SYSTEMATIC REVIEW

Waterproof casts for the management of upper limb fractures in children

A SYSTEMATIC REVIEW AND META-ANALYSIS

N. Badhe,
C. Busby,
A. See,
C. Deacon,
T. Altell,
B. J. Ollivere,
B. A. Marson

From University of Nottingham, Nottingham, UK

Aims
Upper limb fractures in children are often managed in casts. Waterproof casts which allow safe immersion in water may be used. These may improve comfort, convenience, and satisfaction when compared with standard casts. The aim of this review was to compare the efficacy, safety, and satisfaction of waterproof casts with standard casts in the management of upper limb fractures in children.

Methods
A systematic review of randomized controlled trials (RCTs) was conducted in September 2024. Comprehensive searches of Medline, PubMed, Cochrane CENTRAL, and EMBASE databases were performed. Studies were included which recruited children aged 0 to 18 years with upper limb fractures, which were managed in waterproof or standard casts. Patient-reported outcomes, functional outcomes, and complication rates were assessed.

Results
A total of five studies involving 390 children were included. Those managed with a waterproof cast reported significantly superior satisfaction with regard to comfort (mean difference (MD) 1.92 (95% CI 0.15 to 3.69); p = 0.034), itchiness (MD 0.21 (95% CI 0.00 to 0.43); p = 0.047), and overall child and parent satisfaction (MD 0.53 (95% CI 0.01 to 1.05); p = 0.048). Those managed with a waterproof cast also had significantly improved functional outcomes as measured by the Activities Scale for Kids-Performance (ASK-P) score, with a MD of 16.90 (95% CI 6.87 to 26.93; p = 0.001). There were no significant differences regarding heat or sweatiness, pain, return to recreational activities, unexpected returns for cast maintenance, radiological deformity, or skin problems.

Conclusion
Waterproof casts seem to provide an alternative to standard casts in the management of upper limb fractures in children. There were improved functional outcomes at the time of removal of the cast, improved comfort, and less itching. Pooling of the studies was limited due to the heterogeneity of the reporting of outcomes and the small sizes of the studies. Neither long-term outcomes, nor economic analysis based on healthcare-related quality of life, are available. A definitive RCT based on a core outcome set is required to confirm the efficacy and investigate the cost-effectiveness of waterproof casts in children.

Cite this article: *Bone Joint J* 2025;107-B(6):587–594.

Introduction
Fractures of the upper limb account for 80% of all fractures in children, and 70% of children admitted to hospital with a fracture.[1,2] It has been shown in several studies that fractures in children have a remarkable capacity for healing and remodelling. Most of these fractures involving the upper limb are conservatively managed with a cast.[3] The aim of treatment in a cast is to immobilize the fracture, reduce strain, maintain alignment, and promote healing.[4]

Standard synthetic or plaster casts have several limitations. Poor child and parent satisfaction have often been reported due to restrictions in bathing and lack of hygiene, with discomfort and irritation of the skin.[5,6] Children managed

Correspondence should be sent to N. Badhe; email: nb681@cam.ac.uk

doi:10.1302/0301-620X.107B6.
BJJ-2025-0011 $2.00

Bone Joint J
2025;107-B(6):587–594.

