

seven patients required further surgery to treat postoperative complications. The group found that ten months after fixator removal, both the Association for the Study and Application of the Method of Ilizarov (ASAMI) bone score and ASAMI function score were excellent and good in 80% and 20% of cases, respectively. These results are similar to those expected from traditional bone transport for infection or other diagnoses. The authors conclude that despite well founded theoretical reservations, these did not translate into clinical practice. Undertaking bone transport using the Ilizarov method can achieve good outcomes following limb salvage in patients treated for osteosarcoma with neoadjuvant chemotherapy, provided that complications

are recognized early and are managed confidently and precisely.

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Children's orthopaedics

X-ref For other Roundups in this issue that cross-reference with *Children's orthopaedics* see: *Oncology Roundups 4 & 5*.

The Dunn procedure in SCFE

■ The modified Dunn procedure has been utilized for many years to restore the anatomy of hips with severe slipped capital femoral epiphysis (SCFE). The progression of SCFE can lead to a severe deformity, which in turn can lead to femoroacetabular impingement and early osteoarthritis. The logic behind the application of the modified Dunn procedure is the desire to correct the anatomy to ameliorate this risk. This, of course, somewhat simplifies the decision making where the main operative risk is of avascular necrosis (AVN) due to interruption of the blood supply to the femoral head at the time of surgical correction. From a population perspective, the longer-term outcomes are a balance in the increased risks of AVN due to operative intervention and the increased risk of osteoarthritis from femoroacetabular impingement if malunion occurs. There has been increased interest in the Dunn osteotomy in recent years as the link between impingement and osteoarthritis has become more firmly established. While previous series from this group from **Bern (Switzerland)** have included all slip angles, the current paper examines exclusively the unit's experience of severe slips with a slip angle greater than 60°.¹ The review is retrospective, but the unit's entire experience of 131 hips treated with a modified Dunn procedure from 1999 to 2016 was reviewed and 46 hips with a severe slip angle were included. At nine-year follow-up, 40 hips

were available for clinical and radiological review. In terms of the development of osteoarthritis, one hip showed progression, and the group had a mean Hip Disability and Osteoarthritis Outcome Score of 91 points. However, the follow-up here is relatively short as these patients are now only in their third decade. Functional hip scores were high, with a mean Harris Hip Score of 94 points. Importantly, two patients developed AVN and underwent further surgery, but the authors do state that these patients both had acute-on-chronic slips and were unstable intraoperatively, even if considered stable by the Loder classification. Three patients underwent revision due to breakage of screws or change of wires. Overall, the cumulative survival was 86% at ten-year follow-up. This series does seem to support recent changes in practice towards operative intervention. Based on these results, in expert hands and in a unit with large experience, this seems a reliable option to normalize the anatomy in what is a difficult problem to treat. The occurrence of AVN is still a concern and MRI was not used to detect this here, so only disease visible on plain film was included in the results. However, this may be clinically appropriate, especially given the relatively long follow-up interval for which any AVN-related collapse could be expected to be seen. We look forward to longer-term results from this series, particularly with respect to osteoarthritic disease.

What is the cartilage pressure in the Pavlik harness?

■ Pavlik harness treatment is perhaps the most commonly employed means of treating

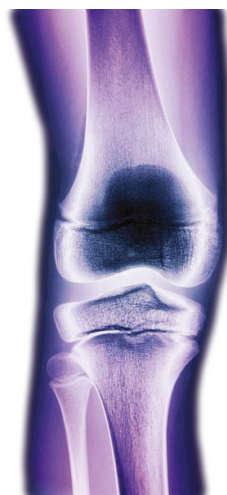
developmental dysplasia of the hip (DDH), but our understanding of the changes we are introducing to the native hip environment is limited. The Pavlik harness works to constrain the hip joint, thereby reducing the eventual instability and promoting normal development. The downside to this approach is the risk that increased cartilage contact pressures may impede nutrition to the cartilage, or that the pressure may directly damage the ossific nucleus or cartilage. In this study from **Edmonton (Canada)**, the authors utilized finite element modelling of normal and dysplastic hips in a Pavlik harness to look at the internal loading environment of the hip in terms of cartilage contact pressures (CCP).² In most clinical cases, our ignorance of these pressures is perhaps not relevant; however, in difficult hips, or in those patients who develop avascular necrosis, it is instructive to consider what the contact pressures might be when there are a range of treatment options available. This group therefore developed a finite element model of CCPs in cartilaginous infant hips subjected to Pavlik harness treatment. Normal and dysplastic hips in a Pavlik harness at 90° flexion and gravity-induced abduction angles of 40°, 60°, and 80° were modelled. In the harness, the contact pressures were found to be distributed in a horseshoe shape along the anterior and posterior margins of the acetabulum, leaving the roof relatively lightly loaded in the normal hip model, but unloaded in the dysplastic hip; it is these pressures that are thought most likely to stimulate the remodelling process. At 40° of abduction in the dysplastic hip, the model predicted equilibrium in a dislocated position, which is

