

function and growth in young children following excision of the proximal humerus for a malignant bone tumour. Although function is favourable when compared with other limb-salvage procedures in children, here at 360, we agree with the authors' conclusion that longer-term analysis is required to determine if this technique proves to be durable into adulthood.

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Children's orthopaedics

X-ref For other Roundups in this issue that cross-reference with *Children's orthopaedics* see: *Wrist & Hand Roundup 6*.

Screening for the limping child: can labs help?

■ Paediatric bone and joint sepsis remains a challenging area for orthopaedic surgeons, and clinical examination is often difficult to perform. The decision to operate must respect the need to avoid the morbidity of over-intervention, and must consider the catastrophic consequences of a missed diagnosis. Kocher's criteria, although now old, are still used in many institutions. Kocher proposed a system based on temperature, weight-bearing status, white cell count, and erythrocyte sedimentation rate (ESR). There have been recent modifications including the now more common C-reactive protein (CRP). This paper from **Peterborough (UK)** postulated that, in the presence of a 'limping child', an ESR or CRP greater than ten was suggestive of a higher rate of pathology and, therefore, the authors' protocol was only to undertake an MRI of the affected limb in these patients.¹ Their paper reports the outcomes of 100 consecutive children recruited between 2010 and 2015 who had been investigated using this protocol. They used a limited MRI protocol scan to screen the limbs of the children for whom

it was hard to localize the symptoms to a specific joint. In those patients found to have a normal limb scanogram, a spinal MRI was then performed. Children under seven years old required a general anaesthetic for their MRI scan. In this reassuringly useful study, an extremely high rate of pathology was identified in these patients, with 75% having a positive scan: 64% had an infective cause (including osteomyelitis, septic arthritis, cellulitis, myositis, and discitis); and 11% had a non-infective cause (including juvenile idiopathic arthritis, cancer, or undisplaced fracture). The remaining 25% had either transient synovitis (13%) or no positive findings. ESR was found to be a more sensitive marker of infection than CRP, with ESR being raised in 97% of cases compared with 70% for CRP. For this reason, the authors suggest including ESR in the battery of initial tests rather than allowing CRP to replace it. Given the high rate of positive MRI scans and the variety of pathologies identified immediately, the authors suggest that all children with a limp or limb pseudoparalysis and an ESR > 10 or CRP > 10 should undergo MRI scanning. There is, of course, concern about the availability of MRI scanning and the need for general anaesthetic for scans in younger children. The authors do not comment about availability nor timing of scans but, here at 360, we

would take the view that acute MRI should be available in all centres treating these patients. Regarding anaesthesia, a feed and swathe may be adequate in very young babies, but, in children up to five years old, the potential risk of neurodevelopmental disorders from anaesthesia must be weighed against the risks of a missed diagnosis by clinicians. Further studies replicating these findings would be useful, but the thresholds published here seem sensible based on this evidence.

The paediatric ACL injury

■ Anterior cruciate ligament (ACL) rupture in the skeletally immature population is increasing in prevalence. Whether this is related to increased access to imaging techniques or an increased level of sports participation is unknown. The optimal management is unclear but, in those favouring early reconstruction, there is a debate about the best technique to employ. The transphyseal reconstruction, as routinely used in the adult population, risks growth inhibition through physeal damage or a tethering effect of the graft. Extraphyseal reconstructions have been popularized to reduce this risk, but they are more technically challenging and can result in a non-anatomical position of the graft. This systematic review from **Oxford (UK)** looks specifically at the long-term outcomes of

ACL reconstruction in the skeletally immature population.² While not common, these injuries are relevant to paediatric surgeons and knee surgeons with soft-tissue practices. The authors identified 18 articles that fit the inclusion criteria of skeletal immaturity, sufficient follow-up (over five years or to skeletal maturity), and patient-reported outcome measures (PROMs) at final follow-up. The mean age at surgery reported in these papers ranged from 10.3 to 15 years, and mean follow-up was from three to 13 years. Two papers detailed conservative treatments, four detailed extraphyseal or hybrid reconstruction, and 12 detailed transphyseal surgical reconstruction. They found that PROMs were significantly better in the operative group than in the conservatively managed groups, although it should be borne in mind that immobilization and rehabilitation regimens have improved in the last decade, and that current conservatively treated patients may possibly have better outcomes. Good long-term results were found in the operative groups that were deemed to have significant growth potential, with no significant difference in leg length, as well as low reported rates of re-rupture (3%) and instability (0.7%). Furthermore, there was no difference found between the reported outcome scores, leg-length discrepancy, coronal plane deformity, and re-rupture