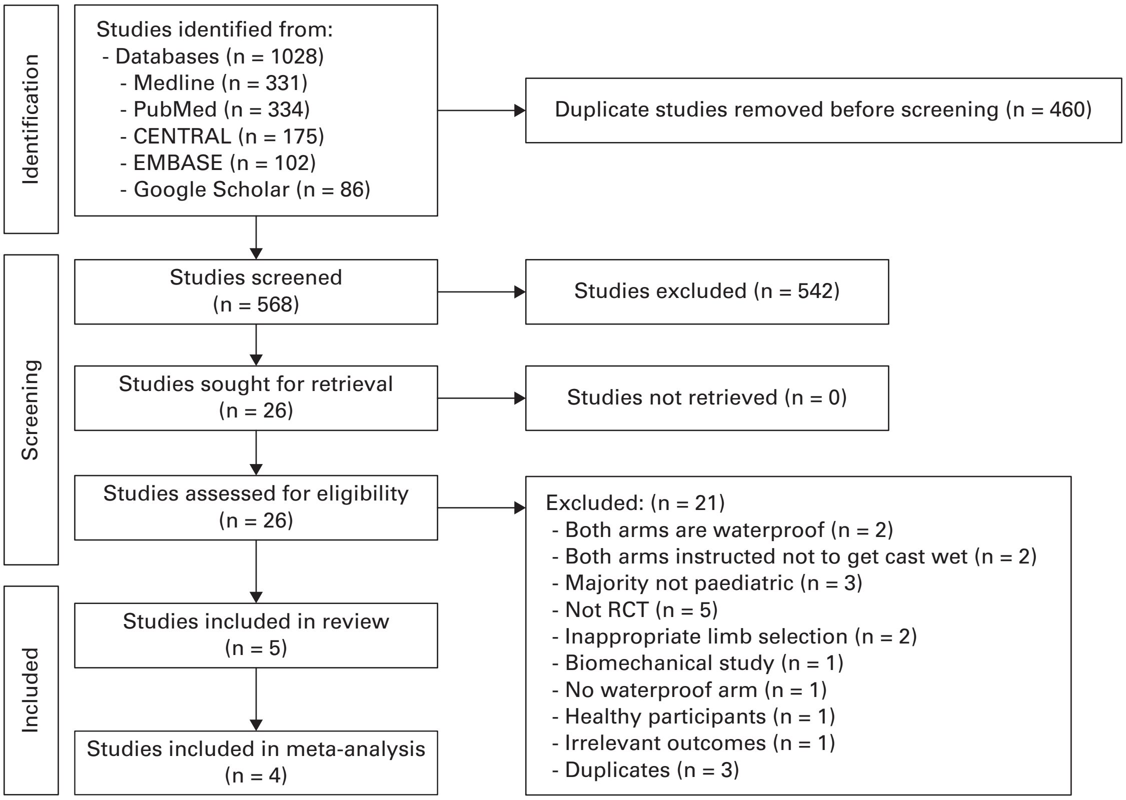

Fig. 1

PRISMA flow diagram. RCT, randomized controlled trial.

conservatively also have limited participation in recreational activities and unexpected returns to hospital to replace damaged or wet casts.[4,7,8]

Unlike standard casts, waterproof casts can be safely immersed in water, allowing patients to bathe and swim during treatment. This improves hygiene, comfort, and convenience.[9] The use of waterproof casts has been reported to be associated with reduced skin-related complications such as itchiness, maceration, and infection.[5,8,10]

There are several types of waterproof casts, including fibreglass casts with waterproof liners (e.g. Gore-Tex (W. L. Gore & Associates, USA) or AquaCast (AquaCast Liner, USA)), synthetic waterproof casts (e.g. polypropylene or polyethylene mesh casts), and hybrid mesh casts.[7,11] These casts all have different properties, including drying time and rigidity, but little has been written about whether they provide better outcomes and satisfaction.[7,12,13]

At current prices, standard paediatric upper limb casts cost between £14 and £30, while waterproof casts cost between £23 and £38.[14] Consequently, the main limitation to the use of waterproof upper limb casts in children is the cost. However, this cost may be offset by fewer unscheduled changes of cast.[6,15] A potential concern with casts which are made with a thicker, water-resistant padding is that this construction has a higher cast index, defined as the ratio of the cast's sagittal to coronal width, measured from the inside edges of the cast at the fracture site.[16] This is important because a higher cast index has been associated with an increased risk of displacement or loss of reduction of the fracture.[9,17,18]

The aim of this review was to identify and evaluate the current evidence for the efficacy and safety of waterproof casts when used for the conservative management of upper limb fractures in children, compared with standard non-waterproof casts.

Methods

A systematic review was conducted on 28 September 2024 to identify all peer-reviewed randomized controlled trials (RCTs) and quasi-RCTs investigating the outcomes of upper limb fractures in children managed conservatively with waterproof compared with standard casts. Prospective registration of the review was completed on the PRISMA database prior to undertaking the searches (CRD42024593179).

Searches were completed using OVID Medline, PubMed, Cochrane CENTRAL, and OVID EMBASE using a strategy with the following key concepts: upper limb fractures; treatment with either casts or surgery; waterproof casts; children and adolescents; and RCTs excluding non-human subjects.

The terms for children and adolescents and the RCT filter were used from a previous Cochrane review.[19] The full search strategy for each database is shown in the Supplementary Material. Additional screening of grey literature was completed using Google Scholar and bibliographic assessment of relevant previous reviews.

Table I. The demographics, immobilization device, and relevant clinical outcomes reported for upper limb fractures in the included studies.

Study	Country	Design	Loss to follow-up, n (%)	Intervention (n)	Control (n)	Mean age, yrs	Female, %	Relevant outcomes reported
Derksen et al (2013)[23]	Netherlands	RCT	0 (0.0)	Swim cast (MOK-cast technique) (34)	Cotton-lined cast (34)	9.80	60.3	Patient/parent satisfaction, participation in swimming
Inglis et al (2013)[10]	Australia	RCT	2 (1.0)	Scotchcast Plus + WetnDry padding (110)	POP + WetnDry padding (89)	9.69	33.7	Itchiness, patient/parent satisfaction, comfort, heat/sweatiness, skin problems, radiological deformity, unexpected return for cast maintenance
Guillen et al (2016)[22]	USA	Crossover RCT	0 (0.0)	BSN DeltaDry lined cast (10)	Cotton-lined cast (10)	13.6	65.0	Pain, itchiness, skin problems, comfort, heat/sweatiness, radiological deformity, unexpected return for cast maintenance
Silva et al (2017)[9]	USA	Crossover RCT	1 (3.7)	HM Cast (12)	Scotchcast Plus (14)	9.4	42.3	Return to activities of daily living (ASK-P), pain, itchiness, patient/parent satisfaction, skin problems
Ong et al (2024)[8]	Singapore	RCT	2 (2.5)	HM Cast (39)	Fibreglass cast (38)	5.45	57.1	Itchiness, patient/parent satisfaction, comfort, heat/sweatiness, return to recreational activities, participation in swimming, skin problems, unexpected return for cast maintenance

ASK-P, Activity Scale of Kids – Performance version; HM, hybrid mesh; POP, plaster of Paris; RCT, randomized controlled trial.

