

# Comparison of splint and conventional cast for treating wrist torus fractures in children (systematic review)

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**Abstract:** Wrist torus fractures in children are common. Although it might be simple and straightforward, the management of these injuries remains controversial and depends on the personal experience and preference of the treating physician. The consensus agreement, however, is that these fractures are inherently stable. Some authors argue that splints should replace the traditional method of cast immobilisation. The splints are viewed as easier to use, more convenient and do not require follow up clinics for removal. It has also been argued that splints are more cost-effective than casts. The aim of this systematic review is to examine the effectiveness and cost-effectiveness of removable splints versus casts in the treatment of torus wrist fractures of children in the current literature. This review followed the Systematic reviews and Meta-Analyses (PRISMA) statement for reporting. Comprehensive electronic database search and handsearch were conducted. Studies were considered for review if they were randomised or quasi-randomised controlled trial and compared removable splints and casts for treating torus fractures of distal radius and/or ulna in children. Four papers identified by two reviewers as potentially eligible for inclusion were appraised and two identified for inclusion were further assessed for any risk of bias. Data were narratively presented and discussed as meta-analysis would not have been possible for the identified studies. The limited available data favours the use of splint as a clinically effective and more cost-effective method of immobilisation. However, the findings of the systematic review are limited by the quality of the identified studies. It has been viewed that explanation to patients and parents and involving them in the decision, plus implementation of safety protocol to avoid under-treatment of misdiagnosed fractures and allow easy access of patients to the clinic, is an alternative way to provide safe, convenient and cost-effective treatment.

**Keywords:** Torus fracture; buckle fracture; distal radius fracture; fracture in children; splint; cast

## 1. Background

Description of the condition: torus fracture

Distal radius injuries are common in children. Forearm fractures represent approximately 35–45% of all fractures in the paediatric age group and about 85% of these fractures occur in the distal radius<sup>[1]</sup>. Because the bone in children is less brittle and has stronger periosteum, it “buckles” rather than breaks, resulting in a bulge in the cortex<sup>[2]</sup> [Figure 1]. The majority of distal radius fractures in children are classified as torus fractures and because of a fall onto the outstretched hand, pain and local tenderness and swelling are common findings on clinical examination. Radiographs usually confirm the diagnosis<sup>[3]</sup>.

Description of the interventions: cast and splint.

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fractures are inherently stable and the risk of displacement is very low or non-existent<sup>[3-7]</sup>. In a review of nine studies on torus fractures<sup>[3, 6-13]</sup>, May and Grayson (2009) found that in none of the studies was there loss of position, lack of recovery, need for orthopaedic intervention or ongoing pain. The authors concluded that buckle fractures will heal regardless of the treatment the patient receives<sup>[14]</sup>.

The traditional backslab cast, applied as initial management by emergency department staff, has a base material of plaster of Paris (POP) powder which is produced by heating gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ )<sup>[15]</sup>. When POP is dipped in water to be used for immobilisation, it produces an exothermic reaction, liberating some heat for a short period (5-10 min)<sup>[16]</sup>. Although uncommon, cases of burn and thermal injuries have been reported, which might be related to the method of application of cast or casting materials<sup>[17, 18]</sup>. The heat produced by the exothermic reaction of gypsum may add to the initial effect of hyperaemia associated with injury, causing localised burns and blisters and resulting in secondary bacterial infections<sup>[16]</sup>. Other recognised disadvantages of POP include skin excoriation, its weight and bulkiness and restrictive nature of the cast, which makes bathing difficult<sup>[5]</sup>. POP is usually replaced in fracture clinics with a lighter weight synthetic casting bandage, *e.g.* Delta-Lite Plus fibreglass casting bandage (Smith & Nephew) and Delta-Cast Conformable non-fibreglass casting bandage (Johnson and Johnson).

Several alternatives have been studied. In a retrospective study of 309 torus fractures of distal radius and/or distal ulna, of which 269 (87%) were treated in a cast and 40 (13%) in a splint, none of the 276 (89%) patients who had available follow-up data had subsequent displacement of their fracture<sup>[4]</sup>. The authors concluded that splinting of torus fractures appears to be a reasonable management strategy. Davidson, et al. (2001) compared traditional forearm plaster of Paris cast and a Futura-type wrist splint<sup>[6]</sup>. Symons, et al. (2001) compared a below-elbow backslab, which was removed after three weeks in fracture clinic, with a similar backslab, removed at home by a parent<sup>[11]</sup>. Solan, et al. (2002) studied a Dynacast Prelude slab (Smith and Nephew) applied at a fracture clinic with no further follow up<sup>[3]</sup>. West, et al. (2005) compared a soft bandage and a cast<sup>[13]</sup>. Van Bosse, et al. (2005) retrospectively reviewed a removable POP splint where parents were instructed on applying splint, based on symptoms<sup>[12]</sup>. Plint, et al. (2006) compared a short below-elbow arm plaster cast and an individually fitted plaster splint<sup>[7]</sup>. Although the alternative methods of immobilisation in these studies vary, they share the common concept of using a flexible (bandage) or removable support (splint) method rather than the usual cast immobilisation, except in Symons, et al. (2001) and Solan, et al. (2002), which compared home versus hospital removal of immobilisation method<sup>[3, 11]</sup>.

