



# News in paediatric orthopaedic surgery: an overview of the latest advances in paediatric orthopaedics and traumatology (2020–2023)

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## Abstract

**Purpose** We propose to survey — even if arbitrarily — the publications in paediatric orthopaedics and traumatology that have had the greatest impact on the specialty during the period extending from the beginning of the COVID-19 pandemic in December 2020 and the end of all health restrictions in March 2023.

**Methods** Only studies with a high level of evidence or clinical relevance were selected. We briefly discussed the results and conclusions of these quality articles to situate them in relation to the existing literature and current practice.

**Results** Publications are presented by dividing traumatology and orthopaedics whose publications are further subdivided according to anatomical districts; articles concerning neuro-orthopaedics, tumours, and infections were presented separately while sports medicine is jointly presented with knee-related articles.

**Conclusions** Despite the difficulties encountered during the global COVID-19 pandemic (2020–2023), orthopaedic and trauma specialists, including paediatric orthopaedic surgeons, have maintained a high level of scientific output, in terms of quantity and quality of production.

**Keywords** Pediatric orthopedics · New · Novelty · Review · Surgery

## Introduction

Between December 2020 and March 2023, more than 100 million people were infected with the SARS-CoV-2 virus (COVID-19), and about three million deaths from the disease were recorded worldwide [1, 2]. Despite the difficulties encountered during the worldwide COVID-19 pandemic, specialists in orthopaedics and traumatology, including paediatric orthopaedic surgeons, have maintained a high level of scientific output, in terms of quantity and quality of production [3]. Therefore, this review of the paediatric orthopaedic literature, covering the period between the onset of the COVID-19 pandemic in December 2020 and the end of all health restrictions in March 2023, aims to present — even if arbitrarily — the publications in paediatric orthopaedics and

traumatology that had the greatest impact on the specialty during this period. Only studies with a high level of evidence or clinical relevance were selected. We briefly discussed the results and conclusions of these quality papers in order to place them in relation to the existing literature and current practices.

Publications were presented by dividing traumatology and orthopaedics whose publications were further subdivided according to anatomical districts; articles concerning neuro-orthopaedics, tumours, and infections were presented in separate chapters while sports medicine is jointly presented with knee-related articles.

## Article selection

The authors of this narrative review article present 70 articles (out of 73 references) they believe summarize the best quality work in paediatric orthopaedics and traumatology published between December 2020 and March 2023.

Each author (NM and FC) independently screened the top-tier publications in orthopaedics and paediatric orthopaedics and selected 100 articles each. From the 200 articles initially selected, each author identified the 50 papers most

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relevant to the specialty; only studies with a high level of evidence or clinical relevance were selected. The articles were also selected to obtain a homogeneous number of articles for each subspecialty of paediatric orthopaedics. From this group of 100 papers, a selection of 70 articles was made by mutual agreement (Fig. 1).

Trauma ( $n=8$ ) and orthopedic ( $n=62$ ) articles are presented separately. Orthopaedics publications are divided according to anatomical districts [upper extremity/hand ( $n=7$ ); hip ( $n=8$ ); foot ( $n=8$ ); spine ( $n=13$ )] while neuro-orthopaedics ( $n=5$ ), tumors ( $n=6$ ), infections ( $n=8$ ) and miscellaneous ( $n=3$ ) are presented in separate chapters; sports medicine is jointly presented with knee-related articles ( $n=4$ ).

