A Comparison of Various Contemporary Methods to Prevent a Wet Cast

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Background: Many traditional methods and commercially available products are available to prevent a wet cast, although there is a paucity of literature regarding the optimal strategy.

Methods: Using a synthetic leg model, a short leg cast was applied and six different methods were tested. Group A (Glad Press'n Seal wrap), Group B (plastic bag with rubber band), Group C (plastic bag with duct tape), Group D (double plastic bags with duct tape), Group E (CVS Pharmacy Reusable Cast & Wound Protector), and Group F (Dry Corp Dry Pro Large Half Leg Waterproof Cast Cover). Casts were submerged in water for two minutes and were weighed. Each group had ten individual trials. Effectiveness was measured by calculating the amount of water absorption using cast weights before and after submersion.

Results: The percentage of water absorption prevention ranged from 62% to 100%, with Groups A and B being the least effective and Groups D, E, and F being the most effective. There was considerable variation in the simplicity of use. Groups C, D, and E were found to be simple to use, with increasing difficulty in Groups A, B, and F.

Conclusions: Our findings conclude that the six methods tested are effective in preventing the majority of water saturation. Although abstaining from contact with water is the most prudent approach, if a cast cover is to be used, double plastic bags with duct tape (100% prevention, $10) and the CVS cast protector (100% prevention, $13) are the preferred contemporary methods to prevent a wet cast.

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Casting is routinely used for fracture care, postoperative immobilization, and correction of congenital anomalies. Typical cast materials consist of an outer shell of plaster and/or fiberglass and layers of soft roll or cast padding with or without a stockinette. Providing appropriate cast care instructions to patients and families is of paramount importance, and one of the essential components when instructing cast care is to educate the patient to keep the cast dry.

Casts, whether plaster or fiberglass material is used, decrease in mechanical strength when exposed to water[1,2]. Patients report that wet casts cause itching, develop an odor, and are difficult to completely dry[3]. As these casts become wet, moisture is absorbed, is transmitted, and is retained within the cotton layer and may produce cutaneous complications including bacterial infections, maceration, ulceration, rashes, and contact dermatitis[4,5]. Furthermore, a wet cast results in a high number of preventable visits to the emergency department[6]. A recent study done by Sawyer et al.[6] evaluated 168 cast-related emergency department visits, with wet casts being the most common reason (29%) for visits.

There are many proposed methods to keep casts dry. Traditional methods include the use of a plastic bag and some form of anchor to provide a seal[7]. Commonly employed anchors include either adhesive tape or elastic bands. In addition, some physicians recommend using plastic wrap as an alternative. There are also a variety of commercial products available, including cast liners such as 3M Scotchcast (3M, St. Paul, Minnesota) and Gore Procel (3M), which have been shown to be an effective alternative to traditional casting[8,9]. In addition, there are a variety of waterproof shields including but not limited to Dry Pro (Dry Corp, Wilmington, North Carolina), CVS Reusable

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Cast Cover (CVS Caremark, Woonsocket, Rhode Island), and Limbo (Thesis Technology Products, West Sussex, England)[10].

The American Academy of Orthopaedic Surgeons (AAOS) current "Cast Care" brochure recommends the use of two layers of plastic or purchasing waterproof shields to keep a splint or cast dry while showering or bathing[11]. Despite the AAOS recommendation, there is a paucity of literature available regarding an optimal strategy. In addition, there is little information on the cost of the various methods for an entire treatment period.

The purpose of this study was to compare the effectiveness of common currently employed methods utilized by patients and recommended by doctors to keep traditional casts dry. Our secondary objectives were to analyze cost and ease of use to help determine the overall preferred method of protection.

Materials and Methods

An experimental study was performed utilizing casts that were applied in a uniform standardized manner onto a plastic mannequin model (MannequinHub, Irvington, New Jersey). No human subjects were used. Our institutional review board stated that this study was exempt.