rate in the transphyseal *versus* extra-physeal groups, which indicates that, based on current evidence, either technique is appropriate. This review is, of course, limited by the quality of the literature available. There are no large randomized trials at present comparing transphyseal and extra-physeal reconstructions, and therefore a gap exists in this area.

Which method is best to predict leg-length discrepancy?

■ Leg-length discrepancy may result from a variety of congenital or acquired causes. Epiphysiodesis is the most common surgical method of treating moderate length discrepancies in children. Critical to success is the timing of the procedure, which is based on an estimation of discrepancy at maturity, for which four main methods of calculation exist. These include the arithmetic method proposed by White and Stubbins (and modified by Menelaus and Westh), the growth-remaining graphs of the distal end of the femur and proximal end of the tibia described by Anderson et al, the straight-line graph method proposed by Moseley (and modified by Beumer et al), and the multiplier method described by Paley et al. This group from **Dallas, Texas (USA)** have performed a neat study to see which of these methods works best.³ The study group included 77 patients, all with preoperative radiographs, no reported postoperative complications, and available follow-up to skeletal maturity. The predicted lengths of both legs and residual leg-length discrepancy at maturity were compared with actual outcomes using the White–Menelaus, Anderson–Green, Moseley, and multiplier methods. All methods rely on the presumed accuracy of three variables: a consistent rate of growth in the shorter extremity, the difference between chronological and skeletal age, and the vagaries of estimating skeletal age. Both the skeletal and chronological ages were therefore compared, and 25% of the



study groups' skeletal age varied from the chronological age by more than one year, making skeletal age the best predictor. Error in prediction of the length of the short leg varied from a mean of 1.8 cm (SD 1.2) for the straight-line graph to 2.5 cm (SD 2.0) for the multiplier method. Prediction error for the long leg (after epiphysiodesis) varied from a mean of 1.2 cm (SD 1.1) for the straight-line graph to 1.7 cm (SD 1.5) for the multiplier method. The multiplier method was the least accurate prediction method; this effect was statistically significant. The other three methods were all comparable. The authors therefore prefer to use the White–Menelaus method, as it is accurate and offers the advantage of simplicity of calculation, without the need for consecutive radiographs to construct graphs or consult growth charts.

Complications and epiphysiodesis

■ Following on from their article on the best predictive method for the timing of epiphysiodesis, this paper from the same institution in **Dallas, Texas (USA)** examines the complication profile of epiphysiodesis.⁴ Asymmetrical leg length is a common issue found in the paediatric clinic. Treatment in the skeletally immature population is far simpler than shortening or lengthening osteotomies in the mature patient, hence the attraction of epiphysiodesis as an option. Both surgeons and families should be aware of the nature and

rate of complications associated with epiphysiodesis. For moderate discrepancies of 2 cm to 5 cm, an appropriately timed epiphysiodesis is a procedure with relatively little morbidity. This paper reviewed a large number of patients in order to quantify the risks and to facilitate parental counselling. Almost 900 patients, who had undergone epiphysiodesis via a variety of methods over a 31-year period, were included in this retrospective study. Patients instrumented with staples, screws, or plates were excluded as there were only five cases, with the preference in this institution being for traditional Phemister, open curettage, or percutaneous methods. Surgeries undertaken with the aim of angular deformity correction were also excluded. There was a relatively low overall complication rate, with a complication reported in 7% of cases; 37 patients (4.3%) developed physeal growth-related complications, including six patients who developed overcorrection of leg-length inequality, and 31 patients who developed angular deformity and/or continued growth of the physis. Of these 31 patients, 15 had re-exploration of the epiphysiodesis site, six underwent corrective osteotomy, and ten received no treatment. General perioperative complications occurred in 2.7% and included laryngospasm (0.1%), neuropathy (0.8%), and knee stiffness (1.6%). Risk factors for angular deformity included underlying congenital aetiology, larger leg size, and younger age. In this very large series, epiphysiodesis can be seen to be a relatively safe and effective procedure for the correction of leg-length inequality, and will obviously remain a mainstay of treatment. The rate of complications in this study was low (7.0%), with the most prevalent complication being the development of angular deformity. This study is obviously limited by the exclusion of instrumented open procedures, which are not uncommonly employed in current practice. However, this study provides a useful

tool for counselling patients prior to this procedure, and highlights the relative safety of this procedure when compared with limb-lengthening surgeries.

