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UNCERTAINTIES

What level of immobilisation is necessary for treatment of torus (buckle) fractures of the distal radius in children?

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What you need to know

- Evidence suggests that most children with torus fractures of the distal radius make a full recovery within six weeks with no serious problems (including repeat injury) when treated with simple splints
- Splint immobilisation and immediate discharge are recommended in guidelines, such as those from the National Institute for Health and Care Excellence (NICE), however the scientific quality of evidence underpinning the guidelines is rated low or very low
- Health professionals may consider bandage treatment or even no treatment in the management of this injury, though the safety and acceptability of this approach to patients are not yet known

Torus (buckle) fractures are the most common fractures of the wrist in children, involving the distal radius and/or ulna bone (fig 1).[1] They typically occur in children up to age 14, usually after a low energy fall.[2] The flexibility of immature bone in children enables force to be absorbed as with the "crumple zone" of a car: crushing—or buckling—as it is injured. Such fractures differ from greenstick fractures, in which the bone bends (rather than crushes), resulting in a complete break in one cortex and a bend on the opposite side (akin to snapping a fresh twig from a tree). Torus fractures result in a mild deformity without a break in the bone surface, and pain is the main clinical feature. The child may need assistance with schoolwork, time off physical activities, and help with self-care during the recovery period.

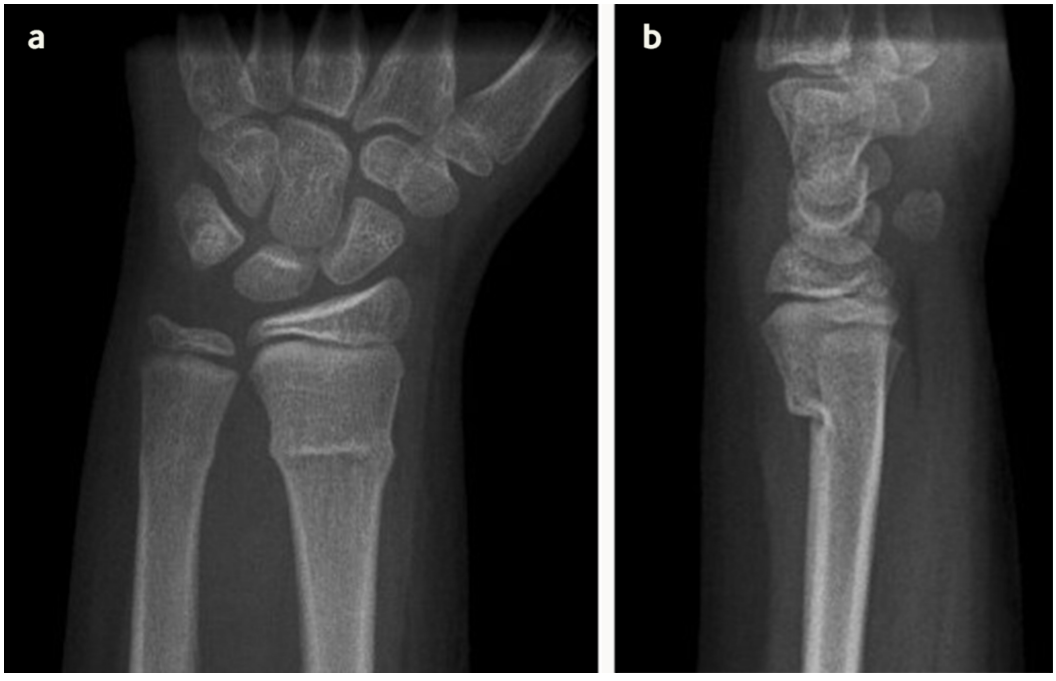

Fig 1 | Anteroposterior (a) and lateral (b) radiographs of the wrist showing a torus fracture of the distal radius and ulna with compression of the bones dorsally, though no break in the bone surface

Parents typically expect that any fracture needs plaster cast immobilisation to ensure adequate healing. However, torus fractures heal quickly, with pain almost completely resolved three weeks after the injury,[3] and simple splints that can be removed at home may be safe and effective treatment.[4]