The following inclusion criteria were applied: those which reported outcomes of children with an upper limb fracture in which most were aged < 18 years; those which directly compared the use of a cast that can be safely immersed in water with one which the children were instructed to keep dry; those which reported at least some components of the core outcome set for childhood limb fractures;[20] and RCTs or quasi-RCTs.

Non-randomized studies, animal studies, review articles, conference abstracts, and studies not published in the English language were excluded.

Titles and abstracts were independently screened by two reviewers (NB, CD). Full-text articles were then independently assessed for eligibility by the same reviewers. Disagreements were resolved by discussion or review by the senior author (BAM).

The PRISMA flow diagram is shown in Figure 1. The initial search identified 1,028 studies, with 576 remaining after removal of duplicates. Screening of the titles and abstracts resulted in the identification of 26 potentially relevant studies, of which five met the inclusion criteria (Table I).[8,10,21–23] No additional studies were included after manually searching the references of the studies.

A total of 390 children were included. Their mean age was 9.05 years (SD 3.98); 176 (45.1%) were female. The children either had a displaced fracture of the forearm requiring closed reduction,[10] a stable distal radial fracture,[21,23] a supracondylar fracture of the humerus,[8] or a mixture of upper limb fractures.[22]

Two randomized crossover trials which met the inclusion criteria were identified.[9,22] Due to the potential period effect, in which healing of the fracture is anticipated to occur during the study, data from the first period of the crossover design were extracted according to the Cochrane handbook.[24] The study by Guillen et al[22] was excluded from the meta-analysis as only the overall paired analysis of medians was reported.

Data were extracted from the studies independently by two reviewers (NB, CB) with disagreements again being resolved through review by the senior author (BAM). The data were extracted into a predefined table. The following information was extracted: title, authors, year of publication, study design, sample size, and demographic and outcome data.

The risk of bias was assessed using the Cochrane Collaboration Risk of Bias 1.0 (ROB 1.0) tool.[25] This tool has been validated for assessing the risk of bias in RCTs according to seven areas: random sequence generation; allocation concealment; blinding of participants and personnel; blinding of the assessment of outcome; incomplete outcome data; selective outcome reporting; and other biases. Two reviewers (NB, CB), as before, independently assessed the risk of bias for each study, and disagreements were again resolved through review by the senior author (BAM).

All the studies were found to have a risk of bias (Supplementary Figure a). Due to the nature of the intervention, the children were not blinded, as they knew whether they could get their cast wet or not. This may have an impact on the results, particularly on the child- and parent-reported outcome measures. Studies were also at a high risk of bias as those who assessed outcomes were also not blinded. The studies by Silva et al[21] and Guillen et al[22] were also rated as having a high risk of bias due to potential period effects.[24] All studies maintained adequate randomization and concealment.

The following outcomes were extracted from each study: pain and discomfort (including overall comfort, itchiness, and heat and sweatiness); return to physical and recreational activities; emotional and psychosocial wellbeing; complications from

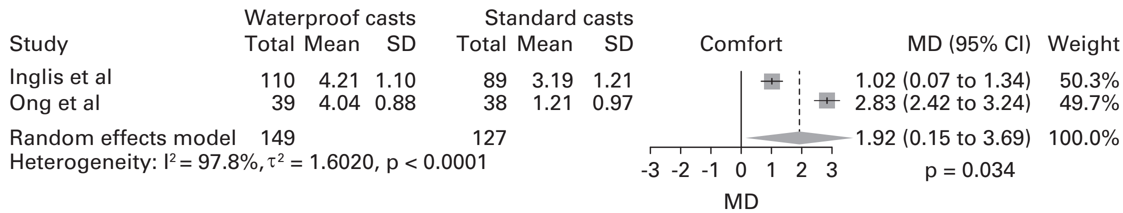

Fig. 2

Forest plot showing comfort in waterproof compared with standard casts. MD, mean difference.

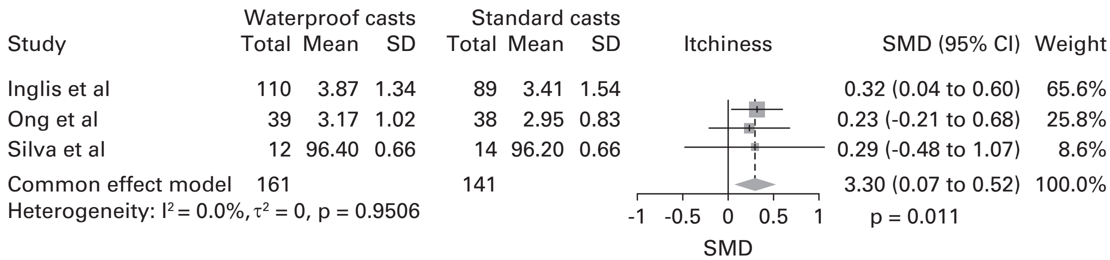

Fig. 3

Forest plot showing itchiness in waterproof compared with standard casts. SMD, standardized mean difference.

the injury and treatment; return to baseline activities of daily living (ADLs); participation in learning; appearance and deformity (including loss of reduction of the fracture); time to union; recovery of manual dexterity; child or parent satisfaction; and healthcare costs (including returns for maintenance of the cast).