Preparation of Casts

Each standardized cast consisted of two 5 × 3-inch (12.75 × 7.62-cm) stockinettes, one 6-inch (15.24-cm) Webril, one 3-inch (7.62-cm) Webril, one 6-inch (15.24-cm) roll of fiberglass, and one 4-inch (10.16-cm) roll of fiberglass. These casts were applied to a pair of commercially available mannequin legs (MannequinHub). Each group consisted of ten casts that were weighed using a Scale-Tronix 4800 pediatric digital scale (Scale-Tronix, Carol Stream, Illinois) (see Appendix). After a cast was made, it was allowed to dry for ten minutes before the initial weight in kilograms was measured. The control group involved submerging the cast in a canister filled with room-temperature water for two minutes and immediately weighing the cast afterwards. The experimental groups were submerged within their protective layer. The protective layers were removed immediately after the two-minute water submersion and the final weights were then measured. Using the specific weight of water, 1 gram is equal to 1 milliliter, the weights of the casts were converted to the amount of water absorbed[7].

Application of Cast Protection

Group A casts used the Glad Press'n Seal wrap (Glad Products, Amherst, Virginia) as the protective barrier (see Appendix). The Press'n Seal wrap came with 2324 × 30.5 cm (915 × 12 inches) of usable material and a single cast required approximately 116.85 cm (46 inches) in length. Group B consisted of a single plastic bag (Great Value Flap Tie Closure trash bags; Great Value, Omaha, Nebraska) with an elastic rubber band (Advantage Rubber Bands; Alliance Rubber, Hot Springs, Arkansas) to create a seal at the proximal end (see Appendix). Group C used a plastic bag with duct tape (Duck Tape; ShurTech Brands, Avon, Ohio) as a seal (see Appendix). The duct tape was applied circumferentially at the proximal end of the plastic bag. Approximately 18.29 meters (20 yards) of a package of duct tape were used for each plastic bag. Group D consisted of two layers of plastic bags with duct tape (see Appendix). The application of this method was identical to Group C, but with an additional plastic bag and duct tape seal applied superficially. Group E involved the CVS Pharmacy Reusable Cast & Wound Protector (CVS Caremark) (see Appendix). The last group of casts, Group F, used the Dry Pro Large Half Leg Waterproof Cast Cover (Dry Corp) (see Appendix). Excess air underneath the protective layers was manually removed before applying the seal to minimize buoyancy when submerged under water. The Dry Pro barrier came with a suction valve and pump device, which removed the excess air and created a vacuum seal throughout the cast.

Statistical Analysis

A nonparametric statistical analysis was performed on the data because of the difference in the distribution of data between groups. First, a nonparametric analysis of variance using the Kruskal-Wallis test was conducted to compare the groups' data as a whole. Second, a nonparametric Mann-Whitney test was done for each group in comparison with the control group. The level of significance was set at $p < 0.05$.

TABLE I Percentage of Prevented Water Absorption*

Group	Water Absorption Prevented
Control	0%
A (Glad Press'n Seal wrap)	72%
B (Single plastic bag with elastic rubber band)	62%
C (Single plastic bag with duct tape)	96%
D (Double plastic bags with duct tape)	100%
E (CVS cast protector)	100%
F (Dry Pro cast cover)	100%

*T tests showed a p value of <0.0001 for each group in comparison to the control group (Group D was unable to be tested). ANOVA included all groups and the control group and had a p value of <0.0001.

Cost Analysis

The monetary cost of the protective barriers and materials used was recorded. All materials, except the CVS Pharmacy Reusable Cast & Wound Protector and the Dry Pro Large Half Leg Waterproof Cast Cover, were purchased from Walmart. The other two items were purchased from their respective manufacturers. Sales tax was excluded in our calculations. The theoretical cost and actual costs were calculated for six weeks of cast care. The theoretical cost for six weeks was calculated by assuming a single use of the protection method per day with the exact amount of materials needed. The actual costs represent how much a consumer needs to spend at retail price for six weeks of cast care. This takes into consideration that an entire package of materials instead of the exact amount needed for a single use must be purchased. The CVS cast protector and the Dry Pro cast cover and rubber bands were assumed to function properly the entire six weeks.

