A Prospective Randomized Crossover Study on the Comparison of Cotton Versus Waterproof Cast Liners

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Abstract

Background: Many fractures are treated with casting which can cause complications likely from inability to wash the extremity. Gore-Tex-based waterproof cast liner has been compared with cotton liner and shown to be superior in physician and patient scoring but also has high cost and difficult application. The purpose of this study is to compare newer generation waterproof liners with traditional cotton liner. It is the first study to compare this new waterproof liner and cotton liner in a crossover model, allowing patients to swim in the pool with the cast. **Methods:** Twenty patients (ages 3–30) with upper extremity injuries were randomized to waterproof-liner or cotton-liner casts made of fiberglass. Patients would switch cast liners halfway between their treatments to fulfill crossover criteria. All fractures were within a 2-week period from original incident. At each clinic visit, patients evaluated comfort parameters through questionnaires, and physicians rated skin condition. Patients were also asked which cast liner they preferred at the end of the study. **Results:** There were no unscheduled cast changes. The waterproof-liner group had better scores for odor ($P = .041$), sweat ($P = .016$), and overall physician-rated score ($P = .038$). There was no significant difference in other patient-rated parameters. Seventy-five percent of patients preferred waterproof casting to the cotton liner. **Conclusions:** This new waterproof cast liner, compared with cotton cast liner, had better odor, sweat, and overall physician scores. The waterproof liners allow patients to rinse casts daily, and the majority of patients prefer waterproof to cotton liner.

Keywords: waterproof, cotton, cast, cast liner, odor, sweat, patient comfort, forearm

Introduction

Casting is commonly used to protect injured limbs, to maintain alignment, and to reduce pain. Cotton bandages impregnated with Plaster of Paris powder—first introduced in 1852—have been used as a standard immobilization technique for decades.¹⁰ Fiberglass casting tape was introduced in 1970s. Often, casts made with cotton or synthetic liners retain water after wetting, resulting in complications that include infection, rash, burn, contact dermatitis, maceration, ulceration itching, and odor.² In 1990, the Gore-Tex-based cast liner (W. L. Gore & Associates, Flagstaff, Arizona) was introduced to reduce complications associated with traditional liners. It has been shown to maintain alignment with better hygiene.^{2,3,6,7} It also has been shown to decrease unscheduled cast changes and hospital visits.⁵ However, there are concerns with difficulty applying it and a cost of \$30 to \$50 more per cast.⁷

Recently, newer waterproof materials have been developed. One of these is Delta Dry by BSN Medical®. It is easily stretched, mesh-like, wrinkle free, and nearly as thin as cotton liner (Figure 1). It is made of polypropylene,

nylon, and polyester fibers which are combined into a 3D open knit structure.^{4,5,8} This patented structure accelerates channel drainage and allows body temperature to evaporate remaining moisture. No studies have evaluated how it performs in terms of hygiene, itch, and skin condition and overall patient preference compared with cotton.

We propose a prospective randomized controlled crossover study measuring this new waterproof cast lining material by evaluating comfort (patient scores), skin condition (physician scores), and comparing number of unplanned cast changes compared with traditional cotton-lined casts. We hypothesize that this newer waterproof casting material will (1) provide improved patient scores in terms of weight, itch, pain, odor, sweat, irritation, fit, and comfort; (2) be

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Figure 1. The two liners used in this study are shown: (a) Cotton liner, (b) Waterproof liner.

avored by patients; (3) cause less skin issues; and (4) carry a lower rate of unplanned cast changes.

Materials and Methods

After institutional review board approval, we carried out a randomized, prospective crossover clinical trial comparing the clinical comfort (patient scores) and effectiveness (physician scores) of 2 cast liners. Between August 2013 and September 2014, patients with upper extremity injuries requiring short-arm and long-arm casts were asked to participate in our study. Exclusion criteria were those patients with open wounds, dementia, or surgical patients. Inclusion criteria were fractures that presented within 2 weeks from the date of injury and that did not need a reduction performed at time of presentation to our clinic. With these criteria, 20 patients were enrolled in the study (Table 1). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients (or parents) for being included in the study.