Statistical analysis. When considered appropriate, results of comparable RCTs were pooled. Heterogeneity was assessed using the I^2 statistic. We considered $I^2 > 75\%$ as considerable heterogeneity,[26] particularly if it could not be explained by the diversity of the methodological or clinical features of the studies.

If mean and SD results were not available, p-values from independent-samples *t*-tests were converted to mean and SD data using the formulae on MetaConverter.[27] Medians, IQRs, and ranges were not transformed. The pooled data were analyzed using R v. 4.3.3 (R Foundation for Statistical Computing, Austria) using random or fixed-effects models. The model used was determined by the extent of the heterogeneity: a fixed-effects model for low heterogeneity and a random-effects model for high heterogeneity. The mean difference (MD) was used to compare continuous variables, and risk ratios (RRs) were used for categorical variables. Significance was set at $p < 0.05$.

Results

Pain in the first two weeks of treatment was reported in one study using the Revised Faces Pain Scale.[9,28] There was no significant difference in the mean pain scores, with a MD of 0.30 (95% CI -0.17 to 0.77; p = 0.223, independent-samples *t*-test). There was also no significant difference in the paired median pain scores (p = 0.575, Wilcoxon signed-rank test) in the 20 children included in the Guillen et al[22] crossover trial.

Comfort on a five-point self-rated scale was pooled from two studies (Figure 2).[8,10] Children managed in a waterproof cast had significantly increased comfort compared with those in a standard cast in the pooled analysis, but with high heterogeneity (MD 1.92 (95% CI 0.15 to 3.69); p = 0.034, random effects model).

Self-reported itch scores were pooled from three studies (Figure 3).[8,10,21] This showed that waterproof casts resulted in less itch compared with standard casts, with a standardized mean difference (SMD) of 0.30 (95% CI 0.07 to 0.52; p = 0.011, common effect model) on a five-point scale. This analysis had low heterogeneity.

Heat and sweatiness scores were pooled from two studies (Figure 4),[8,10] showing no significant difference (MD 0.51 (95% CI -0.08 to 1.09); p = 0.092, random effects model).

Return to outdoor physical activities at the time of removal of the cast was reported in one study. Ong et al[8] found no difference in the proportion of children in a hybrid mesh waterproof above elbow cast returning to activities compared with those treated with a standard fibreglass cast (54% compared with 42%; p = 0.365, chi-squared test).

The number of children who went swimming at time of removal of the cast was repoted in two studies (Figure 5). Children were significantly more likely to report that they were swimming with a pooled relative risk of 5.42 (95% CI 2.17 to 13.54; p < 0.001, common effect model).[8,23]

Skin problems related to the cast were reported in three studies (Figure 6).[8,10,21] All skin complications occurred in children with a waterproof cast. However, this difference was not significant following pooled analysis (RR 5.30 (95% CI 0.65 to 43.45); p = 0.120, common effect model).

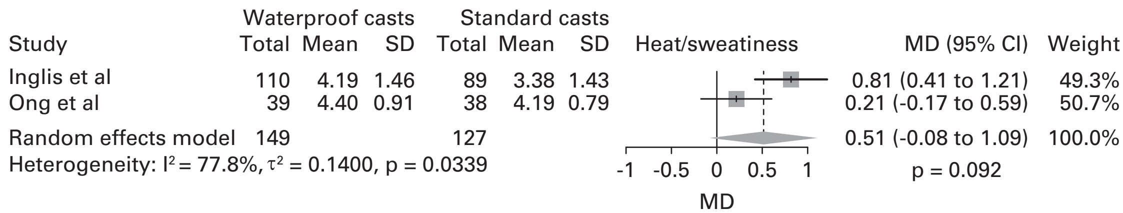

Fig. 4

Forest plot showing heat and sweatiness in waterproof compared with standard casts. MD, mean difference.

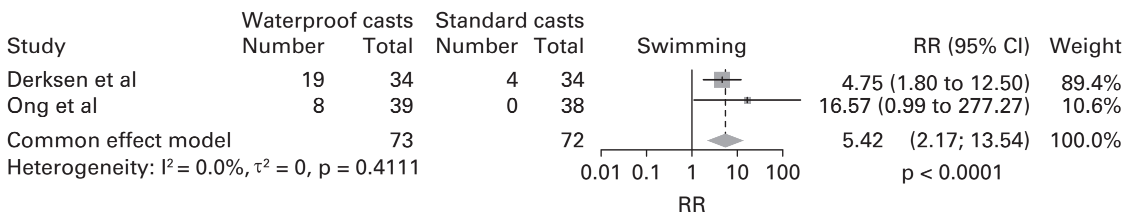

Fig. 5

Forest plot showing swimming in children with waterproof compared with standard casts. RR, risk ratio.