Booster seat use and paediatric road traffic collision injuries X-ref

■ Motor vehicle crashes are a significant cause of paediatric mortality and morbidity. Booster seats significantly improve seatbelt fit for children under the height of 145 cm, and this interesting study sought to identify variations in injuries where different types of restraints were used. Building on existing knowledge, the authors from **Flint, Michigan (USA)** performed a retrospective review of frontal impact crashes over an eight-year time period, using a publicly available statistical sample of crashes from a database that records 5000 collisions per year.⁵ Most children do not attain a height of 145 cm until they are 12 years old; in this study, children aged between five and 12 years who were involved in this sample of car crashes were stratified into three groups: unrestrained; restrained using the vehicle's lap and shoulder seatbelt; and restrained using a booster seat with the vehicle's lap and shoulder seatbelt. The actual height of the children was not known. Abbreviated injury scores (AIS) and injury patterns were examined. As expected, the unrestrained children fared the worst, experiencing moderate to severe injuries up to 19 times more frequently than children who used restraints. They also had more head and face injuries than the restrained group. Both unrestrained and seatbelt-restrained children experienced lower limb fractures that were not observed in the booster seat group; these fractures occurred more frequently in older children involved in more severe crashes. The children restrained by lap and shoulder belt sustained moderate to severe abdominal injuries that were not observed in the booster seat group.

This type of injury can be explained by belt positioning over susceptible organs and soft tissues within the abdomen and torso in children not using a booster seat, the usage of which assists in elevating the body to distribute seatbelt restraints over the pelvic girdle and clavicle. The authors conclude that orthopaedic surgeons should advocate the use of booster seats, in conjunction with a regular seatbelt, as best practice in transportation of children aged five to 12 years.

Casting is effective for recurrence following Ponseti treatment of club foot

■ The Ponseti method has become a mainstay of the management of club foot, and is the first-line treatment for patients presenting with idiopathic club foot. However, despite the popularity of the approach, along with its well described and acceptable complication profile, previous series have shown that up to 40% of patients with idiopathic club foot treated with the Ponseti method experience recurrence of deformity. Many of these patients receive surgery in the form of anterior tibial tendon transfer due to the recurrence of equinus, but an alternative approach is repeated Ponseti casting. Recently, surgeons published a series from their population, demonstrating high rates of requirement for operative intervention for recurrence, generally in the form of a tibialis anterior tendon transfer. This study, performed at The Hospital for Sick Children (SickKids) in **Toronto (Canada)**, evaluated the outcome of a repeat-casting approach.⁶ Patients with recurrent idiopathic club foot treated over an eight-year period with serial casting and bracing were included alongside a control group who had not experienced recurrence. The authors identified 71 patients who were eligible; 35 patients participated. At the time of final follow-up at seven years, success rates were reported as 74%

for the recurrence group and 83% for the control group. The control group did better on a number of reported outcomes, but there was no difference between the groups in terms of the total outcome assessed using the disease-specific instrument club foot scale. Dorsiflexion was significantly higher in controls, at 20° versus 12°, and significantly more controls were found to have a straight lateral border and a hindfoot that was in valgus. Many of the patients in the control group in whom follow-up had been discontinued, but who were recalled for the purposes of the study, had actually had what would be classified as a recurrence, hence the aforementioned less than perfect results in this group. By discharging this group after five years, therefore, these patients were missed. As the authors point out, a better control group for this study would have been the alternative treatment option, namely tibialis anterior tendon transfer. The fact that only half of the eligible patients participated weakens the study. We know that patients who have recurrence after initial success with Ponseti casting are difficult to treat regardless of the method. This study appears to show reasonable results with recurrent casting, and the authors advocate reserving surgery for those who have failure after repeat casting.

