■ ANNOTATION

# Displaced distal tibial Salter-Harris II fractures

## SHOULD WE BE OPERATING?

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**Salter-Harris II fractures of the distal tibia affect children frequently, and when they are displaced present a treatment dilemma. Treatment primarily aims to restore alignment and prevent premature physeal closure, as this can lead to angular deformity, limb length difference, or both. Current literature is of poor methodological quality and is contradictory as to whether conservative or surgical management is superior in avoiding complications and adverse outcomes. A state of clinical equipoise exists regarding whether displaced distal tibial Salter-Harris II fractures in children should be treated with surgery to achieve anatomical reduction, or whether cast treatment alone will lead to a satisfactory outcome. Systematic review and meta-analysis has concluded that high-quality prospective multicentre research is needed to answer this question. The Outcomes of Displaced Distal tibial fractures: Surgery Or Casts in KidS (ODD SOCKS) trial, funded by the National Institute for Health and Care Research, aims to provide this high-quality research in order to answer this question, which has been identified as a top-five research priority by the British Society for Children's Orthopaedic Surgery.**

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### Background

Fractures of the distal tibial physis are estimated to account for up to 40% of all physeal injuries in children.[1-3] The Salter-Harris II (SHII)[4] fracture is the most common type of physeal injury in the tibia, accounting for over 50% of distal tibial physeal injuries.[2,5] The mean age of these injuries is 12.5 years, and almost all occur in patients aged over eight years.[6]

The distal tibial physis contributes between 3 mm and 5 mm of length to the leg each year, accounting for up to 45% of tibial growth, and 20% of overall leg length.[6,7] If this physis is damaged by a fracture, then premature physeal closure (PPC), or growth arrest, may occur. The frequency of PPC is reported to be between 25% and 67%.[6–11] If the PPC is large or centrally positioned, it may prevent further growth uniformly across the physis, causing a difference in the leg length, without introducing an angular deformity. If a peripheral part of the physis is damaged, the PPC causes growth to cease in the damaged area of the physis, while growth continues in the undamaged area, leading to a progressive angular deformity.[2,5,8,12,13] The younger the child at the time of injury, the greater the magnitude of deformity at skeletal maturity. The consequences of PPC may be a permanent limb length difference (LLD), angulation of the distal tibial plafond, or both. These deformities may predispose to pain and arthritis in the medium to long term.[14]

### The controversy?

The treatment of SHII distal tibial fractures primarily aims to prevent the complications and adverse outcomes related to PPC. If completely undisplaced, treatment almost invariably involves immobilization of the limb in a cast. If the fracture is displaced, however, realignment of the fracture is often considered. Realignment typically involves manipulation under anaesthesia to restore anatomical alignment, with or without open reduction to clear interposing periosteum from the physis, and often with internal fixation to hold the reduction.

Proponents of surgery argue that restoring anatomical alignment realigns the physis, thereby reducing the frequency of PPC and maximizing the opportunity for normal growth. Opponents argue that the procedure is a secondary physeal injury, with no difference in the rate of PPC, and that the risks of surgery and the need for additional unplanned procedures outweigh any potential benefit.

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## What is the evidence?

One of the most influential studies was published in 2003,[7] which popularized the concept that a 'residual gap' after reduction heightened the risk of PPC. This study identified six SHI and 45 SHII distal tibial injuries from a cohort of 92 distal tibial physeal injuries, of which follow-up was available in 44 injuries. Among these fractures, 20 had a fracture gap > 3 mm on either the AP or lateral radiographs. In total, 16 developed PPC (36%). Of those with a gap > 3 mm, 60% developed PPC, whereas PPC was present in only 17% without a gap. The authors concluded that displacement after reduction of 3 mm or more, and/or the presence of a physeal gap, was associated with a 3.5-fold increase in PPC. They also suggested that initial displacement, or intervention (i.e. surgical procedure), was not an important factor in predicting PPC.

Other studies, however, have suggested that the rate of PPC may depend upon a range of factors, including initial displacement, residual displacement, mechanism of injury, energy of injury, number of reduction attempts, open reduction and internal fixation (ORIF), and nonoperative management. These studies have propagated the controversies in the management of these injuries, but so far no consensus has emerged that reliably guides the management of these injuries.[3,5,6,8,9,15]

A 2018 systematic review and meta-analysis of six retrospective studies suggested no difference in the rate of PPC between ORIF and closed management of these fractures.[2] In fact, in the subgroup analysis of SHI and II type fractures, children managed with ORIF had a higher rate of PPC, although this did not reach statistical significance. However, the six eligible studies were all level III/IV evidence. The review concluded that nonoperative management may avoid the risks associated with surgery and would not lead to an increased risk of PPC. However, in 2021, a further systematic review and meta-analysis arrived at the opposite conclusions.[16] This review analyzed 12 articles and identified a subgroup of 552 SHII injuries with more than 2 mm of displacement, and the authors suggested that more than 2 mm of residual displacement was associated with a higher risk of PPC. Both reviews commented on the poor methodological quality of studies in this area along with short follow-up and called for carefully designed randomized controlled trials (RCTs) to answer the question.