Silva et al[21] reported return to ADLs using the Activities Scale for Kids-Performance (ASK-P) questionnaire.[29] In this crossover trial, there was a mean difference of 16.9 points in total ASK-P score in the first two weeks (p = 0.003). In the overall four-week study period, the paired difference in ASK-P scores was 7.6 (p = 0.04), both in favour of waterproof casts.

Radiological deformity, defined as a loss of reduction or unacceptable final alignment was reported in two studies. Following closed reduction and immobilization of displaced fractures of the forearm, Inglis et al[10] reported that ten children (5.0%) had loss of reduction requiring a further procedure or plaster wedging. There was no significant difference in the rate of loss of reduction between the waterproof and standard casts (p = 0.756, Fisher's exact test). Guillen et al[22] reported one child (5.0%) with a radiological deformity in the standard cast group. This difference was not significant (p > 0.999, Fisher's exact test).

Child or parent satisfaction scores were reported in four studies.[8,10,21,23] Three of these studies found a significantly higher satisfaction level in children with a waterproof cast, while Silva et al[21] (25.0%) reported similar rates of satisfaction between both groups. Waterproof casts were associated with significantly higher levels of child and parent satisfaction in pooled analysis (SMD 0.61 (95% CI 0.10 to 1.13); p = 0.019, random effects model) (Figure 7).

The cost of the casts was reported in two studies. Ong et al[8] quoted a cost of $114.80 for two-inch and $136.50 for three-inch hybrid-mesh casts with an equivalent cost of a fibreglass cast of $136.50 (no p-values provided). Guillen et al[22] reported that waterproof liners cost $6 more than cotton liners. No formal economic analyses were reported.

Unexpected returns to hospital for the maintenance of a cast was reported in two studies. A significant decrease in these visits was reported by Inglis et al[10] in the waterproof group, with a relative risk of 0.14 (95% CI 0.06 to 0.36). No child returned for maintenance of the cast in either group in the study by Ong et al.[8]

Of the outcomes we intended to evaluate in this review, emotional and psychological wellbeing, participation in learning, time to union, recovery of manual dexterity, and costs were not reported in any of the studies.

Discussion

We found that the use of a waterproof cast in children with an upper limb fracture was supported by five RCTs. There was considerable clinical heterogeneity in these studies with different inclusion criteria, including manipulated forearm fractures, distal radial fractures, supracondylar fractures, and stable upper limb fractures. Further heterogeneity was introduced with different forms of waterproof cast including hybrid mesh, MOK-cast, and water-resistant padding.

In the pooled analysis, waterproof casts showed significant improvements in comfort (p = 0.034, random effects model), itchiness (p = 0.011, common effect model), and overall child and parent satisfaction (p = 0.019, random effects model). There was no difference for pain, heat and sweatiness, skin complications, or loss of reduction.

A study by Selesnick and Griffiths[30] from 1997, involving 337 patients, reported high rates of satisfaction and comfort with good child and physician ratings. Later, in 2005, Shannon et al[6] also reported high rates of satisfaction with waterproof-lined casts, with all 127 children included in their study being 'very satisfied' or 'satisfied'.[6] This is not surprising given the nature of waterproof liners.

A number of waterproof liners are available (e.g. Gore-Tex or Delta Dry (Essity, USA)) and they all share similar properties. The material of the liner has a water-repelling quality while the porous structure of the material itself allows evaporation

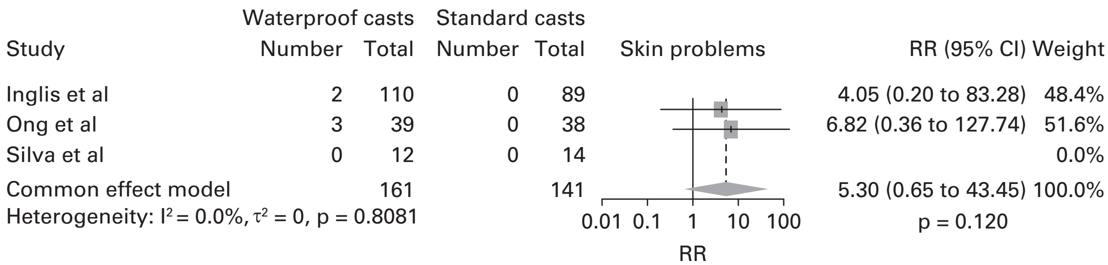

Fig. 6

Forest plot showing skin problems in waterproof compared with standard casts. RR, risk ratio.