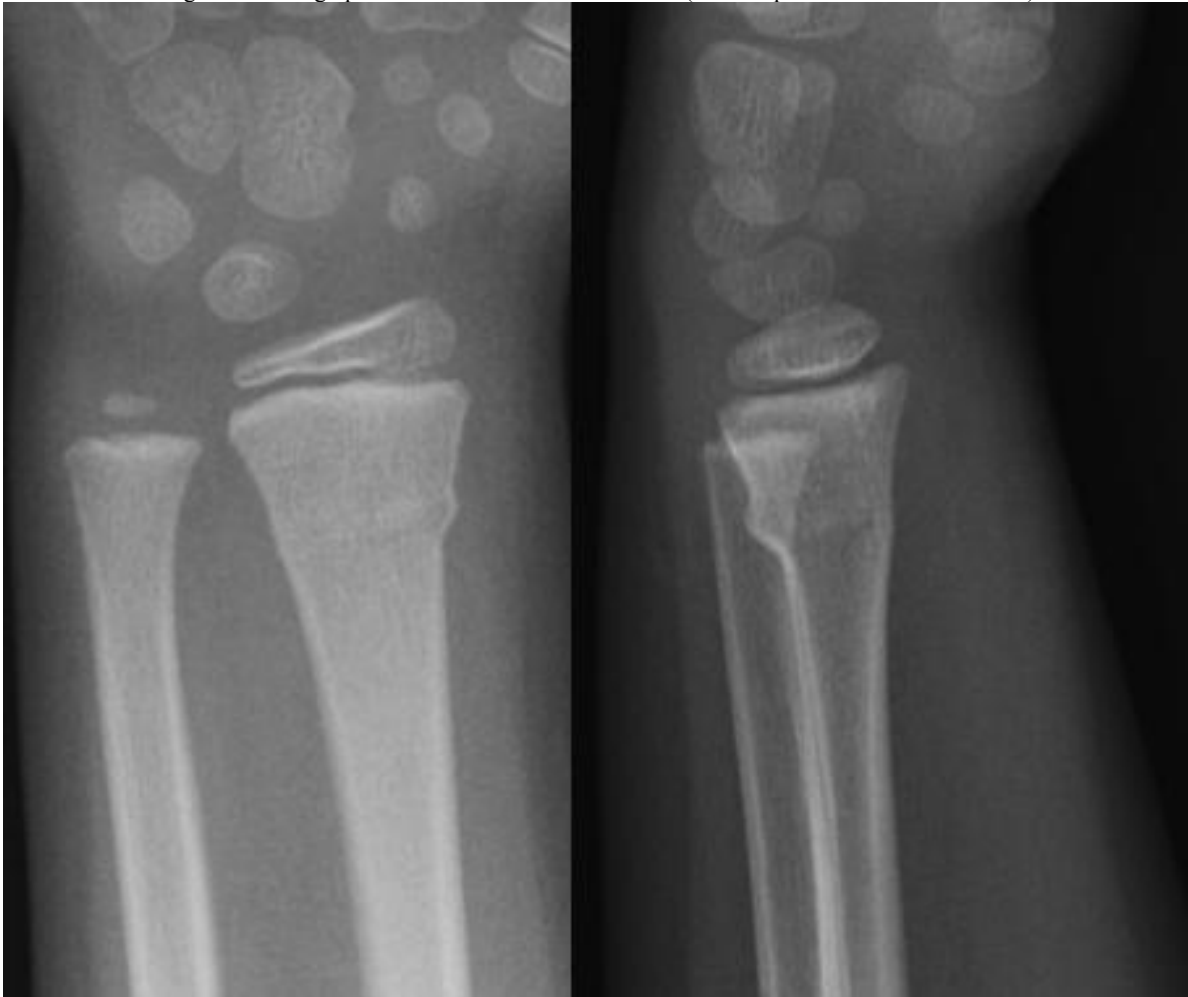
Why is this review important?

Torus fractures of distal radius are commonly encountered by emergency departments and fracture clinic clinicians and practitioners. Literature about the treatment and outcome of torus fractures of distal radius is not widely available, but classical teaching recommends cast immobilisation for 2-4 weeks<sup>[4]</sup>. The use of a splint or removable cast is claimed to provide stability and comfort with the potential of providing higher satisfaction and less follow up in clinics. A literature review by Firmin and Crouch (2009) concluded that splints in treatment of torus fracture in emergency departments had better outcomes and were preferred by patients compared to conventional plaster cast<sup>[5]</sup>. However, the review lacks information about the review process and the validity of included studies. It failed to report whether more than one reviewer was involved in selecting the studies and extracting data or whether measures were taken to minimise the risk of reviewer error and bias. These factors make it difficult to evaluate the reliability of the evidence presented and the review's conclusions should be interpreted with caution<sup>[19]</sup>. In the current literature, one systematic review was found that compared splint and cast in torus fractures among other types of interventions in different wrist fractures in children<sup>[8]</sup>. It concluded that the limited evidence supports the use of removable splint

for buckle fractures. Other than narrative report of cost from one study, there was no further cost-effectiveness comparison or analysis between splint and cast, probably due to lack of research in this area as the review was conducted over five years ago.