## Traumatology

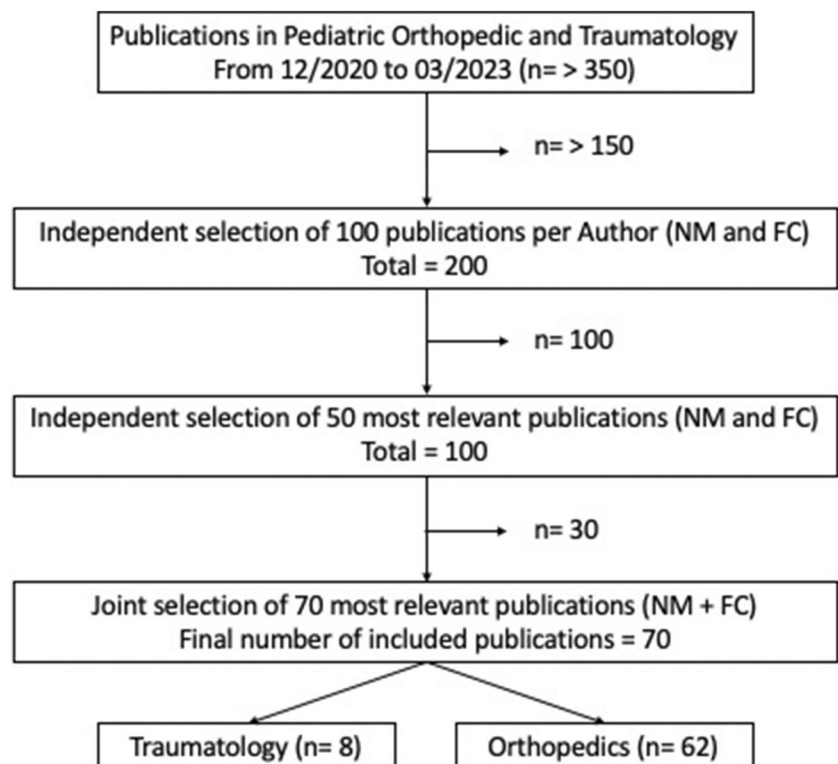
The potential benefits of surgical treatment of clavicle fractures in adolescents participating in sport activities are still debated. Ahearn et al. reported that adolescent athletes returned to sport regardless of whether the clavicle fracture was treated surgically or managed conservatively. Patients with conservatively managed fractures, however, returned to sport four to six weeks before those treated surgically, probably due to the greater severity of the surgically treated fractures; factors that increased the time to return to sport were extent of displacement, comminution, and angulation [4].

Severely displaced lateral condyle fractures are traditionally treated by open reduction and internal fixation. Liu et al. reported that closed reduction and percutaneous pinning in children with Jakob type 3 lateral condyle fracture is a feasible technique that yields excellent and similar clinical and radiographic outcomes compared to open reduction and internal fixation (94.4% and 97.2% respectively) [5].

Shah et al. reported a new closed-focus reduction technique for Judet type III and IV radial head fractures. The technique requires the presence of two surgeons and is performed with the patient under general anaesthesia in dorsal decubitus. First, the radial head is viewed in profile under an image intensifier so that it appears rectangular in shape. Then, the assistant applies varus stress on the medial aspect of the elbow and thumb pressure on the radial head along the posterior-lateral aspect of the injured elbow. This results in partial reduction of the radial head. The elbow is then simultaneously flexed and pronated with continuous pressure on the radial head. This final step anatomically reduces the radial head, and hyper-pronation of the forearm locks the radial head into the correct position. In their series of ten patients, they did not record any sign of growth disturbance, loss of reduction, nor other complications at 12 months follow-up [6].

Displaced fractures of the head of the 5th metacarpal are relatively common between 13 and 16 years of age, affecting mainly boys and the dominant hand by direct impact. Haddad et al. reported excellent outcome of the L-pinning

**Fig. 1** Flowchart of article selection



technique in patients with displaced fracture of the head of the 5th metacarpal. The L-pinning technique combines intramedullary anterograde pinning of the 5th metacarpal and transverse pinning of the 5th and 4th metacarpals. Although the technique was originally designed to treat adult patients, its application in adolescents showed good results particularly in patients with limited growth potential. The main advantage of the technique is that it does not require any postoperative immobilization [7].

Seymour fractures can be complicated by infection. Kiely et al. in their systematic review and meta-analysis on the management of Seymour fractures in children and adolescents found that early debridement (< 48 h) is associated with significantly lower risk of infection and malunion. Moreover, prophylactic antibiotics (< 24 h) significantly reduced the risk of infection. Overall, prophylactic antibiotics and debridement decreased the risk of infection by 70% while delayed presentation and treatment had 35% risk of infection and 16% incidence of osteomyelitis [8].

