Original Contribution

Clinically Evaluating the Strength, Durability and Comfort of Polyester Casting Tape as an Alternative to Fiberglass Tape

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Abstract -- The strength, durability, and patient satisfaction of polyester-based casting tape was clinically evaluated by comparing: (1) cast breakdown characteristics and (2) patient attitudes and activity levels while wearing casts constructed from either polyester casting tape or standard fiberglass casting tape. Short leg walking casts were used exclusively in the study. The recovered casts were subjected to a series of evaluative procedures to determine material breakdowns and a survey form was used to document patient activity levels and overall cast comfort and satisfaction. Based on the results of the study, casts constructed with polyester tape are no more susceptible to breakdowns and are as strong and durable as those constructed from fiberglass tape. Patient attitudes also rated both tapes to be equal in functionality and comfort. However, due to the newness, lightness, and flexible properties of the polyester tape, a perception may exist with both practitioners and patients that polyester tape does not perform as well as standard fiberglass tape.

Introduction

Fiberglass tape bandages were originally introduced in the 1950s as an alternative to plaster of Paris for use in treating orthopedic injuries. In the late 1970s and early 1980s, significant improvements in manufacturing technologies were made, and fiberglass received widespread acceptance by the orthopedics community. Today, fiberglass is the primary casting material used for orthopedic immobilization.

The mechanical properties and characteristics of fiberglass casting materials have been well documented (1,2,3). The potential clinical advantages of fiberglass tape include: increased strength, rigidity, and durability; reduced cast cracking and delaminating, thus requiring fewer repairs or replacements; shorter time to weight bearing; and strong, lightweight, comfortable casts.

Recently, polyester-based casting tapes have been introduced as an alternative to the standard fiberglass tape. The primary difference is that a knitted polyester fabric has been substituted for the fiberglass fabric substrate. The result is a tape that looks and feels much like standard fiberglass tape but is lighter, more conformable, and close fitting, and provides a more comfortable cast for the patient.

One major difference between the polyester and fiberglass substrates is rigidity (4). The fiberglass substrate is very rigid and is more likely to crack or split under load. By comparison, the polyester substrate is more flexible and will give under load rather than cracking and splitting. This flexibility has led to a perception that polyester tapes are weaker and less durable than standard fiberglass tapes (5).

The objective of this research study was to clinically evaluate the strength, durability, and patient satisfaction of polyester-based casting tape by comparing cast breakdown characteristics, patient attitudes, and activity levels with casts and patients fitted with casts constructed with a fiberglass-based tape. This comparison was conducted by evaluating the repair and replacement frequencies, as well as the plantar surface breakdowns, in clinically applied short leg walking casts.

Due to the high stresses and impact damage associated with the mechanics of weight bearing, the short leg walking cast is very susceptible to breakdowns. In addition, such casts are also exposed to environmental conditions such as dirt and moisture that can accelerate materials failures and subsequent cast breakdowns. Previous studies have examined their vulnerability to breakdown, especially along the plantar, or

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weight-bearing surface (6,7,8).

Methodology

During a six-month period from February 2001 through August 2001, all short leg weight-bearing casts removed from patients treated at Orthopedic Associates of Lancaster, Pennsylvania were recovered for evaluation. These casts were constructed from two different types of materials, each selected during alternating months: either 3M Scotchcast Plus, a fiberglass-based casting tape, or 3M Scotchcast Poly, a polyester-based casting tape. Each finished cast was fitted with either a cast shoe or a walking heel to protect it during weight bearing.

The same certified cast technician clinically applied all of the casts following the manufacturer's recommendations and using standard casting techniques. At this time, the technician initiated a survey form that documented application, patient, and repair/replacement/removal information. When the cast was removed, patient activity levels and overall satisfaction with the cast were also documented.

Following removal, the casts were recovered and subjected to a series of evaluative procedures to document and define the nature and degree of breakdowns, especially in the weight-bearing surfaces.

The first step in the evaluative process was the generation of a "footprint" of the weight-bearing surface of the cast that details the areas of material failure within this area. Numerical values were then calculated for each footprint to provide a measure of materials failures in each.

In the second step, physical measurements were made to determine the overall cast wall thickness as well as the specific weight-bearing surface thickness. These results were then combined with the data collected during the step one evaluation and a relationship between thickness and material breakdown was determined.

In the third step, delamination, or the breakdown of the bonding materials between the tape layers, was examined and recorded. The location and layers of delamination were recorded for each cast.

Finally, each cast was inspected for other signs of breakdown of the weight-bearing surface, such as cracking and splitting of the forefoot and heel regions. The cast was also inspected for areas of rubbing, pinching, or folding of the casting materials and noted accordingly.