We aim to provide an up-to-date systematic review of the current available evidence with focus on effectiveness and cost-effectiveness of removable splints versus casts in treating torus wrist fractures in children.

Figure 1: Radiograph of torus fracture of distal radius (anterior/posterior and lateral views)



## 2.Objectives

The aim of this review is to evaluate the effectiveness and cost-effectiveness of removable splints versus casts in the treatment of torus wrist fractures of children. Wrist fractures include distal radius or/and ulnar fractures.

## 3.Methods

TCriteria for including studies for this review

Types of studies

Studies were considered for review if they were randomised or quasi-randomised controlled trial comparing removable splints and casts for treating torus fractures of distal radius and/or ulna in children.

Types of participants

Children, of either sex, with torus wrist fractures were diagnosed objectively through radiological study.

### Types of interventions

The comparison groups were children with torus wrist fractures who were treated with splint and those treated with cast. For the purpose of this review, “splint” refers to any method of removable support while “cast” refers to any continuous immobilisation method for the entire period of treatment, not including any short removal of the cast for replacement (e.g. in fracture clinics).

### Types of outcome measures

The ideal primary outcome of the review would be a restoration of the anatomical position of the fracture and the physical function of the wrist in the shortest possible and pain-free period without complications or need for further intervention. For practical reasons, we classify the outcomes of interest in this review into four groups:

- Positive outcomes: Includes functional assessment (using a validated assessment tool), range of movement, grip strength and, when reported, restoration of anatomy.
- Negative outcomes: Includes pain, complications, deformity and need for further intervention. Complications which will be addressed include both fracture complications (e.g. re-fracture and deformity) and intervention-specific complications (e.g. skin rashes, blisters and burns).
- Patient and parent satisfaction with and adherence (compliance) to immobilisation method.
- Resources use and cost effect: Includes cost of material used to stabilise the fracture, number of visits to the clinic, and any cost incurred due to complications, access to physiotherapy, hospital stay, if any, visits to general practitioner or any unplanned hospital visit (e.g. emergency department), child absence from school and any other reported cost.

### Search methods for identification of studies

The following resources were searched:

#### Electronic databases

A thorough database search was conducted on the following electronic databases:

- Medline (1950 to present)
- Excerpta Medica Database (EMBASE) (1980 to present)
- Allied and Complementary Medicine (AMED) (1985 to present)
- British Nursing Index (BNI) (1992 to present)
- Cumulative Index to Nursing and Allied Health Literature (CINAHL) (1981 to present)
- Health Business Elite (1922 to present)
- The Cochrane Library
- Database of Abstracts of Reviews of Effect (DARE)
- NHS Economic Evaluation Database (NHS EED)
- Health Technology Assessment (HTA)

The Medline, EMBASE, AMED, BNI, CINAHL and Health Business Elite databases were searched through the NHS Library website (<http://library.nhs.uk>). The Cochrane Library was searched on: <http://onlinelibrary.wiley.com/cochranelibrary/search/>; and DARE, NHS EED and HTA were searched on Centre for Reviews and Dissemination (CRD) website: <http://www.crd.york.ac.uk/CRDWeb/>

The key terms searched include: torus fracture, wrist fracture, radial fracture and ulnar fracture. The interventions (cast and removable splints) and outcomes were not included in the search strategy to avoid missing studies that use different names or terms for the same intervention and/or outcome. The search terminology considered synonyms (e.g. buckle for torus), different spelling, if applicable (e.g. British and American English), and derivatives (e.g. fracture, fractures and fractured). Medical Subject Headings (MeSH) terms were also searched. The full search strategy is

available from the author on request. Time or language limitations or other limitations were not applied during the database search.

#### Handsearch, Other sources and grey literature

Leading journals in both Trauma and Orthopaedics and in Emergency Medicine and major general journals were handsearched on their websites or the publishers' websites. Annual meetings and conferences proceedings, and unpublished studies and current trials were also searched (full lists are available from the author on request).

#### Reference lists of identified articles

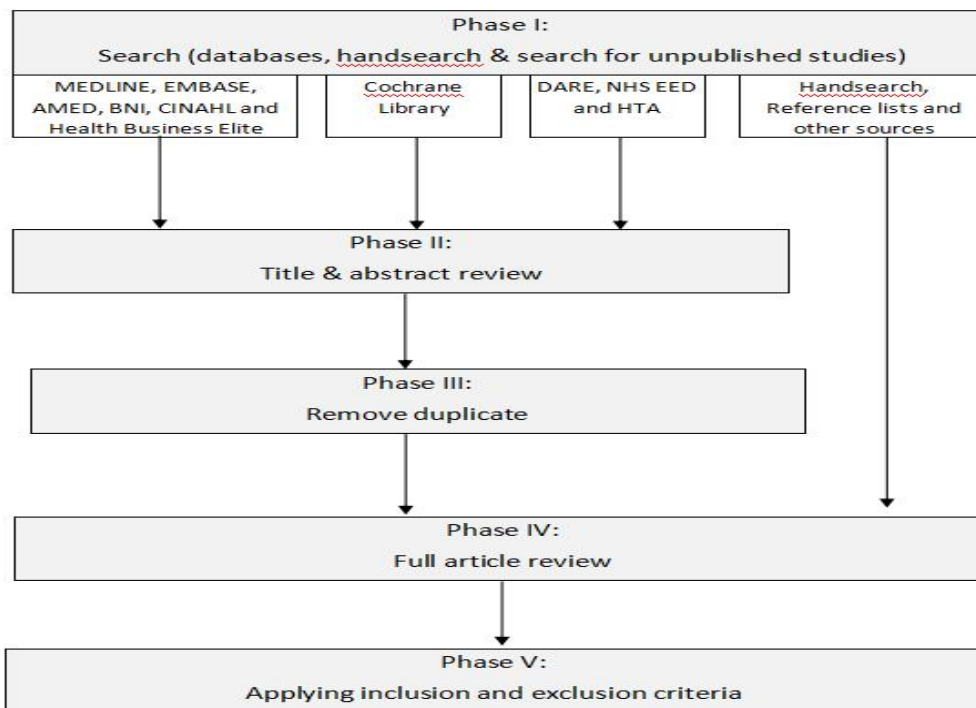
Reference lists of all trials and reviews related to the topic and identified during database search and handsearch were screened for potential studies to be included in this review.