Ease of Use

Each method of cast protection was evaluated on the difficulty of creating the protective layer. Factors included time spent, coverage, durability, and difficulty of application and removal.

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The authors did not receive any external funding or grants in support of their research for this work. In addition, none of the authors have connections or financial arrangements with any commercial entities involved in the study.

Results

Water Absorption Prevention

When each group's data were recorded, the median values, as opposed to the mean, were calculated. Because the data were not normally distributed, the median represents a more accurate representation of a group's effectiveness in preventing water absorption. The control group absorbed a median of 640 mL of water (range, 599 to 707 mL) after two minutes. Group A, Glad Press'n Seal wrap, absorbed 240 mL of water (range, 17 to 340 mL). Subtracting the control from Group A demonstrated that the Glad Press'n Seal wrap prevented 62% of water

TABLE II Cost Analysis

Group	Commercial Price	Cost for Single Use*	Theoretical Cost for Six Weeks†	Actual Cost for Six Weeks†
A (Glad Press'n Seal wrap)	$2.89	$0.14	$5.88	$8.67
B (Single plastic bag with elastic rubber band)	$8.24	$0.10	$4.20	$8.24
C (Single plastic bag with duct tape)	$9.91	$0.15	$6.30	$9.91
D (Double plastic bags with duct tape)	$9.91	$0.30	$12.60	$12.85
E§ (CVS cast protector)	$12.99	$12.99	$12.99	$12.99
F§ (Dry Pro cast cover)	$38.95	$38.95	$38.95	$38.95

*Cost for single use represents the cost for the exact amount of materials needed for one use. †Theoretical costs represent cost for single use for six weeks, assuming one use per day. ‡Actual costs represent retail costs for total materials needed to cover six weeks of cast care. §Groups E and F are single-use products.

absorption. Group B, the single plastic bag with an elastic rubber band, absorbed 243 mL of water (range, 28 to 480 mL) and prevented 62% of water absorption. Group C, the single plastic bag with duct tape, absorbed 26 mL of water (range, 7 to 156 mL) and prevented 96% of water absorption. Group D, the double plastic bags with duct tape, and Group E, the CVS cast protector, had a median water absorption of 0 mL and 100% prevention, but there was no range for Group D and the range was 0 to 1 mL for Group E. Group F, the Dry Pro cast cover, absorbed 1 mL of water (range, 0 to 4 mL) and, on average, prevented 100% of water absorption within our measurements.

There was a significant difference ($p < 0.0001$) in the total effectiveness between groups, as determined by a non-parametric analysis of variance (ANOVA) Kruskal-Wallis test, with a value of 62.24. After this was determined, the non-parametric Mann-Whitney tests on each group, except for Group D (the double plastic bags with duct tape), with the control group showed significant effectiveness ($p < 0.0001$) in preventing water absorption. Each of Group D's experimental trials did not result in a weight change within the sensitivity of our scale and, therefore, a statistical analysis with the control group to calculate its effectiveness was not necessary.

The Appendix summarizes the weight difference of casts after water immersion. The subtraction of the weight of the respective mannequin used was included in the calculation. Mannequin #1 (average weight, 465 g) and mannequin #2 (average weight, 454 g) were measured twenty-five separate times and showed the precision of the scale to be ±1 g. Table I lists the percentage of water absorption prevented by the tested modality using the control group as the baseline.

Cost Analysis

The cost analysis for each method is summarized in Table II. The least expensive method for six weeks of cast care was Group B (single plastic bag with elastic rubber band) at $8.24. The most expensive method was Group F (Dry Pro cast cover) at $38.95. The other costs were $8.67 for Group A (Glad Press'n Seal wrap), $9.91 for Group C (single plastic bag with duct tape), $12.85 for Group D (double plastic bags with duct tape), and $12.99 for Group E (CVS cast protector).

