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ORIGINAL STUDY

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Comparison of waterproof versus cotton cast liners on cast index in pediatric forearm fractures

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Achieving an adequate cast mold is critical for successful nonoperative management of pediatric forearm fractures. A high cast index (>0.8) is associated with an increased risk of loss of reduction and failure of conservative management. Waterproof cast liners offer improved patient satisfaction compared to conventional cotton liners, however they may carry different mechanical properties compared to traditional cotton liners. The purpose of this study was to determine whether the cast index differs between waterproof and traditional cotton cast liners when used to stabilize pediatric forearm fractures. We retrospectively reviewed all forearm fractures casted in a pediatric orthopedic surgeon's clinic between December 2009 and January 2017. Either a waterproof or cotton cast liner was utilized according to parent and patient preferences. The cast index was determined on follow-up radiographs and compared between groups. Overall, 127 fractures met the criteria for this study. Twenty-five fractures had waterproof liners and 102 fractures had cotton liners placed. Waterproof liner casts showed a significantly higher cast index (0.832 vs 0.777; p=0.001), with a significantly higher proportion of casts with index greater than 0.8 (64.0% vs 35.3%; p=0.009). The use of waterproof cast liners is associated with a higher cast index compared to traditional cotton cast liners. Although waterproof liners may be associated with higher patient satisfaction scores, providers should be aware of this difference in mechanical properties and may consider altering their casting technique accordingly.

Keywords: cast index; forearm fracture; pediatric fracture; waterproof.

INTRODUCTION

Forearm fractures account for 45% of all pediatric fractures *(1)*. The standard treatment for many of these fractures includes closed reduction and casting *(1)*. The cast index, originally described by Chess et al., is a radiographic measurement that assesses the quality of a cast mold *(2)*. This measure is calculated by dividing the width of the cast in the sagittal plane by the width of the cast in the coronal plane *(2)*. McQuinn et al. analyzed 155 pediatric distal radius fractures, finding that patients with a cast index of less than 0.8 were significantly less likely to experience loss of fracture reduction compared to those with an index of 0.8 or higher (32% vs. 60%) *(3)*. Bhatia et al. and Kamat et al. subsequently

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corroborated these findings and suggested that a higher cast index is indicative of an inadequate mold and leads to both continued fracture instability and potential failure of nonoperative management *(4,5)*.

Waterproof cast liners have recently been developed to minimize interruption of daily activities during the casting period. Haley et al., in a randomized prospective study including 59 patients who received either a waterproof or cotton cast liner, showed that waterproof liners were associated with decreased subjective itching, discomfort, and irritation *(6)*. Guillen et al. found similar results in a randomized crossover study involving 20 patients, showing that waterproof liners were associated with better scores for odor and sweat *(7)*. Waterproof liners have additionally been associated with a faster recovery of physical function when applied to minimally displaced distal radius fractures *(8)*.

When considering implementation of waterproof cast liners in a pediatric orthopedic practice, it is important to understand whether the ability to achieve a good mold is altered compared to standard cotton liners. It is possible that the mechanical properties of waterproof liners may influence the ability to achieve an adequate cast index. The purpose of the present study was to determine whether the cast index differs between waterproof and standard cotton cast liners when used to stabilize pediatric forearm fractures.

MATERIALS AND METHODS

This study was approved by our institutional review board. A waiver of informed consent was obtained. We retrospectively evaluated all distal radius and forearm fractures treated in a single pediatric orthopaedic surgery clinic between December 2009 and January 2017. Either a waterproof (Delta-Dryâ, BSN medical, Luxembourg City, Luxembourg) or cotton (Webril™, Medline Covidien, Dublin, Ireland) cast liner was utilized according to parent and patient preferences. There was no radiographic or clinical parameter for selecting one cast liner versus another. Patients were included if they were treated with a short-arm cast and had adequate follow-up radiographs in fiberglass.

All casts were applied in the cast room by one of three cast technicians, each with over five years of expertise and identical training. The cast tech followed a strict protocol of four layers of cotton padding or two layers of waterproof padding followed by fiberglass short-arm casting. The cast was then shaped utilizing a uniform interosseous mold, with no alterations based on the location of the fracture or initial displacement. No fracture required a reduction at the time of casting, as they had either been previously reduced in the emergency room or were minimally displaced and did not require a reduction. In accordance with routine clinical practice, no radiographs were taken immediately following cast placement.