The patients were randomized into 2 different treatment groups, group A to first receive a cast with BSN Delta Dry® waterproof cast liner and group B with traditional cotton cast liner (Covidien LLC, Mansfield, Massachusetts). Patients were randomized by selecting an opaque envelope from a file containing an equal number of envelopes for

Table 1. Summary of Patient Demographics.

Age, years (mean $\pm$ SD)	13.6 $\pm$ 10.9
Distribution (n)	
Pediatric	18
Adult	2
Sex (n)	
Female	13
Male	7

each treatment group, and the initial liner was either determined to be waterproof or traditional cotton. Patients were then crossed over to the other cast liner halfway through their casting period. The same type of cast was placed as they had received initially.

Each patient received cast care instructions once randomized. Patients with waterproof liner were instructed to bathe or shower daily and to wash the injured extremity with a mild soap and then rinse the cast thoroughly with clean water. The patients will then be told to hang the cast in a dependent position for 5 minutes to allow the water to drain out. They were encouraged to use aquatic facilities as well but stay away from salt water. Patients with cotton liners were instructed to keep their casts dry at all times.

All patients had fiberglass casting tape for the entire study period. Trained orthopedic cast technicians under the supervision of an orthopedic resident or staff physician placed the casts. Before the study, each cast technician received specific training on correct application of the waterproof liner.

At each follow-up evaluation, patients or their parents completed a questionnaire about cast comfort and adherence to cast instruction. Patients rated comfort variables (weight, itch pain, odor, sweat, irritation, fit, and comfort) on a Likert scale ranging from 0 (no problem) to 5 (severe problem). At the end of the treatment period, after both casts, patients were asked to specify preference, for either the waterproof or cotton cast liners.

For skin condition, each cast was removed prior to being evaluated by a blinded physician who completed a questionnaire. Recorded parameters included cast-related complications and whether the cast was changed because of unplanned reason (such as for skin breakdown, pressure points, or loss of reduction), and the physician-rated presence and degree of skin problems: 0 for no problem; 1 for mild problems, including rashes and itching; 2 for moderate problem, where there is skin breakdown with blistering, ulceration maceration; and 3 for severe problems requiring medical attention, including deep ulceration and infection.

At every follow-up visit, patients were evaluated with an anterior-posterior (AP) and lateral radiograph, and angulations and displacements were measured with reference to limits of acceptable alignment.¹ In addition, the number of unscheduled cast changes was recorded for each group,

Table 2. Ratings between cotton and waterproof cast lining materials.

Parameter	Cotton	Waterproof	P (two-tailed)
	Median (IQR)	Median (IQR)	
Weight	2 (1-3)	1 (0-2)	.327
Itch	2 (1.7-4)	2 (1-3)	.555
Pain	0 (0-1.2)	0 (0-2)	.575
Odor	2.5 (0-3.2)	0 (0-2)	.041
Sweat	2 (0-3.2)	0.5 (0-2)	.016
Irritation	2 (0-3)	2 (0-3)	.834
Fit	0.5 (0-1.2)	0 (0-2)	.787
Comfort	1.5 (0-3)	2 (1-3)	.873
Physician's rating	1 (0-1)	0 (0-0.25)	.038

Note. IQR: interquartile range.

how many casts each patient had during their casting period, and how many weeks each patient remained in a cast. Finally, each patient was asked which cast liner they preferred at the end of the study.

Because normality assumptions were not met, Wilcoxon Signed-Rank Test was used to compare paired medians. The threshold of significance was set to .05.

Results

Twenty patients were enrolled in the study with a mean age of 13.6. There were 18 pediatric patients and 2 adult patients. Thirteen patients were female and 7 male.

Waterproof liners were preferred over cotton for odor ($P = .041$) and sweat ($P = .016$). There was no significant difference in weight, itch, pain, irritation, fit, and overall comfort (Table 2). In the final patient-rating questionnaire, the waterproof liners were preferred 75% of the time compared with cotton liners.