Investigator's Interpretation on Ease of Use

Given ten trials to apply each protective barrier, a subjective assessment on the ease of application concluded that Group E (CVS cast protector), Group C (single plastic bag with duct tape), and Group D (double plastic bags with duct tape) were the least difficult to set up. Each of these methods did not have any obstacles in preparing a secure layer of protection around the casts. The remaining methods had notable problems. Group B (single plastic bag with an elastic rubber band) was difficult to apply because of the band's limited elasticity that made it troublesome to ensure a tight seal. Group F (Dry Pro cast cover) was made of material that was easily torn with slight tension. However, it is worth noting that these tears were inconsequential, as water absorption was unchanged after the tear. The most difficult of all methods was Group A (Glad Press'n Seal wrap). Secondary to one side being entirely adhesive, it was very difficult to efficiently cover the cast without adjusting the material to create a consistent and smooth seal.

Discussion

The aim of our study was to compare contemporary methods to protect casts from water by assessing effectiveness, costs, and ease of use. Our findings suggest that each method tested was effective in preventing the majority of water absorption. However, the double plastic bags with duct tape and commercial products from CVS and Dry Corp, on average, prevented the most appreciable water absorption within the sensitivity of our measurements. When combining cost analysis for a six-week course, the double plastic bags with duct tape ($10) and the CVS cast protector ($13) were substantially less expensive than the Dry Pro cast cover ($39). Comparing ease of use, plastic bag(s) and duct tape and the CVS cast protector were two of the least difficult methods, and the Dry Pro cast cover was one of the most difficult methods. With the above results, we believe that the double plastic bags with duct tape

and the CVS cast protector methods are the best recommendation for patients in need of water protection for their casts.

A similar study conducted by Nielsen et al.[7] also concluded that traditional methods of water protection are preferred over some commercially made products with regard to effectiveness, ease of use, and costs. They compared the effectiveness of three commercial plaster protectors and a large plastic bag with an elastic band seal by directly placing them on bare human arms. Each method's effectiveness was measured by calculating the weight difference of the protective barrier before and after water exposure. Ten trials were conducted in three separate scenarios to assess the difference in effectiveness with activity: (1) two minutes under a shower, (2) one minute of continuous submersion, and (3) swimming. The plastic bag with the elastic band seal had similar results to the three commercial products in the shower (0.9 mL versus 0.5 mL, 0.5 mL, and 0 mL) and in immersion (0.3 mL versus 0.3 mL, 0.4 mL, and 1.2 mL). However, the plastic bag showed more noticeable effectiveness when swimming (0.8 mL versus 0.6 mL and 33.2 mL), in which the third commercial product was unable to be tested because it fell off during the swim. The commercially available barrier devices that Nielsen et al. tested cost £10.10 ($13.82), £17.60 ($24.08), and £17.99 ($24.61), and they stated that the bag and elastic band cost approximately 10 pence ($0.14).

Although the plastic bag with the elastic band proved to be an effective method in the study by Nielsen et al.[7], our study did not yield similar results. In fact, this method was the least effective of all groups. In contrast with our current study, Nielsen et al.[7] only tested one traditional method and no statistical analysis was performed. To our knowledge, our study is the first that compares multiple available traditional methods.

Our results support the AAOS recommendation of using two layers of plastic or purchasing a waterproof shield[11]. Although we were unable to utilize a t test analysis to support the effectiveness of the double plastic bags with duct tape method because of a lack of a standard deviation, we believe that statistical analysis does not need to be conducted to prove its effectiveness and reliability.