Following this initial casting, patients were instructed to return to clinic within a two to three week window depending on their schedule and the availability of clinic appointments. At this return visit, standard AP and lateral radiographs of the forearm were taken within the original cast. The cast index, as originally described by Chess et al., was determined by calculating the ratio of the internal width of the cast in the sagittal and coronal planes at the level of the fracture site on follow-up radiographs (Figure 1) *(2)*. All measures were taken

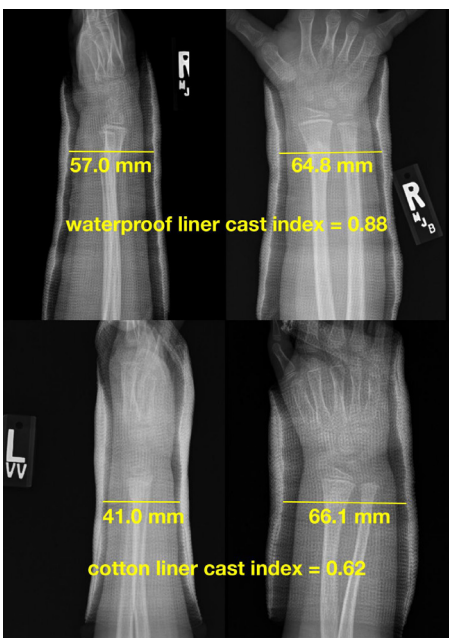

Figure 1. — Measurement of cast index for waterproof and cotton cast liners.

Table I. — Demographics for waterproof and cotton cast liners*

	Waterproof cast liner (n=25)	Cotton cast liner (n=102)	p-value
Age (years)	8.3 ± 3.5	8.5 ± 3.6	0.988
Time since casting (days)	18.6 ± 7.3	18.5 ± 8.2	0.948
Laterality (% right)	44.0%	38.3%	0.599
Gender (% male)	60.0%	66.7%	0.532
Fracture location (% distal half)	96.0%	94.1%	0.713

*Data are expressed as mean ± standard deviation or percentage.

Table II. — Cast index for waterproof and cotton cast liners*

	Waterproof cast liner	Cotton cast liner	p-value
Cast index	0.832 ± 0.070	0.777 ± 0.065	**0.001
Cast index > 0.8 (% casts)	64.0%	35.3%	**0.009

*Data are expressed as mean ± standard deviation or percentage. **Denotes statistical significance based on parameters alpha=0.05, two-tailed Mann-Whitney U test for unequal groups.

by a single orthopaedic surgeon who was blinded to the identity of the liner material.

Patient demographics including age, gender, and laterality were recorded for analysis. Whether the fracture was in the proximal or distal half of the bone was also recorded. Statistical analysis was performed using statistical software. Non-parametric Mann-Whitney U tests were performed for unequal groups. A multivariate regression controlling for cast technician was performed to assess the association between cast index and waterproof cast liner independent of cast technician. Alpha level was set at a two-tailed level of 0.05.

RESULTS

A total of 292 distal radius or forearm fractures were treated with casting during the study period. One hundred twenty-three were subsequently excluded because follow-up radiographs were obtained out of fiberglass. Twenty-seven were excluded because they were transitioned directly from long arm casts into a brace. Three were excluded because they were lost to follow-up. Eight were excluded because they had no follow-up radiographs, and four were excluded because they had inadequate radiographs. Overall, 127 fractures met the inclusion criteria for this study. Twenty-five fractures had waterproof liners and 102 fractures had cotton liners placed.

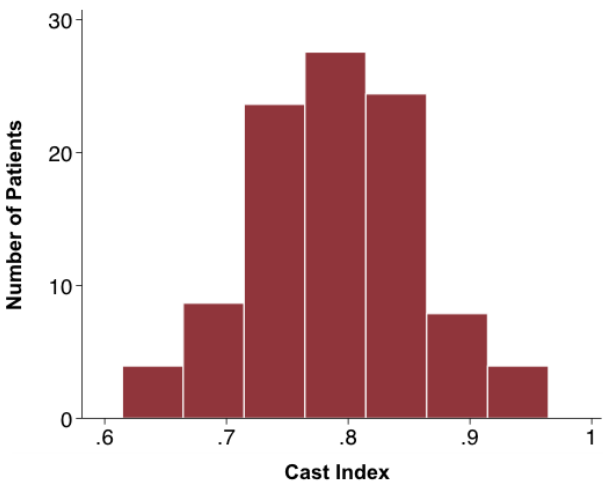

Figure 2. — Distribution of cast index among all patients.