#### Data collection and analysis

##### Selection of studies

To minimize the risk of loss of relevant papers, the search for studies adopted a low threshold search strategy and was carried out in five phases (Figure 2). A thorough database and other sources search was carried out in phase 1. The titles and, when available, abstracts were reviewed (Phase 2). When the titles and/or the abstracts seemed relevant and there were insufficient reasons for exclusion, the whole paper was retrieved after the duplicates were removed (Phase 3 and 4). The studies that met the inclusion criteria and none of the exclusion criteria were examined (Phase 5). This process was performed by two reviewers. No conflict has risen during this review process and involvement of the senior author was not required.

Figure 2: flowchart of searching for studies



#### Assessment of quality of included studies

The assessment tool used in this systematic review for assessing risk of bias is based on criteria for judging risk of bias as described in and recommended by Cochrane's Handbook for Systematic Reviews of Interventions. This type of assessment is domain-based evaluation and was developed between 2005 and 2007 by a working group of editors,

review authors and methodologists<sup>[20]</sup>. It is composed of seven domains, each of which has a set of criteria for a judgement of ‘low risk’, ‘high risk’ or ‘unclear risk’ of bias.

Assessment of quality of included studies was conducted by two reviewers. An expert professor and orthopaedic consultant experienced in the subject worked as supervisor and a clinical librarian was sought for a second literature search. The review team approach was to minimise risk of selection bias or missing potentially included studies.

#### Data extraction

Data from each included study were extracted into two separate data collection forms that were filled separately by the two reviewers. These forms were compared and no conflict was found between them.

Data was collected from the full text of trials.

#### Data analysis

The intention of the protocol of this review was to perform meta-analysis for the quantitative data and meta-synthesis for the qualitative data if the included studies proved to have heterogeneity and statistical tests were to be conducted by an independent statistician. However, a meta-analysis and/or meta-synthesis were not possible due to lack of heterogeneity and, as per the protocol, we presented the result in narrative form.

#### Data presentation

Treatment effect of quantitative data for the outcomes in the inclusion criteria presented using mean differences with 95% confidence intervals (95% CI) for continuous outcomes, and relative risks with 95% confidence intervals (95% CI) for dichotomous outcomes when available and applicable.

#### Reporting of the systematic review

For optimal reporting, the systematic review followed the guide of the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement and checklist, developed to address several conceptual and practical advances in the science of systematic reviews and to help authors improve the reporting of systematic reviews and meta-analyses<sup>[21]</sup>.

## 4. Results

### Literature search and selection of studies

#### Literature search

A total of 254 titles were identified in database search, as presented in (Table 1). A second search by a clinical librarian did not add more identified titles.

Table 1 - Number in identified titles in different databases

DATABASE	NUMBER OF IDENTIFIED TITLES
MEDLINE	83 titles
EMBASE	99 titles
AMED	3 titles
BNI	4 titles
CINAHL	34 titles
HEALTH BUSINESS ELITE	0 title
THE COCHRANE LIBRARY	27 title
SEARCHED ON CRD WEBSITE (DARE, NHS EED AND HTA DATABASES)	4 titles

After reviewing titles and, when available, abstracts, and removal of duplicates, 243 papers were excluded as there was clear reason for exclusion (*e.g.* irrelevant studies, reviews, retrospective studies, case reports, letters and surveys). When the abstract was not available or there was not clear reason for exclusion from the title or abstract, the study was retrieved for full text review. The two reviewers agreed to exclude seven papers for the following reasons:

Short review, comment, opinion or letter [22-25].

Compared cast and continuous use of bandage and did not fit the inclusion criteria of this review [13].

Retrospective comparative study [12].

Review article [26].

A conference proceeding was identified for potential inclusion [27], but the author and conference organiser were contacted for more information with no reply. Manual search for the full study did not return any results and it is likely that it has not been published. No further titles were identified from handsearch or other sources search.

There was disagreement between the two reviewers on the remaining four papers [6,7,28,29], but, after discussion, it was agreed to apply an appraisal checklist tool on these four papers as potentially included studies. The appraisal checklist tool was adapted from Critical Appraisal Skills Programme (CASP)-2013 [30].

