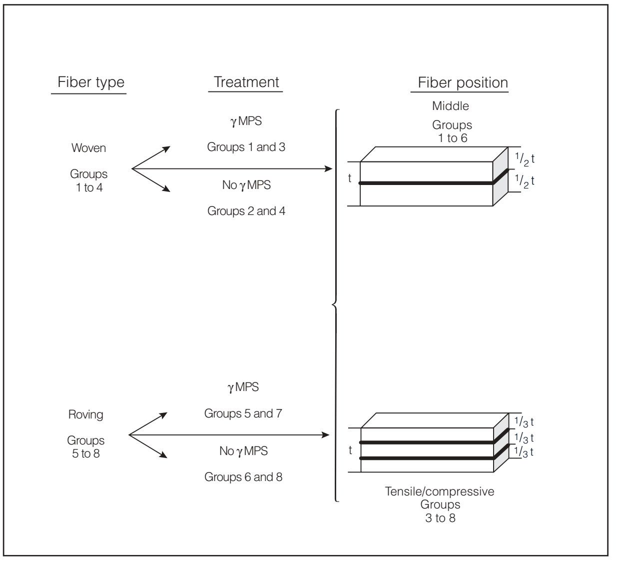

Fig 1 Classification of specimens according to fiber type, position, and treatment. t, thickness.

Results: The flexural strength values are summarized in Fig 2. Comparisons were made among all groups and the control groups. The q strength values were statistically different. The control group specimens showed the lowest values. The production of composites with fibers (woven or roving/PMMA) enhanced the mechanical properties of the conventional heat-polymerized, autopolymerized, and microwave-polymerized materials. The flexural strength of the acrylic resin was higher when roving fiber was used. Also, the structure of a continuous, unidirectional glass fiber plays an important role in the incomplete separation of the pieces of the specimens after fracture.[2] Thermogravimetric analysis was used to

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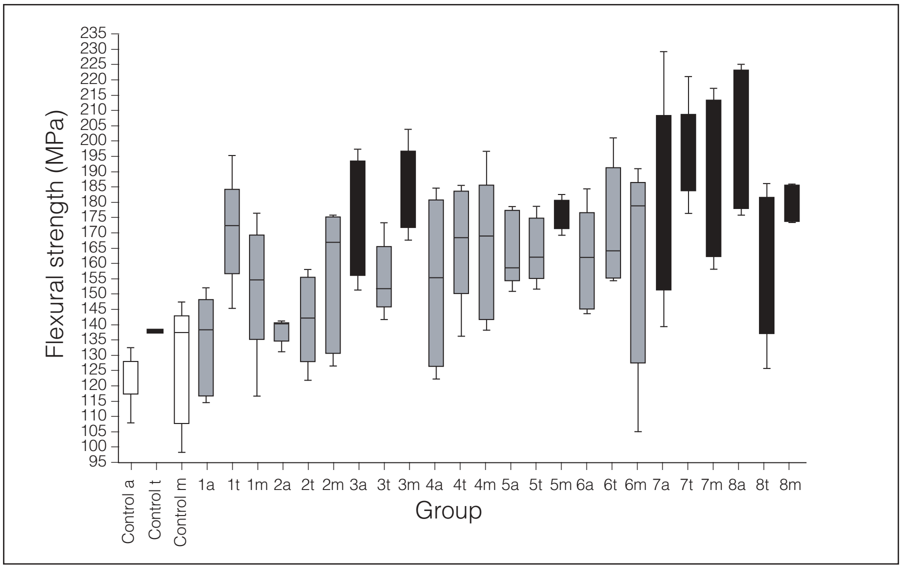

Fig 2 Flexural strength of tested specimens. Black columns refer to groups that were statistically different from the control groups; a = autopolymerized resin; t = heat-cured resin; m = microwave-polymerized resin. White bars, control groups; gray bars, experimental groups; black bars, experimental groups which were statistically different when compared with control groups.

observe the quality and quantity of the coupling agent, γMPS, incorporated into the fibers. The results showed good impregnation and efficacy of the fiber-cleaning treatment. Scanning electron microscopy showed that the adhesion between glass fibers and PMMA was more effective when the fibers were treated with γMPS compared with untreated fibers. However, voids were clearly seen in both situations. Fibers at the tensile side of the specimens were more effective at enhancing their mechanical properties.[3,4]

Conclusion: The acrylic resin reinforced with glass fibers showed higher mechanical strength values. The fiber position, fiber type, and wetting agent are important to mechanical properties.

References

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