No statistically significant differences were found between groups with regard to fracture laterality, age, gender, time since casting, and fracture location (Table I). Mean cast index was 0.79 and the data were normally distributed (Figure 2). The waterproof liner casts showed a significantly higher cast index (0.832 vs 0.777; p=0.001), with a significantly higher proportion of radiographs with cast index greater than 0.8 (64.0% vs 35.3%; p=0.009) (Table II). When controlling for cast

technician in multivariate regression, the cast index was significantly greater in the waterproof cast liner group compared to the standard cotton liner group (0.037; p=0.023).

DISCUSSION

Achieving an adequate cast mold is critical for maintaining reduction of pediatric forearm fractures *(3-5)*. Cast liner materials have inherent differences in their mechanical properties. When deciding which material to use, the most important goal is to achieve a stable reduction with a good mold. Convenience and comfort should be of secondary concern when selecting a cast liner material.

We found that the waterproof liner casts achieved a statistically significantly higher cast index (0.832 vs 0.777) compared to standard liner casts. When controlling for cast technician, the cast index for waterproof liners was statistically significantly greater than standard cotton liners by 0.037. Additionally, the Delta-Dryâ waterproof liner casts had a higher proportion of casts with index greater than 0.8 (64.0% vs 35.3%). These difference may be due to differences in material properties between the waterproof and cotton cast liners. The Delta-Dryâ waterproof liner consists of polypropylene, polyamide, polyester, and acrylic adhesive. It has been our experience that the waterproof liner used does not allow for significant compression when compared to the cotton liner. A cast index greater than 0.8 is associated with redisplacement of pediatric forearm fractures, which can lead to repeated reduction attempts or surgical intervention *(3-5)*. While the differences in cast index found in this study are statistically significant, the clinical significance with regard to fracture displacement will be an area of future focus.

It is important to understand that not all waterproof liners are necessarily equal with regard to their ability to achieve a good mold. Stevenson et al. in a randomized trial comparing two different waterproof cast liners, Wet or Dryâ and Delta-Dryâ, found that the two waterproof liners had different qualitative "moldability" as assessed by cast technicians *(9)*. Thus, our study's findings should be applied in the context of the Delta-Dryâ waterproof liner. Robert et. al. found no significant differences in fracture redisplacement between Gore-texâ (WL Gore & Associates, Flagstaff, AZ, USA) waterproof liner and cotton liner casts when applied to completely displaced distal radius fractures *(10)*. They prospectively compared 36 cotton liner casts with 23 Gore-texâ (WL Gore & Associates, Flagstaff, AZ, USA) liner casts for completely displaced distal radius fractures *(10)*. The Gore-texâ material consists of polyurethane padding laminated between coated expanded polytetrafluoroethylene. Given the differences in materials between the Gore-texâ and Delta-Dryâ waterproof liners, fracture displacement would need to be studied separately for Delta-Dryâ liners.

A limitation of this study is inherent to its retrospective design. However, the groups were statistically similar with regard to fracture location and patient demographics, leading us to believe that the groups were appropriate for comparison. A second limitation involves the unequal number of patients in the waterproof and cotton liner groups. Patients received waterproof liners solely based on patient and parent preference. However, the waterproof liners are not covered by insurance and therefore the additional cost of the waterproof liner is an out-of-pocket cost. This additional cost explains the discordant number of waterproof liner casts versus standard cotton liner casts. It is unlikely, however, that a patient's family's income would influence the cast molding process. Non-parametric Mann-Whitney U were additionally used for unequal groups. A third limitation is the lack of measurement of redisplacement in this study. Given that these casts were placed in situ on minimally displaced or previously reduced fractures at different stages of healing, we did not think that measuring redisplacement would be accurate. Further study would be needed with casts applied at the time of the initial presentation with the reduction to assess for redisplacement. Lastly, multiple cast technicians placed the waterproof and cotton liner casts, which may have introduced some variation in the quality of the molds. However, our cast technicians follow the same protocol for cast application in every encounter. Thus, any variation probably affected both groups similarly. The difference in cast index

persisted when controlling for cast technician in the multivariate regression. Additionally, in practice it is likely that more than one cast technician is applying casts and therefore this study reflects the environment of a busy pediatric orthopaedic clinic.

CONCLUSION

This study demonstrates that the waterproof cast liner has a statistically higher cast index compared to cotton cast liners. Future research would be beneficial to determine whether there is a corresponding increased rate of fracture displacement with this waterproof liner. Surgeons should assess mold quality when utilizing a new cast liner, as cast index may be influenced by differing material properties.

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