In 2016, the National Institute for Health and Care Excellence (NICE) reviewed the treatment of torus fractures of the distal radius. NICE concluded that the quality of evidence for rigid cast immobilisation was poor, and instead recommended either a removable splint or a bandage (the latter essentially postulating that no treatment may be equally as effective as immobilisation since a bandage offers minimal or no structural support). NICE also recommended that children with torus fractures be discharged from the emergency department without subsequent follow-up.[5] Despite this guidance, however, a 2016 survey of 100 UK based emergency

departments found that 40% used casts in the treatment of torus fractures, and 60% routinely planned outpatient follow-up.[3] Likewise, a survey in Ireland identified 70% of responders using traditional casts and clinic follow-up.[6]

Guidelines from Melbourne, Australia and Colorado, US, recommend either a removable splint or rigid cast immobilisation, and studies from the US and Australia have shown high rates of cast immobilisation, outpatient follow-up, and repeated radiographic assessment in practice.[7-9] Canadian guidelines are more similar to NICE in advising treatment with a splint but recommend routine follow-up in primary care (table 1).

Table 1 | Guidelines on the treatment of torus fractures

Country	Guidance	Examples
England and Wales	National NICE recommendation: a bandage or easily removable splint and immediate discharge from the emergency department[5]	NICE Guideline[5]
United States	No national guidance. Colorado Pathway recommends cast or an easily removable splint, and follow-up "as needed" (depending in part upon immobilisation device used)	Colorado Pathway[10]
Canada	No national guidance. Local guidance from Toronto recommends the use of an easily removable splint, and follow-up with a primary care provider	Toronto Pathway[11]
Australia	No national guidance. Melbourne Pathway recommends use of either a cast or an easily removable splint. Immediate discharge from the emergency department is possible when a cast is not used, though orthopaedic follow-up is necessitated if a cast is used	Melbourne Pathway[12]

It is therefore unclear if children with a torus fracture of the distal radius require cast or splint immobilisation, or would do just as well with a bandage or even no immobilisation at all. Furthermore, the safety and acceptability of immediate discharge after diagnosis is not clear.

What is the evidence of uncertainty?

Search strategy and key words

We searched PubMed using the terms "buckle" OR "torus" AND "fracture*" to identify papers between January 2017 and 28 May 2020. A 2018 Cochrane review of randomised controlled trials (RCTs) on interventions for treating wrist fractures in children was also included.[22] For completeness, our search overlapped the period of the Cochrane review (Cochrane search date May 2018). We identified 59 new papers, of which only two were prospective cohort studies, with no new RCTs.

The 2018 Cochrane review of torus fracture treatments included nine RCTs comprising 695 patients in studies comparing removable splints with rigid casts (table 2) and 237 patients in studies comparing bandages with rigid casts (table 3). The quality of evidence was low or very low in all nine studies, as reflected by the absence of blinding in all trials, a high rate of participant attrition, and imprecise estimates of the effect size owing to low sample sizes. These studies demonstrated no differences in pain, function, or serious events between the different interventions used. There were treatment failures, defined by the need to switch to a rigid cast, but these were at parental request rather than specific clinical need. While these trials point to removable splints and bandages being non-inferior to rigid cast immobilisation, the quality of the studies and lack of transparency in reporting precludes a definitive conclusion to be drawn. The clinical pathway in only two of these trials involved discharging participants without follow-up,[13 15] with just 122 participants randomised to either a removable splint or bandage and discharge without subsequent face-to-face follow-up from the emergency department. While immediate discharge is becoming more widely practised, little robust evidence underpins the safety of this approach, and the acceptability to families and clinicians is inconclusive.

Table 2 | Randomised controlled trials comparing removable splints with cast for torus (buckle) fractures