Two primary sets of variables were evaluated as part of the study: cast breakdown characteristics and patient attitudes, activity, and comfort levels. Cast breakdown characteristics included plantar surface breakdown of the forefoot and heel areas, delimitation of the forefoot and heel areas, cracking and splitting of toebox and heel areas, and needed repairs or replacement. Patient attitudes and activity levels included weight of the cast, length of time to full weight bearing, specific activities and activity levels, reported pain or discomfort, and overall comfort.

Findings

A total of 52 short leg walking casts were recovered for evaluation. Twenty-six of the casts were constructed with a polyester-based tape, and 26 with a fiberglass-based tape (Table 1). All but one of the casts were constructed with a weight-bearing surface thickness (five to eight tape layers) that either met or exceeded the manufacturer's recommendations for constructing weight-bearing casts.

Material Breakdown

Of the 52 casts evaluated, 16 (31 percent) displayed some degree of outward materials failure and breakdown in the weight-bearing surface area such as softening or cracking (Table 2). The breakdowns were distributed evenly between the polyester and the fiberglass casts. Eight of the 26 polyester (31 percent) casts and 8 of the 26 (31 percent) fiberglass casts exhibited breakdowns of either the forefoot or heel areas. The majority of the breakdowns occurred in the forefoot area: five for the polyester casts and five for the fiberglass casts. Four casts (three fiberglass and one polyester) displayed breakdowns of both the forefoot and heel areas.

Delamination

Nearly all of the casts exhibited delamination or a breakdown of the adhesive materials between the layers of tape in the weight-bearing surface area: 25 of 26 (96 percent) of the polyester casts and 21 of the 25 (81 percent) of the fiberglass casts. The percentage of delamination for polyester casts was 41 percent (3.4 of 8.3 total layers), and for fiberglass casts, 38 percent (2.9 of 7.6 total layers). While the extent of delamination was slightly greater in the polyester casts, it did not lead to any greater frequency of breakdowns than

TABLE 1. Construction profiles for evaluated casts.

	Polyester	Fiberglass
Tape used		
2 rolls of 5-inch	17	16
3 rolls of 4-inch	3	4
2 rolls of 4-inch	2	2
Other combinations	4	4
Plantar surface tape layers-all	7	7
Plantar surface layers- casts with breakdown	6	7
Weightbearing devices used		
Cast Shoe	20	20
Walking heel	6	6
Mean weight of cast	22.6 oz	24.5 oz

were found in the fiberglass casts. In casts that did not exhibit outward indications of softening and cracking, delamination was still present. Cuts made through the plane of the weight-bearing surface revealed internal delamination and separation of the tape layers.

Cracking and Splitting

Nine fiberglass casts exhibited cracking or splitting of the casting materials along the medial and lateral borders of the forefoot by the base of the first and fifth metatarsals. This outcome is more than double the number (4) found in polyester casts. In addition, one polyester cast exhibited a crack along the posterior border of the heel area.

Repair and Replacement

Four of the casts (three polyester and one fiberglass) needed an additional tape roll applied to repair forefoot breakdown and subsequent cracking of the cast along the medial and lateral edges of the toebox. In all four cases, the patient complained of pain and pinching in the toebox area of the cast during weight bearing. Two casts (one polyester and one fiberglass) were removed and reapplied because of forefoot breakdown and patient complaints of pain and rubbing in both the toebox and heel areas during weight-bearing. These casts had also become very loose-the primary reason why they were reapplied rather than repaired.

Patient Profiles

Table 3 provides a comparison between patients who wore polyester casts that exhibited breakdowns with all patients who wore polyester casts. Table 4 provides a comparison between patients who wore fiberglass casts that exhibited breakdowns with all patients who

TABLE 2. Breakdown profiles for evaluated casts.

	Polyester	Fiberglass
Total recovered	26	26
Plantar surface breakdowns	8	8
Forefoot area	5	5
Heel area	2	0
Both areas	1	3
Delamination of tape layers	24 (92%)	21 (81%)
Forefoot area	7	13
Heel area	0	1
Both areas	17	7
Cracking/splitting		
Toebox sides	4	9
Heel	1	0
Repairs needed	3	1
Replacement needed	1	1

wore fiberglass casts. A review of the tables reveals that the study population was fairly generic and that no major differences were noted that impacted on breakdowns in either group. This finding coincides with previous studies completed by one of the authors that determined that patient age, sex, and weight had no effect on the frequency of breakdowns in weight-bearing casts (9).

Patient Activities, Attitudes, and Comfort Levels

Patients were also asked to provide information regarding their activities while casted to evaluate the functionality of their cast in providing ease of mobility as well as their attitudes regarding the overall comfort of their casts. For these variables, data were evaluated statistically using two-tailed p-values, a technique that determines the variance within each variable. The

TABLE 3. Patent profiles for evaluated polyester casts.