not unexpected as adductor pull can clinically prevent abduction into the safe zone. At 80° of abduction, the lateral aspect of the femoral head also contacted the posterior acetabular edge, thereby potentially jeopardizing blood flow into the femoral head and predisposing to avascular necrosis. Contact pressures overall increased with increased abduction, which is again unsurprising due to the increased muscle tensions. Overall, we agree with the authors that it would be interesting to see the results when this model is applied to difficult hips, and the added information may be of use in developing individualized treatment plans in future.

Ten-year outcomes of selective fusions for adolescent idiopathic scoliosis X-ref

■ There is a paucity of outcome data on selective fusions for adolescent idiopathic scoliosis (AIS) in the literature, for many reasons. These patients are young, which makes them geographically mobile, and fusion techniques have rapidly evolved such that techniques of ten years ago are different to those employed today. We were interested to see this study from **San Diego, California (USA)**, which, to our knowledge, is the first to provide prospective cohort data with a minimum ten-year follow-up of selective fusions for adolescent idiopathic scoliosis.³ This type of fusion strategy is designed to correct the driver of the scoliosis, while preserving as much mobility as possible, for a patient who is expected to live many decades. The strategy seeks to provide a potentially smaller operation with hopefully successful results. Previous studies have shown a gradual partial correction of the noninstrumented 'compensatory' curve over time when compared with the initial postoperative radiograph, but, given the lack of outcome data, judging the appropriate intervention is as much an art as a science. These authors take advantage of their prospectively collected database to conduct a retrospective review of prospectively collected data surrounding selective fusions of the main thoracic or thoracolumbar/lumbar curves. In particular, the authors noted the outcomes of the compensatory curve, which was not in itself instrumented. The results of this series are based on 51 patients, all reported with a minimum ten-year follow-up. The patients had 21 thoracic and 30 thoracolumbar or lumbar curves. At ten years, these curves were corrected by a mean of 51% and 60%, respectively. Impressively, the compensatory curves had a progressive correction to the magnitude of the correction of the instrumented curve at five years, and this was maintained at ten years. The authors report that three patients had deterioration of primary curve correction postoperatively; however,

none experienced deterioration to the pre-surgery level and none required reoperation in the study period. Following these patients is a challenge and this paper had a loss to follow-up of 83%, with 295 cases reported in the original cohort. This somewhat compromises the conclusions and limits inferences that can be drawn. However, this paper does represent the best evidence currently available. It seems likely that the investment required for more thorough follow-up is unlikely to be easily forthcoming, due to the rapid improvements in techniques, which preclude comparisons with older cohorts. We do, however, commend the authors on their efforts and would be interested to see the durability of these results at longer follow-up. Selective fusion, it appears, is a worthwhile undertaking.



'Next day' examination and paediatric spinal clearance X-ref

■ Spinal clearance following trauma in the child is a challenging task, with an immature skeleton, often poor examination compliance, and the occurrence of significant injury without radiological abnormality all contributing to the difficulty level. CT has obviated many of the practical difficulties of plain-film imaging and has also increased sensitivity, but at the cost of irradiation to vulnerable areas such as the thyroid. In children, we are especially aware of these risks and attempt to reduce radiation exposure in the immature skeleton at all costs. This team from **Philadelphia, Pennsylvania (USA)** present their results from a completely different approach.⁴ Their novel and evolving protocol relied on stable patients being admitted to the hospital for 'next day' repeated clinical examination (or within 24 hours) rather than advanced imaging. The authors report a longitudinal cohort treated during the introduction