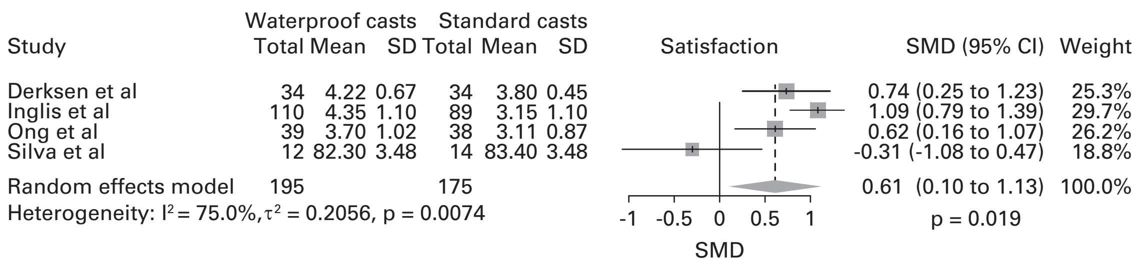

Fig. 7

Forest plot comparing child and parent levels of satisfaction for waterproof compared with standard casts. SMD, standardized mean difference.

of water from the surface of the skin.[6,12] This should lead to reduced irritation of the skin, less itchiness, better comfort, and satisfaction.

Interestingly, pooled data did not show a significant difference in heat and sweatiness between the groups despite the more porous structure of waterproof liners compared with standard plaster of Paris casts. This is likely to reflect a small sample size, as both Inglis et al[10] and Guillen et al[22] showed significantly positive differences independent of the meta-analysis.

A concern with waterproof casts and synthetic liners is the potential for loss of reduction of the fracture, as the porous liners may lead to a higher cast index and lower stability of the fracture. However, we found no evidence of increased rates of loss of reduction in this review, confirming the findings of Robert et al.[31] In this non-randomized comparative study, the use of Gore-Tex liners in the treatment of unstable, off-ended distal radial fractures was evaluated following closed reduction. In 59 children (36 with a standard and 23 with a Gore-Tex-lined cast), no significant differences were found in the final position of the fracture, and no significant increase in the rate of loss of reduction requiring re-intervention was seen with a Gore-Tex-lined cast (22% vs 36%; p = 0.384, Fisher's exact test).

A further concern with waterproof casts is the cost. Disappointingly, no formal cost-effectiveness analysis was available. Some estimates showed that waterproof casting materials were more expensive than standard casts.[14] There were no significant differences in the rates of unexpected return for maintenance of the cast, but it has been suggested in previous non-randomized studies that this may be a further benefit of waterproof casting.[6,15] This could again reflect a low quality of evidence. A larger study may show that standard casting requires significantly more returns for maintenance due to softening following accidental exposure to water.

There were also no significant differences in the radiological deformity or skin problems on meta-analysis between waterproof and conventional casting. Taken as a whole, these results, which suggest that waterproof-lined casts are, at the very least, as safe as conventional casting, with the benefits of being waterproof, may be masked by the small size of the studies. Wolff and James[32] further showed in their early work in 1995 that Gore-Tex-lined hip spicas prevented skin problems and were more cost-effective due to fewer returns for maintenance, further supporting the hypothesis that waterproof-lined casts are likely to be superior to standard casts.[32]

With regard to return to activities, Silva et al[9] reported a quicker return to ADLs. Ong et al[8] also reported a quicker return to recreational activities with waterproof casting, but neither of these were statistically significant. Shannon et al[6] also showed that waterproof liners could withstand water activities with very minor skin issues. Similar to previous results, a lack of statistical significance is likely due to low sample sizes.

In conclusion, there is some evidence that waterproof casts offer advantages compared with standard casts when used in the treatment of upper limb fractures in children. We found, in this systematic review, that waterproof casts may provide more comfort, reduced itchiness, better functional outcomes (particularly with regard to return to ADLs), and higher overall child and parent satisfaction, compared with standard casts. However, the small number of studies which we included in the review and their small sample size, in association with the low-grade level of evidence, and the fact that all studies had a high risk of bias, limit the strength and generizability of the conclusions.

Large RCTs would be needed to reliably determine the safety, efficacy, and cost-effectiveness of using waterproof casts in the management of stable upper limb fractures in children. These trials should include a sufficient sample size and a sufficiently long follow-up to assess child-reported outcomes and radiological evidence of healing. While the initial findings are promising, more robust evidence from RCTs is needed to determine the advantages and disadvantages of the use of waterproof casts for clinical practice conclusively.

Take home message

- Waterproof casting materials may improve comfort, reduce itchiness, and improve satisfaction in children with upper limb fractures compared to traditional non-waterproof casts.
- There is no evidence to suggest that using waterproof casting materials increases the risk of complications.

Social media

Follow B. A. Marson on X @drbmarson

Supplementary material

Risk of bias summary chart; search strategy.