Study ID	Number of participants/ age	Intervention, duration of use, and follow-up	Key outcomes	Other notable findings
Davidson 2001[4]	201 (85 cast, 116 splint). Mean: 8.9 years; range 2 to 15 years	Splint: prefabricated wrist splint. Cast: short arm cast. Follow-up: outpatient clinic three weeks after injury for all children to remove cast and splint. Outcome: success of treatment at 3 weeks in terms of healing and adverse events	All fractures united clinically and radiologically, with no fracture displacement	Compliance with both types of treatment was good except in two very young patients who tried to remove their splints shortly after they had been applied
Karimi 2013[13]	142 (77 cast, 65 splint). Mean: 9.5 years; range 1.2 to 17 years	Splint: prefabricated wrist splint. Cast: short arm cast. Follow-up: removable splints followed by phone call, with home removal of splint at 3 weeks. Casts followed up in clinic at 3 weeks. Outcome: non-validated score of pain and satisfaction at 3 weeks. Adverse events	No adverse events or skin problems in either group. 28 in the splint group, 24 in the cast group experienced mild to moderate pain with activity (P=0.61). 58 in the splint group and 66 in the cast group found the treatment convenient	
Oakley 2008[14]	95 (47 cast, 48 splint). Mean: 8.5 years; range 9 months to 15 years	Splint: fibreglass backslab. Cast: short arm cast. Follow-up: radiographs at 12 to 16 days after injury. Immobilisation extended by two weeks if significant tenderness or discomfort remained. Outcome: patients given a daily diary, including a visual analogue scale (VAS) assessment of pain	No difference in the median pain scores throughout follow-up. 40 in the cast group, and 28 in the splint group had returned to "full activity" by 2 weeks. No adverse events	Study used a splint which is not a direct comparison with a typical splint used in other studies
Plint 2006[15]	113 (56 cast, 57 splint). Mean: 9.72 years; range 6 to 15 years	Splint: prefabricated wrist splint. Casts: short arm cast. Follow-up: casts were removed in clinic at 3 weeks. Splints were removed at home when child comfortable. Phone contact made at 7, 14, 20, and 28 days post injury to record pain and recovery and postal follow-up to 6 months. Outcome: primary outcome measure was the ASKp (Activities Scales for Kids performance) questionnaire performed by phone at 14 days	Patients in the splint group had a significantly higher ASKp score at day 14 post injury than the cast group (P<0.041). Specifically, the children in the splint group had close to "normal" ASKp scores at day 14, whereas those in the cast group had scores that correlate with mild disability. ASKp score was not significantly different between the groups for days 7, 20, and 28 post injury. Five children in the cast group returned to the emergency department for problems with their casts (four returned for wet casts and one had placed a pencil under the cast). No children in the splint group returned to the emergency department for problems with their splint. There were no re-fractures	
Pountos 2010[16]	50 (24 cast, 26 splint). Mean: 9 years; range 2 to 16 years	Splint: prefabricated wrist splint. Cast: plaster cast (unspecified). Follow-up: outpatient clinic 4-6 weeks after injury for all children. Unclear when the splint was removed. Cast removed at clinic visit. Outcome: all had radiographic assessment at follow-up. "Average" pain in the preceding weeks was determined at the follow-up visit using a VAS. An unvalidated assessment of function was also made	No difference in pain scores was observed, with a score of 3.1 in splint *v* 2.9 in the cast group. No difference was observed in the use of analgesia, and no apparent difference in function. The amount of deformity worsened (all by less than 5 degrees) in three patients (two splint group and one cast group).	Three way trial of plaster cast, splint, and tubigrip bandage

Table 2 | Randomised controlled trials comparing removable splints with cast for torus (buckle) fractures *(Continued)*

Study ID	Number of participants/ age	Intervention, duration of use, and follow-up	Key outcomes	Other notable findings
Williams 2013[17]	94 (cast 51, splint 43). Median: 9.5 years (splint) and 9 years (cast); range 2 to 16 years	Splint: prefabricated wrist splint. Cast: short arm cast. Follow-up: all followed up at 3 weeks. Splints removal permitted as the child became more comfortable. Casts removed in clinic at 3 weeks. Phone contact was made at 1, 3, 7, and 21 days post injury to record pain and recovery. Outcome: assessment of pain, convenience, and preference—though unclear if validated tools used	Pain scores were higher in the splint group, though the difference was not statistically significant. The satisfaction was higher in the splint group, with families showing a preference for this treatment	

Table 3 | Randomised controlled trials comparing bandages with cast for torus (buckle) fractures