Outcome of appraisal of potentially included studies:

A summary of the following studies is presented in Table 2:

Table 2 - Criteria of potentially included studies:

Study(Year)Location	N of patients(M/F)	Range (mean) of age in year	N of patients in cast : splint groups	Inclusion and Exclusion criteria	Comparability of baseline characteristics of the groups
Davidson et al. (2001) Liverpool, UK	201 (107/94)	2 - 15 8.9	85 : 116	NA	NA
Plint et al. (2006) Ottawa, Canada	87 (57/43)	N/A a	45 : 42	Inclusion:- age 6 to 15yr- torus fracture of distal radius or ulna Exclusion:- other fractures of same limb requires mobilisation - bilateral wrists fracture-metabolic bone disease-language barrier- from outside of hospital catchment area	Yes
Karimi et al. (2013) Kerman, Iran	142 (103/39)	1.2 - 17 9.5	77 : 65	N/A	N/A
Williams et al. (2013)	94 (59/35)	N/A a	51 : 43	Inclusion:- age 2 to 17yr - radiographically confirmed distal radius buckle fracture Exclusion: - skeletally mature patients-previous distal radius buckle fractures - concurrent other fractures except an ipsilateral distal ulnar buckle fracture	Yes

Randomisation method	Blindness	Outcome measure	F/U period	Sample size calculation	Statistical analysis
Quasi-randomised, based on the day patients attended fracture clinic	NA	-compliance - clinical and radiological healing of fractures - loss of position - cost-benefit	3 weeks	NA	NA
Computer-generated with a block size of 4	No	- primary outcome measures: ASKp score at day 14 post injury - Other outcome measures: ASKp score at days 7, 20, and 28 post injury; change from baseline in ASKp at days 7, 14, 20, and 28; pain; ability to perform daily and sporting activities throughout the study; length of splint use; parent and child satisfaction at day 28; re-fracture at 6 months	28 days in clinic; 6 month phone call	Yes	Yes

Study(Year)Location	N of patients(M/F)	Range (mean) of age in year	N of patients in cast : splint groups	Inclusion and Exclusion criteria	Comparability of baseline characteristics of the groups	
N/A	N/A	- pain severity score - satisfaction of one visit to fracture clinic - convenience of treatment - cast or splint related complications or complaint		3 weeks	N/A	Yes b
Computer-generated with a block size of 10	N/A	- satisfaction - convenience - pain		3 weeks	Yes	Yes

N= Number, M=Male, F=Female, NA=data or information was not available or discussed in the study, yr=year, F/U=Follow up  
 a Range and mean of age of overall population of study was not presented but the figures were presented separately per group  
 b There is superficial touch on statistical analysis. See relevant under ‘Criteria of potentially included studies’ under ‘Result’ chapter.

Davidson, et al., 2001<sup>[6]</sup>:

The report of the study was very precise and lacked exploration of several critical information for a good randomised controlled trial. The study design and conduct were poor. The study was reported as randomised trial, whereas the method of randomisation showed it was quasi-randomised. It is not clear if the randomisation worked. There was no reported inclusion and exclusion criteria, the outcome measures were very limited and there was no power calculation or statistical analysis. It is unlikely that the results can be meaningful for use in this systematic review. The cost-benefit analysis, however, can be narrated as appropriate.

Plint, et al., 2006<sup>[7]</sup>:

The study design was clear and reproducible. The randomisation method was presented and the authors claimed that it worked, although no clear statistical analysis was presented to compare baseline characteristics. The statistical methods were appropriate and the sample size matched the calculated figures. However, there are several questions on the methods of the study, mainly on the sample of the population and the primary outcome measure. Also, there was a risk of bias by absence of blinding. In summary, the results of this paper can be included in the systematic review with caution and acknowledging these questions.

Karimi, et al., 2013<sup>[29]</sup>:

Besides high risk of selection bias and observer bias, the methods of the study are vague in several areas and data analysis and presentation are poor. The recruitment started on the day patients were seen in orthopaedic fracture clinic rather than day of diagnosis and treatment of the condition, which means patients received two periods (with possible two types of interventions) during their treatment, but only one period (and one intervention) was studied and correlated to the outcome. The study cannot be included in the systematic review as it did not meet the inclusion criterion that immobilisation or support should be “for the entire period of treatment”. No further information or data could be extracted from the study due to the lack of information, poor data presentation and analysis and high risk of bias.

Williams, et al., 2013<sup>[28]</sup>:

The methods of the study were well thought-out, clear and repeatable. The randomisation method was stringent and worked well. The statistical methods were justified and appropriate. The sample size calculation was stated, but not clearly how it was done and no results of calculation were presented. However, the methodology can be scrutinised by the absence or any attempt of blinding, the vague intervention (the prefabricated cock-up wrist splint).

There was a risk of bias by absence of blinding and the practicality of the used splints and the way they were used. The results related to resources utilisation were presented in narrative way without presentation of actual figures of cost.



In general terms, the results of this paper can be included in the systematic review with caution and discussion of these risks and practicality issues. However, these results cannot be included in a meta-analysis for the above reasons. The results related to resources cannot be included, as no cost related figures were presented.