Who to screen for DDH? X-ref

■ Screening for the early detection of pathological developmental dysplasia of the hip (DDH) is a controversial issue and there is no international consensus on a single regime. In the UK, selective screening for DDH is performed on all newborns according to the Newborn and Infant Physical Examination (NIPE) guidelines, which have been in place nationally since 2004. This recommends that newborns have Ortolani and Barlow hip examinations within 72 hours of birth, and again at six weeks of age. Positive clinical examination is an indication

for an ultrasound scan of the hips within 14 days of life. This simple paper from **Blackburn (UK)** looks at patients referred to an orthopaedic one-stop screening clinic for positive hip examination at clinical screening over a three-year period.⁷ The positive predictive value (PPV) and sensitivity were calculated and compared with previously published results from the same hospital over the 14-year period prior to this study. During the earlier study, the PPV and sensitivity for neonatal clinical examination screening had remained reasonably static throughout that period. However, somewhat alarmingly, the positive predictive value had decreased from 24% to 4% in the most recent cohort of 124 newborns. Sensitivity, similarly, worsened from 77% to 47%. In terms of imaging of sonographic Graf type IV hips, the PPV has fallen to 16% from over 49% previously. The authors observe that the reason for the clinical examination changes may be multifactorial. They observe that neonatal hip screening in the UK has fragmented, with many stakeholders having responsibility in different areas; it is also possible that a fear of litigation is driving the referral rate. Furthermore, the large number of examiners with different backgrounds and experience undertaking screening may be associated with an increase in false positive and false negative referrals. The controversy about whether universal or selective sonographic hip screening is cost-effective continues. Litigation for delays in diagnoses is expensive and, in the UK, at least, combined clinical and ultrasonographic assessment by a consultant surgeon is approximately £150. Despite the small cohort, this paper supports previous studies that suggest the rate of late diagnosis of DDH is increasing. It calls for a national audit to be repeated, in order to optimize the NIPE screening policy in the UK, and lends support to some other regimes that do not rely on clinical screening from inexperienced clinicians.

Neural axis anomalies in idiopathic scoliosis: a systematic review X-ref

■ There is ongoing controversy about the routine use of preoperative MRI screening in patients with presumed idiopathic scoliosis (IS). Although the term ‘idiopathic’ implies that its aetiology is unknown, many common concomitant neuroaxial abnormalities have been described, which may in fact be an occult pathology in patients presumed to present with IS. These abnormalities may be responsible for causing the deformity, or may influence deformity surgery. As such, knowledge of their presence can be an important factor in clinical decision-making and management plans. Routine MRI screening can be used to rule out these possible underlying causes, but obviously presents the usual conundrum regarding intervention for problems that may be incidental in neurologically intact patients. In this well constructed systematic review from **Utrecht (The Netherlands)**, these authors join the debate on routine MRI screening in IS.⁸ Their study includes a review of 51 previous studies, reporting the outcomes of over 8600 patients. The average prevalence of spinal axis anomalies in the reported literature was 11.4%, amounting to 981 patients in total. The authors extracted those risk factors most highly associated with intraspinal anomalies: early-onset scoliosis before ten years of age, neck pain, headache, male gender, atypical curves, thoracic kyphosis, and abnormal neurological findings. In studies screening all IS patients, the prevalence of anomalies found was 10.5%, 9% when it was part of a preoperative workup, and 14.2% when screening was performed of those IS patients with known risk factors. The majority of anomalies found were neural axis anomalies. Most commonly those were syrinxes (3.7%), isolated Arnold–Chiari malformations (3.0%), and combined Chiari/syrinxes (2.5%). This systematic review shows

that a significant number of patients have intraspinal anomalies on pre-operative MRI in cases that otherwise would have been presumed to be idiopathic. There are currently no clear guidelines on the use of preoperative MRI in diagnostic workup. Of the 50 studies included, 20 advocate routine MRI screening and 30 recommend selective screening of patients based on risk factors. The most important question is, of course, whether neurological complications can be mitigated by early identical identification via MRI scan. Unfortunately, few of the studies included examined this; of those that did, the complication

rate was higher in patients with anomalies, but was still only 0.8% versus 0.2%. Knowing an abnormality exists may enable individual treatment strategies, although for some anomalies there is little consensus in the neurosurgical community about their optimal treatments. The authors note that further studies on the impacts of routine MRI screening are required, but recommend screening patients with risk factors.