Study ID	Number of participants/age	Intervention, duration of use, and follow-up	Outcomes	Other notable findings
Jones 2001[18]	50 (25 cast, 25 bandage) Mean: 6.2 years; range 3 to 10 years	Bandage: a layer of soft wool covered with cotton crepe initially. Cast: short arm cast. Follow-up: removed cast at clinic visit. Wool removal unclear. Outcome: follow-up to determine satisfaction at 3 weeks	High parental satisfaction with both treatments	Unpublished, available only as a conference abstract
Kropman 2010[19]	92 (45 cast, 45 bandage) Mean: 10 years; range 4 to 12 years	Bandage: a layer of soft wool covered with cotton crepe initially. This was converted to a tubigrip at 1 week, to be worn for three weeks. Cast: initially treated in a backslab, which was converted to a full short arm cast at 1 week and removed at 4 weeks. Follow-up: 1 and 4 weeks with radiographs, and at 6 weeks. Outcome: pain diary was completed at home throughout the first three weeks post injury including pain VAS	The mean VAS for pain at 1, 2, and 3 weeks, showed significantly increased pain at week 1 in the bandage group (26 ±19 mm, *v* 20 ±16mm (P=0.03)), though no difference at other time points. None of the fractures showed secondary angulation in either group. No re-fractures were seen during follow-up in either group. No difference between the intake of painkillers was seen between groups (P=0.56). No adverse events	
Pountos 2010[16]	53 (24 cast, 29 bandage) Mean: 9 years; range 2 to 16 years	Bandage: a double tubigrip bandage. Cast: a short arm plaster-of-paris cast. Follow up: outpatient clinic 4-6 weeks after injury for all children. The cast was removed at the clinic visit. Unclear when tubigrip removed. All had radiographic assessment at follow-up. Outcome: "average" pain in the preceding weeks was determined at the follow-up visit using a VAS. An unvalidated assessment of function also made	No difference in pain scores was noted, with a score of 2.3 in bandage *v* 2.9 in the cast group. No difference was noted in the use of analgesia, and no apparent difference in function. The amount of deformity worsened (all by less than 5 degrees) in two patients (1 bandage group and 1 cast group)	Three way trial of plaster cast, splint, and tubigrip bandage
West 2005[20]	42 (21 cast, 18 bandage) (age unclear—though specify children)	Bandage: a layer of soft wool covered with cotton crepe. Cast: initially treated in a backslab, which was converted to a full cast at 1 week. Follow-up: bandages were reviewed in clinic weekly for four weeks, and the bandage changed at each visit. Casts were seen at 1 week and removed at 4 weeks. Outcome: no validated outcome assessment, though reported on process and adverse events	All patients in the bandage group had discontinued its use in week 2. No adverse events or skin problems were noted in either group	Two other children included initially in the bandage group failed to return for their first visit in the fracture clinic and did not make it into the analysis

Is ongoing research likely to provide relevant evidence?

We searched the ISRCTN and ClinicalTrials.gov databases to identify ongoing research related to "wrist fractures" and "forearm fractures" in children. Only one related to the treatment of torus fractures: the FORCE (forearm fracture recovery in children evaluation) study. This is a trial investigating the clinical effectiveness—using the primary outcome of pain at day 3—of "the offer of a soft bandage" and immediate discharge versus rigid immobilisation (ie, cast, backslab, or removable splint) and standard follow-up among children with torus fractures of the distal radius.[21] The FORCE study is limited to children in the UK and has so far recruited more than 900 children from emergency departments throughout England; it is expected to report late in 2021. The trial uses text message and email to collect patient reported outcomes, principally pain and functional recovery, from families for up to six weeks from the injury.

Early patient involvement in the FORCE study found poor acceptability among parents of "no treatment" in children with torus fractures. The intervention arm is thus "the offer of a soft bandage" to be applied and used at the discretion of the family, and this is proving acceptable to participants. The sample size is adequate to quantify rarer adverse events (ie, re-fracture), and is inflated to allow for 20% loss to follow-up given the novel method of electronic follow-up. The size and scope of the FORCE study means it is likely to provide high quality evidence to clarify uncertainties related to the need for immobilisation and follow-up described in this article, but more studies may be needed globally to understand acceptability of interventions in different settings. The inability to blind participants to the intervention will mean the study is prone to observer bias, and the "offer of a bandage" means that "no treatment" is not assessed. A cost effectiveness analysis will also be performed.

What should we do in the light of the uncertainty?