Our study had limitations. One limitation of the study design was our method of immersing the casts in water. Because movement was kept to a minimum when submerged, the results might not accurately reflect the amount of activity that patients may have. The assumption of some of the materials (CVS cast protector, Dry Pro cast cover, and elastic rubber bands) being able to function properly for the entire six weeks of cast care was another limitation of our study, especially as the Dry Pro cast cover was seen to have poor durability. Also, the use of mannequins instead of human subjects might not be an ideal interface. On the contrary, by using plastic mannequins, water would be absorbed entirely into the cast instead of into human skin, which is capable of retaining moisture and causing perspiration to be absorbed in the cotton layer, leading to inaccurate measurements of absorption. Skin irritation from tape adhesive was also a concern that could not be assessed with our experimental design. Finally, investigator bias was another limitation. Application of casts, protective methods, and analysis of ease of use were done by a single investigator (S.N.), so it is likely that there will be variations in results if done by a large group of users.

To our knowledge, this is the first study that compares multiple contemporary methods of preventing a wet cast. It was designed because of the common clinical implications of a wet cast and typical inquiries from patients and families. Knowledge of the various methods that tested effectiveness may aid in the prevention of mechanical cast failure, infections, skin irritations, and multiple repeat medical visits secondary to a wet cast. Future projects may include human subjects and different intensities of activity with these various protective methods to create more realistic experimental scenarios. One subject that remains to be explored is how much water must be minimally absorbed to cause clinical manifestations. Finally, a survey of patients and/or caregivers could serve as a better investigation for assessing ease of use and overall patient satisfaction.

The purpose of the present study was to determine the most ideal method of water protection for patients wearing casts. Obviously, the most prudent method would be for the patient with a cast to completely abstain from contact with water. However, if the patient chooses to venture near or in water, our study concluded that the traditional use of double plastic bags with duct tape or the CVS cast protector would be the preferred methods because of their reliable effectiveness, ease of use, and minimal costs.

Appendix

(eA) Figures showing photographs of the Scale-Tronix pediatric digital scale and Groups A through F and a table demonstrating the weight differences of casts are available with the online version of this article as a data supplement at jbjs.org. ■

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References

1. Berman AT, Parks BG. A comparison of the mechanical properties of fiberglass cast materials and their clinical relevance. J Orthop Trauma. 1990;4(1):85-92.

2. Wytch R, Ross N, Wardlaw D. Glass fibre versus non-glass fibre splinting bandages. Injury. 1992;23(2):101-6.

3. Bucholz RW, Heckman JD, Court-Brown CM, Tornetta P. Rockwood and Green's fractures in adults. 7th ed. Philadelphia: JB Lippincott; 1975.

4. Shannon EG, DiFazio R, Kasser J, Karlin L, Gerbino P. Waterproof casts for immobilization of children's fractures and sprains. J Pediatr Orthop. 2005 Jan-Feb;25(1):56-9.

5. Selesnick H. A more comfortable cast? A trial of waterproof liner. Phys Sportsmed. 1993;21:106-16.

6. Sawyer JR, Ivie CB, Huff AL, Wheeler C, Kelly DM, Beaty JH, Canale ST. Emergency room visits by pediatric fracture patients treated with cast immobilization. J Pediatr Orthop. 2010 Apr-May;30(3):248-52.

7. Nielsen DM, Ripley LG, Ricketts DM. Keeping plaster casts dry: what works? Injury. 2005 Jan;36(1):73-4.

8. Robert CE, Jiang JJ, Khoury JG. A prospective study on the effectiveness of cotton versus waterproof cast padding in maintaining the reduction of pediatric distal forearm fractures. J Pediatr Orthop. 2011 Mar;31(2):144-9.

9. Kruse RW, Fracchia M, Boos M, Guille JT, Bowen JR. Goretex fabric as a cast underliner in children. J Pediatr Orthop. 1991 Nov-Dec;11(6):786-7.

10. Naram A, Makhijani SN, Chao JD. Inexpensive alternatives for extremity cast and bandage protection. Orthop Nurs. 2011 Mar-Apr;30(2):117-8.

11. American Academy of Orthopaedic Surgeons. OrthoInfo. Care of casts and splints. 2011 Apr. http://orthoinfo.aaos.org/topic.cfm?topic=A00095. Accessed 2013 Nov 26.