References

1. **Marson BA**, **Manning JC**, **James M**, **Ikram A**, **Bryson DJ**, **Ollivere BJ**. Trends in hospital admissions for childhood fractures in England. *BMJ Paediatr Open*. 2021;5(1):e001187.
2. **Yang H**, **Wang H**, **Cao C**, **et al**. Incidence patterns of traumatic upper limb fractures in children and adolescents: data from medical university-affiliated hospitals in Chongqing, China. *Medicine (Baltimore)*. 2019;98(38).
3. **Bryson DJ**, **Shivji FS**, **Price KR**, **Lawniczak D**, **Chell J**, **Hunter JB**. The lost art of conservative management of paediatric fractures. *Bone Joint 360*. 2016;5(1):2–8.
4. **Nguyen S**, **McDowell M**, **Schlechter J**. Casting: pearls and pitfalls learned while caring for children's fractures. *World J Orthop*. 2016;7(9):539–545.
5. **Haley CA**, **DeJong ES**, **Ward JA**, **Kragh JF Jr**. Waterproof versus cotton cast liners: a randomized, prospective comparison. *Am J Orthop (Belle Mead NJ)*. 2006;35(3):137–140.
6. **Shannon EG**, **DiFazio R**, **Kasser J**, **et al**. Waterproof casts for immobilization of children's fractures and sprains. *J Pediatr Orthop*. 2005;25(1):56–59.
7. **Lan TY**, **Chen CW**, **Huang YH**, **et al**. Biobased polyester versus synthetic fiberglass casts for treating stable upper limb fractures in children: a randomized controlled trial. *BMC Musculoskelet Disord*. 2024;25(1):23.
8. **Ong EJY**, **Lee NKL**, **Mishra N**, **et al**. Improved comfortability and satisfaction of hybrid-mesh casts in the conservative management of pediatric supracondylar humeral fractures: a randomized controlled trial. *J Pediatr Orthop*. 2024;44(3):157–163.
9. **Silva M**, **Avoian T**, **Warnock RS**, **Sadlik G**, **Ebramzadeh E**. It is not just comfort: waterproof casting increases physical functioning in children with minimally angulated distal radius fractures. *J Pediatr Orthop B*. 2017;26(5):417–423.
10. **Inglis M**, **McClelland B**, **Sutherland LM**, **Cundy PJ**. Synthetic versus plaster of Paris casts in the treatment of fractures of the forearm in children: a randomised trial of clinical outcomes and patient satisfaction. *Bone Joint J*. 2013;95-B(9):1285–1289.
11. **Kwan S**, **Santoro A**, **Cheesman Q**, **et al**. Efficacy of waterproof cast protectors and their ability to keep casts dry. *J Hand Surg Am*. 2023;48(8):803–809.
12. **Trivellas M**, **Hennrikus W**, **Gupta R**, **et al**. Waterproof cast liners for pediatric forearm fractures – a comparison of two products. *Trauma*. 2021;23(1):51–54.
13. **Stevenson AW**, **Gahukamble AD**, **Antoniou G**, **Pool B**, **Sutherland LM**, **Cundy P**. Waterproof cast liners in paediatric forearm fractures: a randomized trial. *J Child Orthop*. 2013;7(2):123–130.
14. **Clifford AL**, **Jennings A**, **Baez C**, **Boschert E**, **Ihnow S**, **McQuerry J**. Financial implications associated with the use of waterproof casting material in pediatric patients. *J Pediatr Orthop*. 2025.
15. **Witney-Lagen C**, **Smith C**, **Walsh G**. Soft cast versus rigid cast for treatment of distal radius buckle fractures in children. *Injury*. 2013;44(4):508–513.
16. **Kamat AS**, **Pierse N**, **Devane P**, **Mutimer J**, **Horne G**. Redefining the cast index: the optimum technique to reduce redisplacement in pediatric distal forearm fractures. *J Pediatr Orthop*. 2012;32(8):787–791.
17. **Nolte M**, **Luchetti T**, **Bohl D**, **Kogan M**. Comparison of waterproof versus cotton cast liners on cast index in pediatric forearm fractures. *Acta Orthop Belg*. 2022;88(4):733–737.
18. **Mutimer J**, **Devane P**, **Horne J**, **et al**. The cast index: a simple radiological predictor of plaster cast failure in paediatric distal forearm fractures. *Orthopaedic Proceedings*. 2010;92-B(SUPP_IV):598–98.
19. **Marson BA**, **Ikram A**, **Craxford S**, **Lewis SR**, **Price KR**, **Ollivere BJ**. Interventions for treating supracondylar elbow fractures in children. *Cochrane Database Syst Rev*. 2022;6(6):CD013609.
20. **Marson BA**, **Manning JC**, **James M**, **et al**. Development of the CORE-Kids CORE set of outcome domains for studies of childhood limb fractures. *Bone Joint J*. 2021;103-B(12):1821–1830.
21. **Silva M**, **Avoian T**, **Warnock RS**, **Sadlik G**, **Ebramzadeh E**. It is not just comfort: waterproof casting increases physical functioning in children with minimally angulated distal radius fractures. *J Pediatr Orthop B*. 2017;26(5):417–423.
22. **Guillen PT**, **Fuller CB**, **Riedel BB**, **Wongworawat MD**. A prospective randomized crossover study on the comparison of cotton versus waterproof cast liners. *Hand (N Y)*. 2016;11(1):50–53.
23. **Derksen RJ**, **Commandeur JP**, **Deij R**, **Breederveld RS**. Swim cast versus traditional cast in pediatric distal radius fractures: a prospective randomized controlled trial. *J Child Orthop*. 2013;7(2):117–121.
24. **Higgins JE**, **Li T**. Chapter 23: Including variants on randomized trials: Cochrane. 2024. https://training.cochrane.org/handbook/current/chapter-23#section-23-2 accessed 18/12/2024 (date last accessed 18 December 2024).
25. **Higgins JPT**, **Altman DG**, **Gøtzsche PC**, **et al**. The Cochrane collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. 2011;343:d5928.
26. **Deeks JJ**, **Higgins JPT**, **Altman DG**, **McKenzie JE**, **Veroniki AA**, **on behalf of the Cochrane Statistical Methods Group**. Cochrane Handbook for Systematic Reviews of Interventions: Analysis data and undertaking meta-analyses. 2024. https://training.cochrane.org/handbook/current/chapter-10#section-10-10 (date last accessed 25 April 2025).
27. **No authors listed**. Meta-Analysis Accelerator. 2023. https://meta-converter.com/ (date last accessed 25 April 2025).
28. **Hicks CL**, **von Baeyer CL**, **Spafford PA**, **van Korlaar I**, **Goodenough B**. The Faces Pain Scale-Revised: toward a common metric in pediatric pain measurement. *Pain*. 2001;93(2):173–183.
29. **Young NL**, **Williams JI**, **Yoshida KK**, **Wright JG**. Measurement properties of the activities scale for kids. *J Clin Epidemiol*. 2000;53(2):125–137.
30. **Selesnick H**, **Griffiths G**. A waterproof cast liner earns high marks. *Phys Sportsmed*. 1997;25(9):67–74.
31. **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;31(2):144–149.
32. **Wolff CR**, **James P**. The prevention of skin excoriation under children's hip spica casts using the goretex pantaloon. *J Pediatr Orthop*. 1995;15(3):386–388.

