Hybrid casts: A comparison of different casting materials

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Casting and splinting materials used in orthopedics have historically consisted of plaster of Paris and, more recently, fiberglass. Plaster is cost-effective and malleable enough to help to hold reductions. Fiberglass is stronger and lighter, but more expensive. The hybrid cast of plaster and fiberglass optimizes the advantages of both materials in fracture management; it is sufficiently strong, yet still cost-effective.

(Key words: Hybrid, plaster, fiberglass, casting, fracture)

Plaster of Paris has been used for more than 150 years in fracture immobilization.¹ The substance derives its name from the fact that gypsum (calcium sulfate) was mined from quarries in Montmartre, a district in Paris. Cotton bandages impregnated with the plaster provided easy application and rapid setting time.² Plaster of Paris was first used for fracture management in 1851 by Antonius Mathysen, a Dutch army surgeon.³ The advantages of plaster are its molding capabilities, low cost, and ability to be fabricated into rolls. The rolls are cloth bandages that have plaster of Paris and a binder added to produce the final casting material. The disadvantages of plaster are its low strength-to-weight ratio, poor radiolucency, messy application, and long length of time needed for drying before bearing weight.

Synthetic cast material (fiberglass) became popular in the early 1970s. Ini-

tially, synthetic casts were rigid and difficult to apply. Incorporating silicone into the fiberglass resin and adding a more extensible yarn have made synthetic casts easier to apply.² In addition to weighing less, synthetic casting material has greater strength, porosity, and radiolucency when compared with plaster. Numerous studies have shown fiberglass materials to be much stronger than plaster.^{4,5} Berman and Parks⁶ discuss the high resistance of fiberglass to degradation caused by water. Disadvantages of fiberglass include increased costs, possible skin abrasions, and difficulty in molding fracture reductions.

Hybrid casting uses both plaster and fiberglass. When the materials are combined, the fiberglass is applied to cover the primary plaster shell. We found no studies comparing material strengths of hybrid casts. The present study compares the material strengths of these treatment options.

Materials and methods

Three models of casts were tested. Group 1 consisted of all-plaster casts and group 2, all-fiberglass casts. Group 3 casts were hybrid models, which were composed of two layers of plaster material covered by two layers of fiberglass. The laboratory cast design, as described by

Callahan and associates,^{5,7} was constructed by applying the cast material around Styrofoam cylinders 6 cm in diameter and 25 cm long. In every case, the roll was started at one end and proceeded up and down the cylinder for a final thickness of four layers. The casting rolls overlapped 50% at each layer. The Department of Orthopedics applied all the casting models. All casts were allowed to dry for 5 days. Ten casts were tested in each group. The cast cylinders were placed on wooden supports that were 5 cm thick and 25 cm apart (Figure). A force was applied by a blunt wedge to the center of each model using a hydraulic three-point bending machine. Each cylinder was loaded to failure at the speed of 5 mm/sec. Load to failure was defined as a sudden drop in load observed on a medium-capacity Instron Universal Testing Machine (Instron, Canton, Mass).

Results

The materials used in this study were divided into the following three groups:

- ☐ group 1, plaster;
- ☐ group 2, fiberglass; and
- ☐ group 3, hybrid.

Ten casts in each group underwent a three-point bending test. Each group had load to failure measured in newtons: group 1 mean, 91.14 N (range, 29.4 N to 147 N); group 2 mean, 436.1 N (range, 245 N to 290 N); and group 3 mean, 401.8 N (range, 294 N to 490 N).

After each cast had failed, it was removed from the machine and observed. The fractured fiberglass and hybrid casts were more stable than the fractured plaster casts after load to failure. All the groups tested broke down at the fulcrum of the testing machine. The failed plaster casts had multiple fatigue lines and were more unstable in comparison to the fiberglass and hybrid casts. The fatigue lines of the plaster casts propagated further from the fulcrum. The fiberglass and hybrid casts had fewer fatigue lines. The failure of these casts was confined to their centers, where the force was applied.

An F test and a Tukey test were conducted by an independent statistician

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Figure. Load-to-failure test.

who compared all three groups. Analysis of the results of the F test (the variance ratio test) indicated that the three groups of casts (plaster, fiberglass, and hybrid) were significantly different materials ($P < .0001$). The Tukey test post hoc analysis indicated that both fiberglass and hybrid casts had significantly higher strength than the plaster casts. However, the fiberglass and hybrid casts were not significantly different from each other in regard to strength ($P > .05$). Evaluation of the three groups shows that fiberglass and hybrid casts are comparable, and both of these casts are significantly stronger than plaster casts ($P < .05$).

Discussion

Casting of extremities is one of the most common orthopedic procedures done in the office setting today. Plaster of Paris casts have a long history of use. These casts do have problems in longevity secondary to their inherent brittleness. Fiberglass casting material has superior strength, but the material can be difficult to mold in acute fracture reductions. In addition, fiberglass is costly and can irritate the skin, especially collagen-depleted skin of elderly people. A review of the literature did not reveal any other

studies evaluating hybrid casting.

This study has shown that hybrid casts have significantly more strength than traditional plaster casts. The fact that only half the amount of synthetic fiberglass is required for the hybrid cast results in a 10% cost reduction in our institution per applied cast. Plaster casts have the lowest unit cost for each cast applied. However, because plaster casts break down more often in a specific fracture-healing period, more plaster casts have to be applied to heal a fracture. Thus, the cost savings in base materials with plaster of Paris casts are lost in the costs of reapplication materials, labor, and increased use of radiology services.

This study shows that hybrid casts offer the durability and strength needed for fracture immobilization. Hybrid casting techniques offer some cost savings for orthopedic care of fractures. The combination of these factors has made hybrid casting a reality in today's changing healthcare delivery system.

Comment

Hybrid casting is a sound option in orthopedic fracture care. We have shown this casting technique to be comparable in strength to fiberglass casting. Furthermore, cost savings are achievable

through the use of hybrid casts in comparison to full synthetic or plaster casts.

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