of this protocol. This retrospective review includes the results of 762 patients treated over a four-year period between 2011 and 2014. During this time, there were three protocols in use. The 2011 protocol included the outcomes of 259 patients, the 2012 protocol included the outcomes of 330 patients, and the 2014 protocol included the outcomes of 143 patients. The 2011 protocol was the more traditional use of imaging as the emergency department saw fit, the 2012 version discouraged CT and instituted repeated examination after a period to allow symptoms to settle, and the 2014 protocol recommended the spinal surgeons should make the decision as to whether CT is indicated. During the period of study, the CT use went from 90% in 2011 to 42% in 2012, and dropped further to 28.7% in 2014. There were no complications reported that the authors attributed to waiting for spinal clearance, but, inevitably, there was an increase in time to collar removal after these protocols were introduced. Length of stay was unaffected; patients with a significant trauma history in this age group are likely often admitted for observation even in the absence of other injuries. While collars can be responsible for pressure sores, and although serial examination necessitates remaining in hospital – with the potential detriment to both the patient and the hospital that this incurs – this relatively minor inconvenience allows a safe reduction in the ionizing radiation exposure, which must surely be significantly safer for the patient. The sample size is relatively small, but this paper suggests that the avoidance of CT and repeated expert clinical examination is a safe way of reducing radiation exposure in this group.

Minimally displaced humeral lateral condyle fractures X-ref

■ Treating minimally displaced lateral condyle fractures remains a source of controversy. Not only is the degree of displacement that mandates surgical intervention a frequent point for discussion, but the assessment of such fractures is also compromised by the radiolucency of the articular cartilage. Either an MRI scan or an arthrogram is required for definitive diagnosis of the integrity of the medial hinge, which is thought to be an important discriminator when assessing stability. As a proxy, the Song classification was developed, which includes descriptions of five stages. Stage 1 has a lateral cortex fracture that is not seen to propagate. In stage 2, this fracture propagates towards the joint but narrows progressively, suggesting that the hinge itself may be intact. In stage 3, the fracture line does not narrow, implying hinge disruption; in stages 4 and 5, they are frankly displaced. This

paper from **Dallas, Texas (USA)** focuses on the management of type 2 fractures where the hinge is likely intact and therefore conservative management may be acceptable.⁵ The authors report 738 paediatric lateral epicondyle fractures that were retrospectively reviewed and assigned a Song classification. Of these, there were 139 Song stage 2 fractures over a six-year period, with a mean age of 4.6 years, that formed the study cohort. These patients underwent either cast treatment only, Kirschner wire fixation *in situ*, or reduction and percutaneous pinning after failed cast treatment. Failure was defined as an increasing Song score. Of the 114 patients who underwent initial cast treatment only, 20 displaced and required surgery. These patients were all detected in the first two weeks following injury at a mean of 6.5 days; 82% of patients were successfully managed in cast. With regards to the 25 patients who had a prophylactic pinning as their initial treatment, in addition to the initial surgery, these patients required on average one more x-ray and one more clinic visit than those treated in cast. However, these patients experienced no more complications and no significant difference in maximum fracture displacement. One of the prophylactic pinning patients (4%) required open reduction, compared with 18% who went on to displace in the initially casted group. This paper is hampered by its retrospective nature and the inherent potential bias of a nonrandomized comparison study, but it does show that treating lateral condyle fractures conservatively is acceptable, as long as imaging in the first two weeks does not demonstrate any displacement. It seems that until there is a randomized trial on this subject, the appropriate initial management remains conservative, and pinning should be reserved for those fractures where initial displacement has occurred.

Pemberton osteotomy versus San Diego acetabuloplasty in DDH

■ Developmental dysplasia of the hip (DDH) in older children often necessitates surgery to improve femoral head coverage, and a pelvic osteotomy with or without femoral intervention is usually required past infancy. Two widely used surgical options in this position are the Pemberton osteotomy and the modified San Diego acetabuloplasty. The San Diego acetabuloplasty is a predominantly lateral acetabuloplasty that involves an incomplete osteotomy superior to the acetabulum, through which the pelvis is opened to 'close down' the acetabulum. The Pemberton osteotomy, by contrast, is a complete osteotomy that aims to achieve the same thing but has a mostly lateral and anterior coverage. This paper from **San Diego, California**