For skin condition as rated by the blinded physician, waterproof liners resulted in better skin condition (waterproof 0.0; cotton 1.0; $P = .038$; Table 2). Only one patient lost alignment and had to be manipulated; this occurred after being in a cotton-lining cast. There were no unscheduled cast changes. There were no major adverse skin reactions in either group.

Discussion

Early waterproof technology showed promise with improved patient comfort scores and reduced unwanted cast changes. Newer material has been introduced that boast improved water resistance with more ease of application. Our goal was to compare this new material with cotton in terms of patient ratings, preference, and skin condition.

The first randomized study to compare cotton and waterproof cast liners (Gore-Tex) demonstrated that the waterproof-liner group had better scores for itch, discomfort,

irritation, overall patient score, and overall physician score.² Previous to this study, it had been purported by several authors that waterproof lining had resulted in less skin problems and less unscheduled cast changes.^{2,3,6,7} However, none of these previous studies had had a comparison group when measuring patient-rated scores on itch, comfort, odor, irritation, and overall patient scoring. To date, our study is the second study to compare these 2 groups in a randomized fashion, but with a newer type of waterproof lining. In addition, we are the only study to allow our patients to swim in the pool, and we are the first study to crossover our patients in a randomized fashion.

In our study, patients found that the waterproof liners resulted in less odor and sweat scores and preferred them 75% of the time compared with traditional cotton liners. A waterproof cast liner allows casts to become wet and perhaps improves hygiene and comfort. Advantages of waterproof casting are clear to orthopedic surgeons and patients. Kruse et al found improved patient hygiene and decreased incidences of skin irritation in patients treated with lower extremity waterproof casts.³ Selesnick et al reported only a 5.9% minor skin complication rate and minimal complaints of odor, itching, and drying difficulties from the cast.⁶ In a randomized prospective study, Hadley et al confirmed the advantages of Gore-Tex by showing superior scores for itch, discomfort, and irritation and overall patient satisfaction score and overall physician satisfaction score as compared with cotton group.² The results from this study are in line with previous studies, specifically showing that newer waterproof liners had improved patient-rated odor and sweat scores and were preferred by patients over cotton liners.

There were no major adverse reactions in the waterproof group, and only 1 cotton-liner patient required re-manipulation. Wolff et al found the incidence of unscheduled cast changes was 14% in the non-waterproof group versus 2.9% in the waterproof group in their study of hip spica casts.⁹ Similarly, Hadley et al found that 33%

of cotton casts required an unscheduled change without a major adverse reaction (defined as a necessary re-reduction or operative fixation) versus only a 10% unscheduled cast change rate with the Gore-Tex casts.² The results in this study are again in line with previous studies on older waterproof technology, with only 5% (1/20) unscheduled cast changes in the non-waterproof group versus 0% in the waterproof.

Our findings should be interpreted in light of its limitations. We had only 20 patients in our crossover study. More patients may be needed to show a difference in other patient-rated parameters to show favor of either waterproof or cotton lining. Furthermore, while there have been reported application issues with Gore-Tex,⁷ we did not specifically investigate this parameter. In addition, our study was not designed to study costs, but at our institution, 1 waterproof-liner roll costs approximately 6 dollars more than cotton. However, our study also has strengths. A major strength is the crossover design, where patients were randomized to either group, then crossed over. This allowed each patient to serve as one's own control. In addition, this is the first study to allow patients to swim, which is perhaps a more rigorous test and likely creates a more realistic living, especially for the pediatric patients.

In conclusion, when used in the upper extremity, waterproof cast liners had better odor and sweat scores, had better physician scores, and were preferred by patients compared with cotton cast liners. They were found to maintain fracture reduction equally compared with cotton liners and perhaps have a lower risk of unscheduled cast changes. Although they are more expensive than traditional cotton linings, modern waterproof liners should be considered by any orthopedist who desires to improve patient satisfaction in fracture care, especially in the pediatric population.

Authors' Note

This article was selected for presentation at the AAHS meeting in The Bahamas, January 21-24, 2015, and it was also invited for consideration as a finalist for the Resident Award Competition.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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