Overall outcome of appraisals of potentially included studies:

Following in-depth review and critical appraisal of these papers, two papers did not meet the inclusion criterion of using the immobilisation device for the entire period of treatment. Davidson, et al. (2001) and Karimi, et al. (2013) recruited subjects in orthopaedic fracture clinic after they received different intervention when diagnosed in emergency department<sup>[6, 29]</sup>. The other two studies<sup>[7, 28]</sup> can be included with caution and discussion on the risk of bias in both of the two trials.

In Plint, et al.'s study (2006), the eligible age for inclusion was 6 to 15 years and the primary outcome measure was ASKp score at day 14 post-injury and secondary outcomes were ASKp score at days 7, 20, and 28 post-injury; change from baseline in ASKp at days 7, 14, 20, and 28; pain; ability to perform daily and sporting activities throughout the study; length of splint use; parent and child satisfaction at day 28; and re-fracture at six months. Patients were randomised to either cast or splint group. Those in the splint group were advised to use the splint for comfort only. In Williams, et al's study (2013), the age of the included subjects was 2 to 17 years and was randomised to cast or splint group. Those in the splint group splints were advised to wear the splint as much as possible. The primary outcome of the study was satisfaction, convenience and pain<sup>[28]</sup>.

With the differences between age groups, the way patients were advised to use the splints and the outcome measures between the two studies, there is clear lack of heterogeneity between the groups in these two studies and a meta-analysis is unlikely to be meaningful; additionally, with the above mentioned risks of bias, any meta-analysis will carry the same risks of bias and the results are unlikely to be generalisable. The results of these two studies are, therefore, presented and discussed in narrative way in this systematic review and detailed analysis based on the criteria for judging risk of bias<sup>[20]</sup> is applied.

Assessment of risk of bias in the included studies:

Both studies<sup>[7, 28]</sup> carried variable degrees of risk of bias from low to high in different domains and unclear risk in the majority of the domains assessed based on the criteria for judging risks of bias<sup>[20]</sup>. Detailed outcome of assessment is in Table 3.

Table 3 - Assessment of risk of bias in the included studies

<b>RANDOM SEQUENCE GENERATION</b>	
Plint et al., 2006	'Low risk' Using a computer random number generator;
Williams et al., 2013	'Low risk' Using a computer random number generator;
<b>ALLOCATION CONCEALMENT</b>	
Plint et al., 2006	'Low risk' Central allocation (web-based); initially then: Sequentially numbered, opaque, sealed envelopes.
Williams et al., 2013	'Low risk' Sequentially numbered, opaque, sealed envelopes.
<b>BLINDING OF PARTICIPANTS AND PERSONNEL</b>	
Plint et al., 2006	'Unclear risk' Insufficient information to permit judgement of 'Low risk' or 'High risk' ; The study did not address this outcome.

Williams et al., 2013	‘Unclear risk’ Insufficient information to permit judgement of ‘Low risk’ or ‘High risk’ ; The study did not address this outcome.
<b>BLINDING OF OUTCOME ASSESSMENT</b>	
Plint et al., 2006	‘Unclear risk’ Insufficient information to permit judgement of ‘Low risk’ or ‘High risk’ ; The study did not address this outcome.
Williams et al., 2013	‘Unclear risk’ Insufficient information to permit judgement of ‘Low risk’ or ‘High risk’ ; The study did not address this outcome.
<b>INCOMPLETE OUTCOME DATA</b>	
Plint et al., 2006	‘Unclear risk’ ‘Unclear risk’ Insufficient reporting of attrition/exclusions to permit judgement of ‘Low risk’ or ‘High risk’ (e.g. number randomized not stated, no reasons for missing data provided).
Williams et al., 2013	‘Low risk’ No missing outcome data.
<b>SELECTIVE REPORTING</b>	
Plint et al., 2006	‘Unclear risk’ Insufficient information to permit judgement of ‘Low risk’ or ‘High risk’ .
Williams et al., 2013	‘Unclear risk’ Insufficient information to permit judgement of ‘Low risk’ or ‘High risk’ .
<b>OTHER BIAS</b>	
Plint et al., 2006	‘High risk’ Had a potential source of bias related to the specific study design used; and Had some other problem.
Williams et al., 2013	‘High risk’ Had a potential source of bias related to the specific study design used; and Had some other problem.

#### Cost-effectiveness analysis:

Cost-effectiveness analysis between cast and splint for treatment of distal radius torus fractures is scarce in the literature. When analysing the cost differences between the groups, Davidson, *et al.* (2001) estimated a saving of £4505 if those in the cast group were treated with splints (based on £53 saving per patient). The authors estimated the cost of treatment in cast group at £116.98 (which involved a radiograph in emergency department, a temporary splint, attendance at the clinic, application of cast and future attendance for removal of cast) and cost of treatment in splint groups of £65.75 (which involves a radiograph in emergency department, application of splint and clinic attendance)<sup>[6]</sup>. The details of estimated costs of treatment are presented in Table 6. No cost related to child absence from school, parents’ time off to attend clinic or other similar forms of cost were included.