## A call to action

While surgical reduction and fixation is likely to improve radiological alignment, it does not necessarily follow that performing this surgery improves outcomes for patients. The occurrence of PPC may, or may not, have a clinically relevant consequence. Most distal tibial SHII fractures occur in adolescents within a few years of skeletal maturity and therefore even if radiological PPC, angular deformity and/or LLD do occur, they may have little or no impact on short-, medium-, and long-term outcomes. In contrast, a subset of children with SHII distal tibial fractures may benefit from early appropriate surgical intervention that reduces the potential short-, medium-, and long-term complications that can be associated with PPC.

If surgical intervention is not better than cast treatment, then nonoperative treatment of SHII distal tibial fractures would be more appropriate. This would avoid unnecessary surgery, reduce the burden on inpatient resources, operating theatre capacity, and reduce the complications associated with surgery. However, if surgical intervention is superior, children who may have developed PPC with nonoperative treatment would minimize the complications of deformity.

This ongoing uncertainty among children's orthopaedic surgeons regarding the optimal approach to treatment of these injuries has resulted in members of the British Society of Children's Orthopaedic Surgery (BSCOS) and the Orthopaedic Trauma Society (OTS) jointly prioritizing this question as one of their top five most important trauma research priorities in children.[17] This resulted in the National Institute for Health and Care Research (NIHR) commissioning a RCT to address this question.

## The ODD SOCKS trial

The Outcomes of Displaced Distal tibial fractures: Surgery Or Casts in KidS (ODD SOCKS) trial is a multicentre prospective randomized superiority trial of conservative versus surgical treatment (with or without fixation) for displaced distal tibial fractures in children. ODD SOCKS will randomize all displaced SHII distal tibial fractures (with or without a fibula fracture) in children aged eight to 15 years, where the treating clinician believes the child may benefit from surgical reduction (with or without fixation). If an emergency reduction is required to realign the limb for neurovascular/soft-tissue reasons, it will be possible to randomize the patient if they meet the above inclusion criteria after this initial reduction attempt. Patients will be excluded if the injury is more than a week old, or an absolute indication for surgery exists (open fracture or displaced intra-articular fracture that requires fixation).

Patients will be randomized to either anatomical reduction (with or without fixation) or to cast immobilization. In order to ensure that the randomized groups are balanced, participants will be stratified by hospital, age group (8 to 12 years, 13 to 15 years), and severity of deformity to ensure that there is balance between the groups.

Patient and parent groups have been integral to the conception and design of the study, and have informed the outcomes measured; we have integrated the paediatric fracture core outcome set.[18] The primary outcome for the trial is the Patient Reported Outcomes Measurement Information System Mobility Score for Children (PROMIS Mobility) at two years.[19] This validated outcome score will allow us to understand the functional relevance for patients of the two treatments.

The trial will use electronic data collection, with follow-up at six weeks, three months, six months, one year, and two years. Secondary outcomes will include PPC, angular deformity, LLD, need for further surgery, patient satisfaction, complications, cost-effectiveness, pain (Wong-Baker Faces Pain Rating Scale),[20,21] and a quality of life score (EuroQol five-dimension youth score).[22] Health economics analysis will be used to compare the cost-effectiveness of each treatment.

Any complications will be recorded, including the need for further interventions in either group, such as surgery to correct deformity or remove metalwork. Radiographs performed as part of routine practice will be collected, as will ankle radiographs

at two years post-injury. These images will be assessed by independent reviewers to measure the anterior distal tibial angle and the lateral distal tibial angle,[23] and to identify evidence of PPC. Leg length difference will be measured clinically according to a standardized protocol, to detect any clinically significant leg length discrepancy.

A total of 192 patients will be required to detect a difference between the two groups. Recruitment will start in 2023 and the research group will report the outcomes of the trial in 2028. We look forward to starting the NIHR ODD SOCKS trial, and encourage all children's orthopaedic surgeons to participate in this study to resolve the research priority highlighted by BSCOS and the OTS.

## Take home message

- The current evidence base for the management of displaced Salter-Harris II fractures of the distal tibia is of poor methodological quality and comes to contradictory conclusions.
- A position of clinical equipoise exists as to the best management for these injuries, and this has been identified as a research priority by the British Society of Children's Orthopaedic Surgery.
- The ODD SOCKS trial is a multicentre prospective randomized superiority trial of conservative versus surgical treatment that aims to answer the question by identifying which treatment produces the best outcomes for patients.

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