(USA) takes the opportunity to compare these two interventions.⁶ The Pemberton osteotomy relies on an open triradiate cartilage and an iliac osteotomy to alter orientation and coverage. The San Diego acetabuloplasty was originally aimed at acetabular deficiency in neuromuscular patients. The pathology in neuromuscular cases is more frequently a posterosuperior or direct lateral deficiency, in contrast to the anterolateral deficiency of DDH. The San Diego acetabuloplasty uses a cut through the sciatic notch and anterior inferior iliac spine, with the medial cortex of the ileum undisrupted and the acetabulum then hinged on the triradiate cartilage. Being from the originating centre of the San Diego acetabuloplasty, the authors state that they find the latter technique easier to conceptualize and teach. However, the authors did undertake a mixture of these two techniques in their centre on 390 hips over a nine-year period. For the purposes of this paper, they screened all cases undertaken up to 2015 for idiopathic DDH, with more than two years' follow-up and no missing data, resulting in a final cohort of 83 hips operated in 59 patients. There were 45 hips in the modified San Diego group and 38 hips in the Pemberton group, and the mean follow-up was 4.9 years. Overall, 78% of San Diego hips and 94% of Pemberton hips had good or excellent modified McKay criteria outcomes; 100% and 97%, respectively, were good or excellent on the Severin scale. Acetabular index was decreased by approximately 15° in both methods, with no significant difference in any of these outcomes between the two groups. No San Diego hips and one Pemberton hip had avascular necrosis grade II or higher on the Kalamchi and MacEwen criteria. Overall, the results of both techniques seem good, but, as the authors point out, the San Diego technique may be more versatile for addressing a variety of directions of acetabular deficiencies, and these do often occur in idiopathic DDH rather than just neuromuscular aetiologies. Firm conclusions are limited, as the final sample sizes were small, the approach was retrospective, and this is a designer centre.

Surgical release of post-traumatic elbow contracture X-ref

■ Post-traumatic elbow stiffness can be challenging to treat, regardless of the age of the patient. In this world of smartphones and computer games, our classic understanding of what constitutes functional range of movement may not be as well tolerated, as many common activities may require more elbow supination and flexion (perhaps as much as 142°) than previously necessary. This paper from **St Louis, Missouri (USA)** and **San Francisco, California (USA)** therefore set out to examine a

cohort of patients who were under the age of 21 years and who underwent an open surgical release following post-traumatic stiffness, over a seven-year period.⁷ Between the two centres, the authors were able to identify 26 patients, with a mean age at time of injury of 12 years (5 to 19). The majority of patients had originally suffered radial head/neck fractures, fractures of the proximal ulnar, or fractures of the distal humerus. There were six patients with fracture dislocations. The mean age at time of surgery was 14 years (7 to 20), and the operative techniques described are open release of the anterior and/or posterior joints with sharp dissection of capsule, removal of heterotopic ossification, and osteoplasties of the joint surfaces as required (e.g. olecranon fossa). This represents a similar approach to that commonly undertaken in the adult patient. If instability was noted intraoperatively, the medial and/or lateral collateral ligaments were reconstructed. Pleasingly, a mean increase of flexion/extension of 49° and 70° supination/pronation was achieved, which functionally represents an excellent outcome. Follow-up in this cohort was to a mean of 42 months. The authors demonstrated a maintenance of 85% of intraoperatively gained range of movement, which seems to represent a worthwhile endeavour and a good result. Those patients who had previously received surgery gained range and maintained it, albeit to a smaller magnitude compared with those who had not had previous surgery, likely denoting the severity of injury and the presence of previous surgical scarring. Those patients who required an intraoperative ligament repair, or who used a continuous passive motion (CPM) machine postoperatively, did not significantly change their outcomes. Overall, this is a catch-all bundle of patients and pathologies, but, given the good results, we should probably not be reticent about performing open releases in this age group if the functional deficit is significant, and postoperative CPM is probably not required.

Congenital talipes equinovarus relapse and Ponseti method

■ The Ponseti method for correction of clubfoot deformity is, without doubt, the current benchmark treatment in modern-day practice. While initial results are reported almost universally as very good, the late-relapse rate is less well studied in the literature. It is known that the Ponseti method is not entirely successful, even in idiopathic clubfoot. However, the evidence to support informed practice, particularly with regards to the incidence of – and risk factors for – recurrence is somewhat limited. One of the chief obstructions in the way of