Other studies presented limited information of cost benefit of splint compared to cast. Williams, *et al.* (2013) concluded that there was significantly more ‘resource utilisation’ in cast group than in splint group. Resource utilisation compared in the study included assistant required when immobilisation was placed, time of immobilisation and physician delay of at least one hour from radiograph to immobilisation<sup>[28]</sup>. Although these might reflect cost, no cost figures were presented. Karimi, *et al.* (2013) estimated 6 US dollars saving per patient treated with splint compared to cast. The authors did not present detailed cost-effectiveness analysis, but calculated the cost in cast group, which involved screening visit, radiography in emergency department, visit to fracture clinic, cast application and second attendance for cast removal (15.3 US dollars in Iran) compared to the splint group, which involved screening visit, radiography in emergency department, visit to fracture clinic and application of splint (9.3 US dollars in Iran)<sup>[29]</sup>.

The limited presentation of cost analysis of splint compared to cast supports the logical view of splint being more cost-effective. It needs less resources (one person to apply and quicker time of application) and can be managed at home,

compared to attending fracture clinic (typically twice), which incurs costs on the treating hospital, parents and the community, due to absence from work and school. Cumberland, et al (2009) estimated annual saving of £56,096 for their hospital if all children with distal radius torus fracture had been treated with splint and managed from emergency department based on predefined protocol<sup>[27]</sup>.

## 5. Discussion

Clinical-effectiveness:

Wrist torus fractures are inherently stable and previous studies suggested that the risk of displacement does not exist<sup>[3-7]</sup>. In their review study, May and Grayson (2009) concluded that these fractures will heal regardless of the treatment provided<sup>[14]</sup>.

Several studies attempted to determine whether alternative methods of support or immobilisation are superior to the traditional way of cast immobilisation<sup>[4,6,12,13,7]</sup>. This systematic review found very few papers examining use of splint in management of distal radius torus fracture<sup>[6,7,28,29]</sup> and in only two of the studies splints were used from the day the fractures were diagnosed<sup>[7,28]</sup>. The conclusion in all of these studies was that there were no significant difference in outcome between casts and splints; and some papers found that splints were more cost effective and utilised less resources<sup>[6,28,29]</sup>. However, there are several concerns and questions about the methodology and results of these papers. The findings of these studies cannot be accepted and generalised without further clarification and any application of these results should be undertaken with caution. One can argue that the consensus agreement among all studies that examined different methods of immobilisation of distal radius torus fracture is that they are stable and don't tend to displace, no matter what the immobilisation device is<sup>[3-7,12,13,28,29]</sup>. Also, the theory supports the use of splint, which has less potential side effects and is more convenient for children and parents. Splints are removable devices, so they have the same function as cast (immobilisation) and can be removed for showering and hygiene. Additionally, they are lighter and cheaper than casts and do not require follow up clinic for removal. However, argument can go against the use of splint. It has been shown that other types of fractures can be misdiagnosed as torus fractures, even by more experienced clinicians. In Davidson, et al. (2001), a greenstick type fracture was misdiagnosed as torus fracture and not noticed until three weeks follow up clinic<sup>[6]</sup>. This was despite the fact that the authors stated that the diagnosis of torus fracture was confirmed on the day the patients attended fracture clinic and recruited in the study by the treating physician; and in Williams, et al. (2013) study a transverse distal radius fracture with a distal ulnar buckle fracture was treated from emergency department with splint. The child was called next day to return for application of cast<sup>[28]</sup>. Also, in rare occasions, torus fractures are not always straight forward and can be associated with other injuries that require specific treatment and intervention. In a case report, Eren, et al. (2009) reported distal radioulnar joint subluxation associated with torus fracture of distal radius in a one and half-year-old boy, which required manipulation and application in cast<sup>[31]</sup>. On the other hand, splints were previously studied in Colles fractures in adults<sup>[32,33]</sup> and children with minimally angulated distal radius fractures<sup>[34]</sup> with promising results on the use of splints in these injuries. Torus fractures are more stable and splints are more likely to be safer in their treatment.

The evidence remains scarce and a robust and well-conducted RTC is required to answer these questions. However, given the stable nature of torus fractures, it might be safer to use splints as a method of immobilisation and support with a tight safety net to ensure misdiagnosed fractures are treated appropriately, appropriate training of clinicians treating these injuries and involvement of parents in the decision, explaining both options to give them the choice. This helps patients by using a removable and more convenient device, the health system in the current economic environment by reducing follow up clinics and the community by reducing child absence from school and parents from work for clinic attendance.

Cost-effectiveness:

The concept of using splints compared to casts in treating distal radius torus fractures in children might be superior when cost and use of resources are considered. Splints are cheaper, easier and quicker to apply and do not require follow up clinics for removal. Also, they do not need the child to take time off from school and parent(s) time off from work to attend the follow up clinic. These incur social and economic cost, such as cost of hospital transport when required, absences and sickness from work and school, as well as personal costs like travel and car parks. However, a good evidence-based practice to support this theory is lacking in the current literature. This systematic review found three papers discussed cost and use of resources in splint versus cast in distal radius torus fracture<sup>[6,28,29]</sup> and in one study<sup>[29]</sup> no detailed figures were given apart from the final estimated saving per case in splint group. Williams, *et al.* (2013) also presented limited information and considered resources utilisation rather than cost. The authors found that use of splints required less utilisation of resources than using casts<sup>[28]</sup>. The findings in Davidson, *et al.* (2001) were also in favour of splints, with a significant cost saving<sup>[6]</sup>. The authors only included cost of treatment (Table 4). However, it is more likely a further saving (in favour of splints) would have been found in cost related to child and parent absence from school and work. There are, however, several concerns and questions about the conduct of this study, as previously discussed. The impact of these on the cost analysis is not clear.