Given the uncertainty, we suggest hospitals and clinical teams develop a protocol for management of children with this injury. The guideline most based in evidence is that produced by NICE, which recommends the use of a removable splint and immediate discharge. Implementation of this pathway requires clinicians to proficiently distinguish between torus fractures and other wrist injuries, and could benefit from a system-wide check (ie, early radiological review of suspected torus fractures by a senior clinician). Any form of removable splint is acceptable, including backslab and prefabricated wrist splint, as the recovery and pain appear similar. Important guidance for parents and patients includes keeping the affected wrist immobilised for three weeks before removing the splint at home, giving simple analgesia as needed, and returning to the clinic if the child has any difficulties with pain or re-injury.

Recommendations for future research

Lack of evidence regarding the treatment of torus fractures is indicative of the quality of the evidence in children's trauma, which possibly reflects the difficulty of conducting research in this area. There are many common children's fractures for which notable uncertainties and variation in treatments exist nationally and internationally, which often relate to whether surgery should or should not be undertaken. A desire to address these uncertainties has prompted the development of a research agenda by the British Society for Children's Orthopaedic Surgery.[23] A collaboration of UK paediatric orthopaedic surgeons and emergency clinicians is now engaged in a series of high quality randomised controlled trials in this area—notably for the treatment of medial epicondyle fractures of the elbow (www.SCIENCEStudy.org) and severely displaced fractures of the distal radius in young children (<11 years) (www.CRAFFTStudy.org). This collaboration has become global—extending into the US, Canada, Australia, and New Zealand.

Future trials may investigate the optimal treatment of distal tibial growth plate injuries, and the management of "toddler fractures" of the tibia.

What patients need to know

- Torus (or buckle) fractures of the wrist bones are the most common fractures in children and typically result in pain that resolves within three weeks
- Evidence shows that most patients make a full recovery with no serious problems, including no evidence of repeat injury, when simple splints are used to "rest" the wrist
- Doctors are unsure if these fractures really need to be treated with a splint to "rest" the wrist, or if they are just as well treated more like a sprain with free movement from the outset. Research is ongoing to find the answer to this.

Education into practice

- What methods of immobilisation would you use in a child with a torus fracture?
- What is the local arrangement for follow-up of children with torus fractures?

How patients were involved in this article

Phoebe Gibson is a parent representative and co-author on the management group of the FORCE study and has co-produced this article with the clinical team.

Contributor statement: DCP drafted the initial version of the manuscript. PG, DR, and SM edited the manuscript. All authors approved the final version of the manuscript. DCP is the guarantor and corresponding author.

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1 Naranje SM, Erali RA, Warner WC, JrSawyer JR, Kelly DM. Epidemiology of pediatric fractures presenting to emergency departments in the United States. *J Pediatr Orthop* 2016;36:e45-8. doi: 10.1097/BPO.0000000000000595. pmid: 26177059

2 Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. *J Hand Surg Am* 2001;26:908-15. doi: 10.1053/jhsu.2001.26322. pmid: 11561245

3 Widnall J, Capstick T, Wijesekera M, Messahel S, Perry DC. Pain scores in torus fractures: Using text messages as an outcome collection tool. *Bone Jt Open* 2020;1:3-7. doi: 10.1302/2633-1462.12.BJO-2019-0002 pmid: 33215100

4 Davidson JS, Brown DJ, Barnes SN, Bruce CE. Simple treatment for torus fractures of the distal radius. *J Bone Joint Surg Br* 2001;83:1173-5. doi: 10.1302/0301-620X.83B8.0831173 pmid: 11764434

5 National Clinical Guideline Centre (UK). Fractures (non-complex): assessment and management (NG38). 2016. https://www.nice.org.uk/guidance/ng38

6 Abdelhady A, Ahmed A, Umana E, O'Donnell J. Management of paediatric buckle (torus) wrist fractures in Irish emergency departments: a national survey. *Ir Med J* 2018;111:793.pmid: 30520614

7 Ling SJ, Cleary AJ. Are unnecessary serial radiographs being ordered in children with distal radius buckle fractures?*Radiol Res Pract* 2018;2018:5143639. doi: 10.1155/2018/5143639. pmid: 29686900

8 Luther G, Miller PE, Mahan ST, Waters PM, Bae DS. Decreasing Resource Utilization Using Standardized Clinical Assessment and Management Plans (SCAMPs). *J Pediatr Orthop* 2019;39:169-74. doi: 10.1097/BPO.0000000000000873. pmid: 30839474