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Research

X-ref For other Roundups in this issue that cross-reference with Research see: *Knee Roundup 3; Shoulder & Elbow Roundup 7; Trauma Roundup 4.*

Alpha-defensin and the Synovasure lateral flow device for the diagnosis of prosthetic joint infection X-ref

■ Prosthetic joint infection (PJI) continues to be a challenging complication following arthroplasty. Before even considering a management plan for PJI, it is important to come to a reliable diagnosis, although this can be surprisingly difficult in some cases. Whilst conventional inflammatory markers – C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and white blood cell (WBC) count – have been used for some time, new biomarkers have more recently been identified, the most highly studied of which is alpha-defensin. Alpha-defensin is an antimicrobial peptide that interrupts bacterial cell wall synthesis, and its activity is an indirect marker for bacterial activity. An assay, enzyme-linked immunosorbent assay (ELISA), has been developed to measure the amount of alpha-defensin quantitatively, either in the laboratory

or with a lateral flow cassette (Synovasure) in the operating theatre as a point-of-care testing system. This point-of-care test is extremely useful as a result can be obtained in ten minutes of the sample being obtained. The aims of this study from Nottingham (UK) were to evaluate the diagnostic use of alpha-defensin, focusing on more recent studies, and to evaluate the lateral flow cassette used in point-of-care testing in theatres.¹ The authors undertook a thorough meta-analysis; 179 studies were identified, of which 11 studies met the inclusion criteria. Of these, four reported a laboratory-based ELISA to measure alpha-defensin with a pre-specified threshold value of 5.2 mg/l and six used a lateral flow cassette. The pooled sensitivity of the ELISA was 0.95 (0.91 to 0.98) and specificity was 0.97 (0.95 to 0.98). In comparison, the lateral flow cassette had a pooled sensitivity of 0.85 (0.74 to 0.92) and specificity of 0.90 (0.91 to 0.98). In addition, there was a significant difference in the likelihood ratio test between the laboratory and the lateral flow test for sensitivity but not for specificity. The key points of this study were that, whilst the sensitivity and specificity of an

alpha-defensin assay performed in the laboratory are excellent when using a pre-specified threshold value of 5.2 mg/l, the results of using a lateral flow cassette showed lower sensitivity and specificity. This is an apparent conflict with the manufacturer's data sheet, which suggests a 100% positive agreement and 96% negative agreement with the laboratory test. Although the reasons for this difference are not clear, the authors postulate that it may be due to patient selection, technical errors occurring during the test, or point-of-care users being less diligent in performing the tests compared with trained laboratory staff. The authors highlight that industry involvement in the positive studies for Synovasure may have resulted in a publication bias. The authors also pointed out that the Synovasure performs with a similar sensitivity and specificity to the leucocyte esterase test or synovial CRP, although it is more expensive. The conclusions of this study are based on the current literature of using a point-of-care test in theatre, the lateral flow cassette, to test for the presence of an infected arthroplasty. At best, the Synovasure can be used as an adjunct to

diagnose a PJI, but it would appear that the sensitivity of this test is not quite as robust as was previously thought. Therefore, users of this device as a point-of-care test should exercise considerable caution and take into account more conventional tests when trying to diagnose a PJI.

Readmission after cervical spine arthrodesis: rates, trends, causes, and risk factors X-ref

■ The authors of this study from New York, New York (USA) have done some interesting work on establishing healthcare utilization following elective surgery, in this case cervical spine arthrodesis.² This is a very timely study, as the push to reduce costs has resulted in shortening of admissions, reduction in follow-up, and a general 'slimming down' of planned care pathways. The authors performed a retrospective database analysis of patients to quantify emergency department (ED) utilization and inpatient readmission rates after primary cervical arthrodesis. Capturing the data for readmission, representation, and complications is always tricky, as patients occasionally present to other healthcare providers.