Author information:

N. Badhe, Research Intern, Medical Student, Department of Orthopaedics and Trauma, Academic Unit of Injury, Recovery and Inflammation Sciences, University of Nottingham, Nottingham, UK; School of Medicine, Cambridge University, Cambridge, UK.

C. Busby, MBBS, BSc (Hons), MRCS, PhD Student in Orthopaedic and Accident Surgery
C. Deacon, BMedSci, BMBS, MSc, MRCS, PhD Student in Orthopaedic and Accident Surgery
Musculoskeletal, Surgery, Inflammation and Recovery Theme NIHR Biomedical Research Centre, University of Nottingham, Nottingham, UK.

A. See, MBBChir, MA, MRCS, Academic Clinical Fellow, Department of Orthopaedics and Trauma, Academic Unit of Injury, Recovery and Inflammation Sciences, University of Nottingham, Nottingham, UK.

T. Altell, MD, MRCS, Orthopaedic Resident, Nottingham Children's Hospital, Queens Medical Centre, Nottingham, UK.

B. J. Ollivere, MD, FRCS, Professor of Orthopaedic Trauma

B. A. Marson, PhD FRCS, Clinical Associate Professor in Paediatric Orthopaedics
Department of Orthopaedics and Trauma, Academic Unit of Injury, Recovery and Inflammation Sciences, University of Nottingham, Nottingham, UK; Musculoskeletal, Surgery, Inflammation and Recovery Theme NIHR Biomedical Research Centre, University of Nottingham, Nottingham, UK.

Author contributions:
N. Badhe: Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.
C. Busby: Data curation, Methodology, Writing – original draft, Writing – review & editing.
A. See: Data curation, Formal analysis, Supervision, Writing – original draft, Writing – review & editing.
C. Deacon: Methodology, Writing – original draft, Writing – review & editing.
T. Altell: Writing – original draft, Writing – review & editing.
B. J. Ollivere: Supervision, Writing – original draft, Writing – review & editing.
B. A. Marson: Conceptualization, Data curation, Methodology, Writing – original draft, Writing – review & editing.

Funding statement:
The authors received no financial or material support for the research, authorship, and/or publication of this article.

ICMJE COI statement:
A. See reports an AOUKI Major Project Grant, unrelated to this study. B. J. Ollivere reports multiple grants from the NIHR and MRC, royalties or licenses from Smith & Nephew, consulting fees from Theragenix and AgNovis, payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing or educational events from Smith & Nephew, payment for expert testimony from the Rail Accident Investigation Branch and General Medical Council, various patents planned, issued, or pending, and is an editorial board member for *The Bone & Joint Journal* and is editor-in-chief of *Bone & Joint 360*, all of which are unrelated to this study. B. A. Marson reports funding from the Nottingham NIHR Biomedical Research Centre MSK theme, related to this study, as well as grants or contracts from Gwen Fish Trust and AOUKI, unrelated to this study.

Data sharing:
The data that support the findings for this study are available to other researchers from the corresponding author upon reasonable request.

Trial registration number:
CRD42024593179.

This article was primary edited by J. Scott.