9 Williams BA, Alvarado CA, Montoya-Williams DC, Matthias RC, Blakemore LC. Buckling down on torus fractures: has evolving evidence affected practice?*J Child Orthop* 2018;12:123-8. doi: 10.1302/1863-2548.12.170122. pmid: 29707050

10 Children's Hospital Colorado. Clinical Pathway: Buckle Fracture. https://www.childrenscolorado.org/4adc96/globalassets/healthcare-professionals/clinical-pathways/fracture-buckle.pdf

11 Koelink E, Schuh S, Howard A, Stimec J, Barra L, Boutis K. Primary care physician follow-up of distal radius buckle fractures. *Pediatrics* 2016;137:e20152262. doi: 10.1542/peds.2015-2262 pmid: 26729537

12 Victorian Paediatric Orthopaedic Network. Clinical practice guidelines: distal radius and or ulna metaphyseal fractures—emergency department. https://www.rch.org.au/clinicalguide/guideline_index/fractures/Distal_radius_and_or_ulna_metaphyseal_fractures_Emergency_Department_setting/

13 Karimi Mobarakeh M, Nemati A, Noktesanj R, Fallahi A, Safari S. Application of removable wrist splint in the management of distal forearm torus fractures. *Trauma Mon* 2013;17:370-2. doi: 10.5812/traumamon.5094. pmid: 24350129

14 Oakley EA, Ooi KS, Barnett PLJ. A randomized controlled trial of 2 methods of immobilizing torus fractures of the distal forearm. *Pediatr Emerg Care* 2008;24:65-70. doi: 10.1097/PEC.0b013e318163db13. pmid: 18277840

15 Plint AC, Perry JJ, Correll R, Gaboury I, Lawton L. A randomized, controlled trial of removable splinting versus casting for wrist buckle fractures in children. *Pediatrics* 2006;117:691-7. doi: 10.1542/peds.2005-0801. pmid: 16510648

16 Pountos I, Clegg J, Siddiqui A. Diagnosis and treatment of greenstick and torus fractures of the distal radius in children: a prospective randomised single blind study. *J Child Orthop* 2010;4:321-6. doi: 10.1007/s11832-010-0269-3. pmid: 21804894

17 Williams KG, Smith G, Luhmann SJ, Mao J, Gunn JD, 3rdLuhmann JD. A randomized controlled trial of cast versus splint for distal radial buckle fracture: an evaluation of satisfaction, convenience, and preference. *Pediatr Emerg Care* 2013;29:555-9. doi: 10.1097/PEC.0b013e31828e56fb. pmid: 23603644

18 Jones S, Smith I, Jones M. Treatment of distal radius buckle fractures. In: *Poster Abstract 41*. 2001.

19 Kropman RHJ, Bemelman M, Segers MJM, Hammacher ER. Treatment of impacted greenstick forearm fractures in children using bandage or cast therapy: a prospective randomized trial. *J Trauma* 2010;68:425-8. doi: 10.1097/TA.0b013e3181a0e70e. pmid: 19935115

20 West S, Andrews J, Bebbington A, Ennis O, Alderman P. Buckle fractures of the distal radius are safely treated in a soft bandage: a randomized prospective trial of bandage versus plaster cast. *J Pediatr Orthop* 2005;25:322-5. doi: 10.1097/01.bpo.0000152909.16045.38. pmid: 15832147

21 Achten J, Knight R, Dutton SJ, etal. A multicentre prospective randomized equivalence trial of a soft bandage and immediate discharge versus current treatment with rigid immobilization for torus fractures of the distal radius in children: protocol for the Forearm Fracture Recovery in Children Evaluation (FORCE) trial. *Bone Jt Open* 2020;1:214-21. doi: 10.1302/2633-1462.16.BJO-2020-0014.R1. pmid: 33225292

22 Handoll HH, Elliott J, Iheozor-Ejiofor Z, Hunter J, Karantana A. Interventions for treating wrist fractures in children. *Cochrane Database Syst Rev* 2018;12:CD012470. doi: 10.1002/14651858.CD012470.pub2. pmid: 30566764

23 Perry DC, Wright JG, Cooke S, etal. A consensus exercise identifying priorities for research into clinical effectiveness among children's orthopaedic surgeons in the United Kingdom. *Bone Joint J* 2018;100-B:680-4. doi: 10.1302/0301-620X.100B5.BJJ-2018-0051. pmid: 29701090