establishing the success of the Ponseti method in terms of relapse is the variability of the threshold for diagnosis and the classification of a relapse in the reported literature. This variation makes assessment of actual long-term results and comparison between studies quite difficult. In order to assess the magnitude of the problem and to assimilate reported relapse rates, this systematic review from **London (UK)** examined relapse as a primary outcome measure of the Ponseti method.⁸ Studies reporting outcomes for idiopathic clubfoot published between 2012 and 2017 were included in the initial literature search. The authors identified 84 studies reporting the outcomes of over 7000 patients and 10 000 clubfeet, and based their conclusions on review of these results. Reported relapse rates varied widely between 1.9% and 45%. Only 57% of the studies reported here included a definition or criteria for relapse, with the Pirani score the most commonly used method. In all, 45% of the papers included data on further surgical procedures with a tibialis anterior transfer rate

of between 0.6% and 48.8%. More invasive techniques, such as posteromedial or posterolateral release, ranged from 1.4% to 53.3%. Clinical assessment and scoring of the corrected and relapsed foot was poorly recorded and defined, and, as the authors point out, where inconsistencies with the definition exist, it is difficult to compare outcomes between studies. The authors therefore sensibly suggest that a consensus definition of relapse is required, and hopefully this will be forthcoming. Ideally, this would be applicable as a tool or score to use at every point throughout the treatment course.

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Research

X-ref For other Roundups in this issue that cross-reference with Research see: *Spine Roundup 2*.

Machine learning in osteosarcoma histology X-ref

■ Here at 360, we were delighted to see this study from **Dallas, Texas (USA)** on innovative uses of modern computer analysis for medical diagnosis.¹ The use of machine learning and artificial intelligence (AI) is growing in medicine, particularly in diagnostics, where reproducible patterns and correlations make it an ideal environment for machines to take on data analysis. In this article, the group explore the potential scope of AI in the estimation of tumour necrosis after chemotherapy in osteosarcoma. The authors digitized 40 whole slide images that represented a range of osteosarcoma cells following chemotherapy. In all, 13 machine learning tools and a single deep learning architecture were taught to divide the digitized images into viable tumour, necrotic tumour, and nontumour cells, and the best performing was analyzed using receiver operating characteristics for discrimination of necrotic from viable tissue and tumour from nontumour cells. This paper shows that machine learning tools perform very well, and that the outputs in real, whole slide images are a clinically useful tumour prediction map. This study

reports the first fully automated tool to assess viable and necrotic tumour in osteosarcoma, employing advances in histopathology digitization and automated learning, and paves the way for the use of machine learning tools in other types of tumour diagnosis.

Gene therapy for osteosarcoma: is TP53 a potential candidate?

■ Targeted therapy is one of the promising avenues pursued by oncologists in treating orthopaedic and other tumours. Although there has been some success in the field and there are viable viral vectors, the success of treatment depends to a large extent on the suitability of the candidate gene, as well as the level of transformation. This study from **Los Angeles, California (USA)** reports on the output of a meta-analysis evaluating the clinical relevance of mutant TP53 tumour suppressor gene in patients diagnosed with osteosarcoma, as well as an *in vitro* study of the therapeutic effect of targeting mutant TP53 utilizing CRISPR-Cas9 technology and the TP53 inhibitor N5C59984.² The authors report on a meta-analysis of the nine studies they identified through their literature search. The review was undertaken to synthesize all the data available and to establish the relationship between mutant TP53 and the overall survival of patients

with osteosarcoma. The output and analysis presented in this review demonstrated that mutations in TP53 predicted poor two-year survival in patients diagnosed with osteosarcoma, and that CRISPR-Cas9 effectively inhibited the consequent mutated protein with subsequent positive results in decreasing proliferation, migration, and tumour formation activity and increasing susceptibility to doxorubicin. The p53 activator NSC59984 showed similar effects. The team go on to show that knocking out the mutant TP53 decreased the expression of the oncogenes, antiapoptotic proteins, and survivin (an inhibitor of apoptosis protein) in osteosarcoma cells. The authors conclude from their review and collected data that targeting TP53 may improve treatment outcomes in osteosarcoma patients.

Anticoagulation and venous thromboembolism X-ref

■ It is now standard practice among surgeons carrying out lower limb arthroplasty to offer chemical thromboprophylaxis postoperatively. Since the recommendations made by the National Institute for Health and Care Excellence (NICE), the debate about appropriate drugs, and the duration of their use, has raged. This article from **Philadelphia, Pennsylvania (USA)** sought to test the hypothesis that low-molecular-weight