Total Population	
Age	31 years (9-70 years)
Gender	12 male, 14 female
Patient Body Weight	173 pounds (74-275 pounds)
Patient Build	5 slight, 13 medium, 8 heavy
Length of Time Weightbearing	18 days (7-37 days)
Population with Breakdowns	
Age	27 years (14-37 years)
Gender	4 male, 4 female
Patient Body Weight	180 pounds (120-210 pounds)
Patient Build	6 medium, 2 heavy
Length of Time Weightbearing	17 days (7-29 days)

results are shown in Table 5.

As with the patient profile data, no major differences were noted that would indicate the superiority of one tape over the other. A review of the p-values indicates that the mean overall patient activity levels as well as overall comfort is the same for both polyester and fiberglass casts.

TABLE 4. Patient profiles for evaluated fiberglass casts.

Total Population	
Age	36 years (4-76 years)
Gender	17 male, 9 female
Patient Body Weight	147 pounds (40-228 pounds)
Patient Build	3 slight, 18 medium, 5 heavy
Length of Time Weightbearing	19 days (6-42 days)
Population with Breakdowns	
Age	36 years (6-76 years)
Gender	5 male, 3 female
Patient Body Weight	136 pounds (50-195 pounds)
Patient Build	7 medium, 1 heavy
Length of Time Weightbearing	16 days (12-22 days)

TABLE 5. Patient activity and comfort levels.

	Polyester	Fiberglass
Activity levels		
Return to work or school	14	13
Go out socially	23	26
Go shopping	14	13
Perform household chores	22	17
Exercise	8	10
Activity levels:	2.38	2.31
p - 0.551; Mean value based on scoring scale of: very active =1, active = 2, normal =3, inactive =4, very inactive =5.		
Reported pain or discomfort	9	8
Overall comfort:	2.00	1.65
p - 0.165; Mean value based on scoring scale of excellent =1, good =2, fair =3, poor =4.		

Discussion

The results indicate that the differences between the performance of the polyester casting tapes and the fiberglass casting tapes are small. An equal number of material breakdowns and delaminations of the weight-bearing surfaces were identified in both polyester and fiberglass casts. The patient populations, activity levels, and comfort levels were also very similar.

However, the fiberglass casts were much more likely to develop cracks and splits in the toebox area. This outcome is potentially due to the low flexibility and high rigidity of the fiberglass under load. As was noted previously, one major difference between the polyester and fiberglass substrates is rigidity. The fiberglass substrate is very rigid and is more likely to crack or split under load. By comparison, the polyester substrate is more flexible and will give under load rather than cracking and splitting.

One minor variation in the results occurs when comparing the repair and replacement frequency of the polyester and fiberglass casts. The polyester casts were more likely to be repaired or replaced. This tendency is unusual, since the frequency of breakdowns was equal for both types of casts.

Since the polyester tape is the newer of the two tapes evaluated in this study, the higher repair and replacement frequency may be more a matter of attitude and perception than of the actual performance of the tape. In addition, the lighter weight and increased flexibility of the polyester tape under load may also add to the perception of low strength.

A review of patient comments noted on the evaluation forms reveals that several of the patients who were fitted with polyester casts had previous experiences with fiberglass casts. Their comments reflected on the feeling of instability or lack of strength in their polyester cast and the need for strengthening or reinforcement. They preferred the hardness of the fiber cast to the less rigid polyester cast.

In one case, the parent of one patient even suggested that their child's cast seemed flimsy and should be reinforced although it exhibited no outward signs of breakdown.

Based on the results, short leg walking casts constructed with polyester casting tape are no more susceptible to breakdowns, and are as strong and durable as walking casts constructed with fiberglass tape. Unfortunately, due to the newness, lightness, and flexible properties of the polyester tape, perceptions may exist with both patients and healthcare providers that polyester is not as strong or durable as fiberglass tape.

Special effort will be needed to overcome these perceptions during the clinical use of polyester tapes. Traditionally, casts have been made with hard, rigid materials such as plaster or fiberglass, a likely contributor to the perception that a cast must be heavy and rigid to be effective. To overcome this belief, specific product applica-

tion and performance characteristics and training of the healthcare practitioner as well as increased patient education and awareness should be considered.

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David Witmer is employed at the Pennsylvania State University and has been involved in both private and public health and safety research initiatives. He holds both bachelor of arts and master of science degrees in industrial design and educational systems. During the past few years, he has been investigating the strength and durability of synthetic casting materials. The author has been a NAOT member for several years.

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