

Short Communication

Are Waterproof Casts More Cost Effective than Non-Water Proof Casts?

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• Casting treatment; Reimbursement; Waterproof casts; Children

Abstract

Background: Casting treatment is not without risk. Casts can become wet leading to skin breakdown and unplanned return visits. Reimbursement for waterproof casts is limited due to lack of evidence supporting their need; out of pocket charges are often incurred. The purpose of this study was to compare clinical outcomes and costs of treatment of extremity injuries with non-waterproof casts (NWPC) compared to waterproof casts (WPC).

Methods: This retrospective review included children between 2-18 years treated with an upper or lower extremity cast. Medical records and hospital costs for casting during summer months (May-August) between 2013 - 2015 were obtained. Demographic and clinical characteristics were summarized and stratified according to extremity. Bivariate comparisons were conducted and stratified by extremity. Outcomes including unplanned return clinic visits, complications, and cast complaints were compared across cast type (NWPC versus WPC). A decision tree cost analysis was conducted to determine the expected unit cost of a NWPC versus a WPC, when considering total cost and the expected likelihood of an unplanned return.

Results: A total of 3,476 casts were applied in 3,418 children. The average age was 9 years (SD = 4.1) and the cohort was 58% (n=2012) male. The majority of casts were upper extremity (73%) with most being short in length (66%) and were NWPC (70%, n = 2036/3476). Children with NWPC returned more frequently for unplanned clinic visits compared to WPC (1% versus 6%, p<0.001). While return visits were higher for NWPC, the WPC were more likely to have a cast complication (100% versus 22%) or cast complaint (44% versus 9%); these were typically easily treated in clinic. Despite the increased cost of return visit, WPC casts remained more expensive than NWPC; this was an increase of 4% for upper extremity casts and 14% for lower extremity casts.

Conclusion: Children treated with a WPC were significantly less likely to incur extra clinic visits compared to children treated with NWPC. However, WPC were found to be slightly more expensive than NWPC. Insurance coverage for these WPC should still be considered during summer months to make this a viable option for all patients.

Level of Evidence: Level III

INTRODUCTION

Casting is the mainstay of treatment for most pediatric extremity fractures. While operative rates for pediatric fractures is increasing [1], many pediatric fractures are still treated by casting alone. However, casts are not without potential problems and complications [2-5]. Casts are constructed of two main elements: the soft padding protecting the skin, and a hard layer providing the support for the injured extremity. The hard layer historically was made from plaster-impregnated cloth, however modern casting now uses fiberglass for its relatively lighter weight to strength ratio [5]. The soft padding typically comprises cotton padding and fabric lining. The fiberglass layer is waterproof, but the cotton padding and lining are not; when the cotton padding gets wet it acts like a cotton sponge and soaks up water [5]. Because wet cotton

padding underneath the fiberglass layer cannot breathe, it will not dry. Skin next to wet cotton padding will become macerated and risks infection and breakdown [6]. When the cotton padding gets wet, the entire cast needs to be changed, and this results in extra visits to the clinic and, sometimes, after hours visits to the Emergency Department (ED) [6]. Commercial and non-commercial cast covers can be used to try and protect a cast during bathing and hygiene. However, these methods all have shortcomings, and despite this protection the casts can still get wet [7].

Waterproof padding can be used to replace the cotton padding under the fiberglass cast, and this has been an acceptable alternative for over two decades [6]. This creates a cast that can be fully immersed in water. Comparisons of waterproof casts (WPC) to non-waterproof casts (NWPC) have found that they are equally effective at holding a

reduction [8], have better physician rated scores [9], and are preferred by most patients [9]. Despite this, insurance companies typically do not cover the increased cost of the waterproof padding, requiring an out-of-pocket expense that not all families can afford. However, since the NWPC often incur additional clinic and/or ED visits for wet casts and skin problems associated with them, it is not clear if the NWPC is less expensive when compared to the WPC particularly in the summer months.