Table 4 - The estimated cost of treatments as presented by Davidson et al. (2001)

<b>Treatment</b>	<b>Cost (£)</b>
<b>Radiographs</b>	16.00
<b>Clinic attendance</b>	47.00
<b>Plaster of Paris backslab</b>	2.03
<b>Plaster of Paris cast</b>	5.42
<b>Temporary splint</b>	1.56
<b>Futura splint</b>	2.75

In another study, on children with acceptably angulated wrist fractures, von Keyserlingk, *et al.* (2011) performed detailed analysis of cost-effectiveness of casts versus splint. In a single site blinded randomised control trial, the authors studied casts and splints in management of skeletally immature children who presented to emergency department of the Hospital of Sick Children (Ontario, Canada) with minimally displaced (complete or greenstick) wrists fractures. Age group included was 5 to 12 years old. 100 patients were enrolled between April 2007 and September 2009. After removing those who were subsequently excluded for diagnostic errors and loss to follow up, data of 92 patients with mean age of 9.3 years were analysed. Patients in both groups were immobilised for four weeks and attended follow up fracture clinic at one and four weeks of the study, where clinical assessment was carried out and parents completed a clinical and expenses diary. At six weeks following the injury, parents completed ASKp questionnaire, range of movement and strength of the injured wrist were measured and parents again completed a clinical and expenses diary. The diary included questions on health care use and other paid resources related to the injury. The recorded resources included health visits, tests, procedures and surgeries, medications, time off school and/or work, unpaid work and any child care or transport. The authors looked at costs from a social perspective and included healthcare expenses, family resources and any productive costs incurred due to the treatment and up to six weeks post-injury. The source of cost was supplied by provincial statistical reports and local administrative data sources and was assessed for 2009. Where costs were not available for 2009, the authors look at values for other years and used the Canadian Consumer Price Index for Health and Personal Care to calculate the inflation. Mean ASKp score was estimated at week six. The authors used a gamma model to estimate means and standard errors (SE) for the cost and analyse the data using SAS Version 9.1

(Statistical Analysis System, Cary, NC). They found that mean total cost cast in cast group was \$950.35 and \$877.58 in splint group, with a mean difference of \$72.76 (SE 45.88). For healthcare cost, the mean cost was \$768.22 in cast group and \$670.66 in splint group, with a mean difference of \$97.56 (SE 9.24). They also found that mean ASKp score was 91.4 in the cast group compared to 92.8 in the splint group. They concluded that using splint in managing these injuries was cheaper and more effective<sup>[35]</sup>.

Although this study was done on minimally angulated greenstick and complete fractures, if the same concept is applied on torus fractures it is highly likely that similar savings can be achieved. The fact that greenstick and complete fractures are less stable than torus fractures supports the safety of splint use in the latter as there were no clinical concerns in this study. However, the use of provincial statistical reports and the local administrative data sources of Ontario to source the costs limit the generalisability of findings, as cost varies between different countries and the results cannot serve as reference for funding decisions across different health care programmes.

Limitation of the systematic review:

There is some gap between the ideal evidence-based medicine and the real world of daily practice. Personal experience and opinions are difficult not to influence clinicians' practice, especially in a field where the evidence is very limited. Systematic reviews are limited by the limitations of the included studies, and have been criticised for emphasising on the validity of the studies without considering the applicability of the information provided by them <sup>[36]</sup>.

Torus fractures of distal radius in children, although common, remain one of the most controversial injuries in their treatment and have been influenced considerably by individual expertise and preferences. This systematic review has found limited number of studies addressing the question of the review. The validity of these studies is questionable and the results cannot be generalised. The overall findings of this review could be scrutinised based on the validity of the included studies. Additionally, the data could not form a meta-analysis for lack of quality and heterogeneity. However, this review has discussed strengths and weaknesses of these studies and drawn its findings based on the limited available evidence in the literature. It has highlighted the gap in the literature and it is hoped that a well-designed and conducted RTC on the subject will be undertaken to answer these gaps in this important subject.

Conclusion

Although considered simple and straightforward injuries, torus fractures of distal radius management remains a controversial issue and varies considerably in practice. The evidence found in this systematic review is limited in its quantity and quality. The limited available data favours the use of splints as a safe, convenient and cheap alternative. However, no concluding data are found to support this. No data are found to favour the use of cast, either. We conclude that it might be wise to involve the child and parents in the decision-making and apply a stringent safety net when splints are applied from emergency department and no further fracture clinic is given, such as supplying open access to the clinic should any problem arises and ensuring all radiographs are reviewed by experienced paediatric orthopaedic surgeons or radiologists.

Based on this, we recommend that the nature of the injury and options for treatment are explained in detail to the injured children and their parents, giving them the choice and involving them in the decision. We stress applying a safety net system to avoid any misdiagnosed or maltreated fractures. We also recommend implementing a clinical governance programme to monitor and audit the practice and whether it can be carried on safely or discontinued with return to the traditional management..

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