The purpose of this study was to compare the cost of NWPC (including unexpected visits to the clinic and ED, as well as skin related complications due to casting) to WPC (including the cost of unexpected visits to the clinic and ED and the waterproof materials) during the summer months over a three-year period.

MATERIALS AND METHODS

This retrospective study was conducted at a pediatric academic medical center in the Northeastern part of the United States. Data were collected during the summer months (May-August) from 2013-2015. IRB approval was obtained. This study was accepted as a minimal/no risk retrospective study limited to secondary use of data; due to this, we had a waiver of consent for those involved.

Children were included in the study if they met the following criteria: 1. age 2-18 years, 2. sustained an isolated upper or lower extremity injury requiring casting, 3. treated with either a WPC or a NWPC, and 4. the WPC or NWPC was applied during the summer months from 2013-2015. Patients who underwent surgery or who were treated with a hip spica casts were excluded. In addition, patients who were not eligible for a WPC according to hospital policy were excluded from the study including post-operative patients, patients with exposed pins, and those whose casts were applied in the ED. Patient records and hospital cost data for cast applications along with associated unplanned returns to the clinic and ED for a cast change due to a wet cast, a cast complaint or cast complication were obtained.

Data Analysis

Patient and cast characteristics were summarized for the cohort and stratified by extremity. Bivariate comparisons were conducted between upper and lower extremity casts using chi-squared tests or Student's t-test as appropriate. Comparisons in outcomes including unplanned return clinic visits, ED visits, complications, and cast complaints were conducted across cast type (WPC versus NWPC) stratified by extremity. For events with significant risk reduction, the number needed to treat

(NNT) was calculated to assess the benefit of WPC over NWPC. A decision analysis was conducted to determine the expected unit cost of a WPC versus a NWPC when considering total cost and the expected likelihood of an unplanned return. A sub-analysis was completed to assess any variation in cost given the location of return (ED versus clinic) but none was detected, so pooled analyses are reported. Cost is reported as proportional to a NWPC referent (ref) to protect the privacy of hospital billing.

RESULTS

Three thousand four hundred seventy-six casts applied in 3,418 patients were analyzed. Patients were an average of 9 years (SD=4.1) at initial casting and the cohort was 58% (N=2012) male (**Table 1**). The majority of cases were upper extremity casts (73%, N=2553) and when considering both upper and lower extremity casts, most casts were short in length (66%, N=2304) (**Table 1**). Bivariate analysis found that when compared to lower extremity casts, upper extremity casts were more frequently applied in males (60% vs 52%; $p<0.001$), were less commonly short (61% vs 81%; $p<0.001$) and were more commonly waterproof (35% vs 16%; $p<0.001$). Due to vast differences between upper and lower extremity casts, all analyses were stratified by extremity.

The majority of the patients (70%, N =2435) were placed into a NWPC compared to 30% (N=1041) who were placed into a WPC. WPCs were more likely to be applied to the upper extremity (86%) and were short in length (76%) whereas a smaller percentages of NWPC were applied to the upper extremity (68%) and were short in length (62%) ($p<0.001$).

Unplanned returns

Thirty-five percent (898/2553) of upper extremity casts were WPC (25% long casts, 75% short casts) (**Table 2**). Only 9 (9/898, 1.0%) of the patients with upper extremity WPC returned for an additional clinic visit compared to 97 (97/1655, 5.9%) of patients with upper

Table 1: Patient and cast characteristics for all subjects and by limb casted.

Characteristic	All subjects (N=3476)		Arm casts (N=2553)		Leg casts (N=923)		P
	Freq.	(%)	Freq.	(%)	Freq.	(%)	
Age at casting (years; mean (SD))	9.4	(4.1)	9.3	(4.0)	9.5	(4.4)	0.12
Sex (% male)	2012	(58%)	1529	(60%)	483	(52%)	<0.001
Cast length							<0.001
Long	1172	(34%)	998	(39%)	174	(19%)	
Short	2304	(66%)	1555	(61%)	749	(81%)	
Cast type							<0.001
Non-waterproof	2435	(70%)	1655	(65%)	780	(85%)	
Waterproof	1041	(30%)	898	(35%)	143	(16%)	

extremity NWPC ($p<0.001$). Of the 9 WPC that returned, 100% experienced a complication and 44% had an additional cast complaint (**Table 2,3**). Of the 97 NWPCs that returned, 100% had a wet cast, 22% also experienced a complication, and 9% had an additional cast complaint (**Table 2,3**). Fifteen percent (143/923) of lower extremity casts were WPC (18% long casts, 83% short casts) (**Table 2**). No difference was detected in the proportion of lower extremity WPC that returned for an additional clinic visit compared to lower extremity NWPC casts (4.6% vs 4.9%; $p>0.99$) (**Table 2**). Of the 7 lower extremity WPC that returned, 100% experienced a complication and 71% had an additional cast complaint (**Table 2,3**). Of the 36 lower extremity NWPC that returned, 100% had a wet cast, 47% also experienced a complication, and 22% had an additional cast complaint (**Table 2,3**).

Costs

Decision analysis was conducted to compare overall expected cost of WPC versus NWPC stratified by extremity (**Figure 1**). No differences were detected in the cost of unplanned returns to the ED versus unplanned returns to the outpatient clinic (OC) for WPC (proportional cost ED/OC, 1.00) or NWPC (ED/OC, 0.97) ($p=0.94$), so unplanned returned costs were analyzed ignoring the location of return. The estimated risk of an unplanned return for an upper extremity WPC was 1.0% compared to a risk of 5.9% for an unplanned return of an upper extremity NWPC ($p<0.001$). Based on these expected risks and the estimated cost of each event, it was found that waterproof casts only present a 4% increase in overall cost compared to NWPCs (**Table 4**). Furthermore, we would need to apply an upper extremity WPC to 21 patients in order to prevent

Table 2: Characteristics and outcomes by limb and by cast type.

Characteristic	Arm casts					Leg casts				
	Waterproof (N=898)		Non-waterproof (N=1655)		P	Waterproof (N=143)		Non-waterproof (N=780)		P
	Freq.	(%)	Freq.	(%)		Freq.	(%)	Freq.	(%)	
Age at casting (years; mean (SD))	9.2	(3.7)	9.3	(4.2)	0.51	9.2	(4.7)	9.6	(4.4)	0.31
Sex (% male)	528	(59%)	1001	(61%)	0.43	65	(46%)	418	(54%)	0.09
Cast length					<0.001					0.74
Long	226	(25%)	772	(47%)		25	(18%)	149	(19%)	
Short	672	(75%)	883	(53%)		118	(83%)	631	(81%)	
Outcomes	Freq.	(%)	Freq.	(%)	P	Freq.	(%)	Freq.	(%)	P
Unplanned Return	9	(1%)	97	(6%)	<0.001	7	(5%)	36	(5%)	>0.99
Complaint	4	(44%)	9	(9%)	0.01	5	(71%)	8	(22%)	0.03
Complication	9	(100%)	21	(22%)	<0.001	7	(100%)	17	(47%)	0.03
Wet cast	0	(0%)	97	(100%)	<0.001	0	(0%)	36	(100%)	<0.001
Return Location					0.21					0.67
Emergency department	0	(0%)	18	(19%)		1	(14%)	9	(25%)	
Orthopedic clinic	9	(100%)	79	(81%)		6	(86%)	27	(75%)	

Table 3: Complications and complaints by limb and cast type.

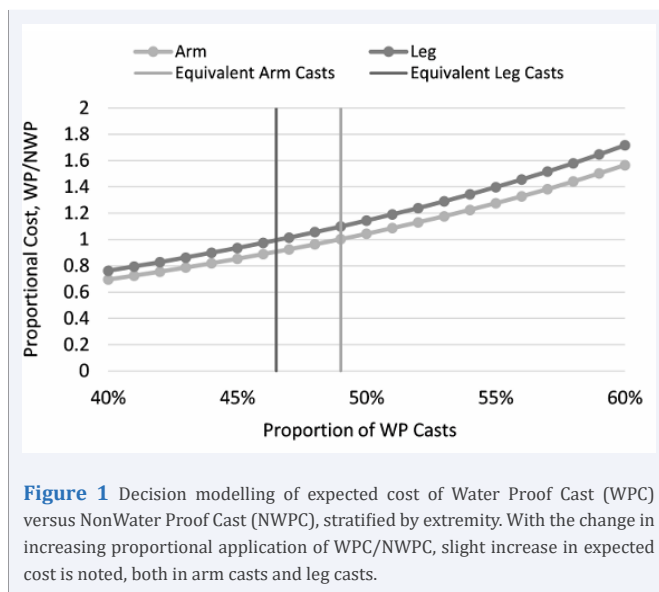
Arm casts					Leg casts				
Return for complication ^a	Waterproof (N=10)		Non-waterproof (N=24)		Return for complication ^a	Waterproof (N=8)		Non-waterproof (N=18)	
Elbow Pressure Sore	1	(10%)	0	(0%)	Foot Excoriation	1	(13%)	0	(0%)
Fingers/thumb Pressure Sore	0	(0%)	1	(4%)	Foot Maceration	1	(13%)	11	(61%)
Forearm Excoriation	1	(10%)	2	(8%)	Foot Rash	0	(0%)	1	(6%)
Forearm Maceration	0	(0%)	6	(25%)	Foot Redness	0	(0%)	1	(6%)
Forearm Pressure Sore	3	(30%)	0	(0%)	Heel Maceration	2	(25%)	4	(22%)
Forearm Rash	0	(0%)	5	(21%)	Heel Pressure Sore	1	(13%)	0	(0%)
Forearm Redness	1	(10%)	0	(0%)	Heel Rash	1	(13%)	0	(0%)
Hand Excoriation	0	(0%)	1	(4%)	Leg Rash	0	(0%)	1	(6%)
Hand Maceration	0	(0%)	8	(33%)	Popliteal Fossa Pressure Sore	1	(13%)	0	(0%)
Hand Pressure Sore	0	(0%)	1	(4%)	Toe Redness	1	(13%)	0	(0%)
Palm/fingers Excoriation	1	(10%)	0	(0%)					
Wrist Maceration	1	(10%)	0	(0%)					
Wrist Pressure Sore	1	(10%)	0	(0%)					
Wrist Rash	1	(10%)	0	(0%)					
Return for complaint ^b	Waterproof (N=4)		Non-waterproof (N=9)		Return for complaint ^b	Waterproof (N=5)		Non-waterproof (N=8)	
Pain	1	(25%)	3	(33%)	Pain	4	(80%)	5	(63%)
Itching	3	(75%)	6	(67%)	Odor	0	(0%)	1	(13%)
Rash	1	(25%)	0	(0%)	Burning	1	(20%)	1	(13%)

^aThere were 60 complications in 54 patients.

^bThere were 26 complaints in 26 patients.

Table 4: Decision cost analysis for cast type by limb

Decision paths		Outcomes	Expect Probability of Outcome	Proportional Cost of Outcome	Proportional Probability \times Cost
Arm	Waterproof (35%)	Returned (1%)	(1%)	2.3	0.0
		Not returned (99%)	(99%)	1.1	1.2
	Non-waterproof (65%)	Returned (6%)	(6%)	2.1	0.1
		Not returned (94%)	(94%)	<i>Ref</i>	<i>Ref</i>
Leg	Waterproof (15%)	Returned (5%)	(5%)	2.0	0.1
		Not returned (95%)	(95%)	1.1	1.1
	Non-waterproof (85%)	Returned (1%)	(1%)	1.8	0.1
		Not returned (99%)	(99%)	<i>Ref</i>	<i>Ref</i>



one additional unplanned return. The estimated risk of an unplanned return for a long WPC was 4.9% compared to a risk of 4.6% for an unplanned return of a lower extremity NWPC ($p>0.99$). Based on these expected risks and the estimated cost of each event, it was found that lower extremity WPC would present a 14% increase in overall cost compared to lower extremity NWPC (Table 4).

DISCUSSION

Casting remains the mainstay of treatment for many pediatric orthopaedic extremity fractures. However, problems with casting remains an ongoing issue, and wet casts are particularly problematic requiring additional costly clinic or ED visits, and occasionally skin care issues [3-10]. Various methods and devices have been used to prevent NWPCs from getting wet, some more effective than others [7]. WPC have been shown to be safe and effective [11], but many insurance companies are unwilling to pay for the increased cost of the waterproof lining. This requires out of pocket fees from the patient's family to cover the cost of the waterproof casting materials; not all families can afford this expense and so availability

is differentially available depending on socioeconomic status. However, no prior study has assessed the cost effectiveness of waterproof casts, and weighed the increased cost of the initial material of WPCs against the potential cost savings of decreased return visits that can occur with NWPC when they get wet. In our study of casting during the summer months, we found that there were more unplanned returned visits to the clinic or ED when a NWPC was applied compared to a WPC. While skin complaints and complications were higher with in the WPC cohort, they did not incur cost increases. This may be due to the fact there these complications were easily treated in the clinic. However, despite this increased return rate for the NWPC, we found that the costs of WPC remained 4% higher for upper extremity casts and 14% higher for lower extremity casts when compared to the costs of a NWPC. While no other studies have performed a cost analysis of WPC compared to NWPC, other studies have compared the two types of casting materials. In a randomized prospective study of a NWPC to a WPC for treatment of fully displaced distal radius fractures, Robert et al., found that there was no difference in ability to hold a reduction [8]. Haley et al., [12], conducted a randomized prospective comparison of standard cotton liners to waterproof liners in patients ≥ 10 years old with either upper or lower extremity injuries. They found that the patients with waterproof-liners had better scores for itch, discomfort, irritation, and overall patient score when compared to standard cotton lined casts [12]. Efficacy study of waterproof linings for pediatric patients with short-arm, long-arm and short-leg casts found high satisfaction rates (79% very satisfied) with some minor skin integrity issues [6]. Guillen et al., did a randomized prospective cross over study of the comparison of cotton versus waterproof cast liners and found that 75% of the patients preferred the waterproof liner [9]. There are several limitations of this study. It is a retrospective study, and there are inherent faults with this including potentially missing skin issues, clinic or ED visits, or other problems due to lack of documentation. Because of multiple flaws in the submitted patient billings, we had

to utilize decision analysis and optimize the appropriate billing to best model the comparison between WPC and NWPC. Finally, we chose to only study the summer months, because in the Northeast United States, the WPC is not utilized as frequently or a critical a resource in the colder months; other locations may find WPC more useful year-round.

WPCs themselves have some limitations. They do need to get wet every day, and can take up to an hour to dry. Waterproof liners have been reported to cause transient altitude induced compartment syndrome in some children [13].

CONCLUSION

In summary, we did not find WPC to be cost effective relative to NWPC in the summer months. While there was an increase in unplanned returns with NWPC, the costs of these visits were not offset by the increased cost of the material in WPC. However, the increased costs of WPC compared to NWPC was only 4% for an upper extremity cast and 14% for a lower extremity cast. While this initial study would benefit from further research to confirm the results, consideration of the cost and medical insurance implications of this research should be considered. Further discussions with insurance companies to consider covering the material costs of WPC despite the slight increase in costs would make this resource available to all insured patients regardless of socioeconomic status. This would

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