Despite the recent trend toward surgical treatment of pediatric diaphyseal tibia fractures, the evidence from the literature is relatively scarce. Bradman et al. offered a new perspective on the management of spiral fractures of the tibia in children < five years of age. They compared the outcome of non-displaced spiral tibial fractures managed with above-knee cast immobilization versus motion-controlled ankle boots (MCA) in children aged < five years. Immobilization of non-displaced spiral tibial fractures in an MCA boot showed similar fracture healing and faster return to full weight-bearing compared to above-knee cast immobilization [9].

Rivera et al. compared the outcome of treatment by closed reduction and casting (CRC) with surgical treatment with elastic stable intramedullary nailing in children aged ten to 18 years with displaced diaphyseal fractures of the tibia. The authors found that the mean time to return to full weight-bearing was only one week longer in patients managed with CRC, with no statistically significant differences in non-union and complication rates between the two techniques. In conclusion, they recommended that in patients with displaced diaphyseal fracture of the tibia, a first attempt at CRC should be made, as complications tend to be more severe in patients managed with elastic stable intramedullary nailing [10].

To date, there is no consensus on the best treatment option for Lisfranc's lesions due to their rarity in the pediatric population. The systematic review by Peak et al. suggested a stepwise approach based on the stability of the Lisfranc joint complex. Specifically, if the weight-bearing radiographs show that the distance between the proximal base of the 1st and 2nd metatarsals or between the distal base of the medial wedge and the proximal base of the 2nd metatarsal is > 2 mm, or that there is a loss of alignment

between the 2nd metatarsal and the medial wedge, or that there is evidence of speckling indicating an avulsion in the Lisfranc joint complex, surgical treatment should be considered. Surgical treatment should also be considered in the presence of soft tissue injury. Regarding surgical fixation, Peak et al. found that K-wires and screw fixation are viable options for managing unstable injuries of the Lisfranc joint complex [11].

## Orthopaedics

### Hand and upper limb

Edwards et al. reviewed the outcome of 85 surgical releases performed in 59 patients with syndactyly and found 31% of complications per operation at two year follow up. However, only 8% of complications required reoperation or readmission (donor site dehiscence, web or scar revision, or wound infection requiring); more than one surgical procedure and more than one operated web space were risk factors for complications [12].

Hu et al. have compared existing classifications for thumb polydactyly and felt that they could not recommend one classification over the other. They reported that the Wassel-Flatt classification does not allow classification of the full spectrum of congenital thumb duplications (CTD) and does not correlate with surgical interventions; the Rotterdam classification is complex, with many categories rarely encountered in clinical practice, and the Chung et al. classification had the lowest reliability [13]. Wu et al. reviewed 2108 patients with 2300 CTDs and proposed a comprehensive classification system based on the classification schemes of Wassel-Flatt and Chung et al. This classification allows classifying the entire spectrum of CTDs and is based on the location of the deformity and the anatomical abnormality at the origin of the duplication. The classification is characterized by four main groups based on the pathoanatomy at the origin of the extra digit: A (joint), B (epiphysis), C (bone), and D (soft tissue); in addition, each group includes four subtypes based on the location of the duplication, from distal phalanx to metacarpal or interphalangeal to carpal-metacarpal (1 through 3); the fourth subtype only includes the triphalangia of the main thumb but not extra thumb regardless of the duplication level [14].

Morrow et al. evaluated the long-term hand function outcomes of primary nerve reconstruction for total brachial plexus birth injury (BPBI). They reported that primary nerve reconstruction targeting the lower trunk as the first priority to restore hand function resulted in sufficient functional movement of the hand and upper extremity to perform bimanual activities in 81% of patients with a complete BPBI at eight years of age. These findings contrast with

those found in adults who, unlike children, have brachial plexus injuries secondary to high-velocity, high-energy injuries [15].

BPBI can lead to muscle imbalance in the shoulder causing glenohumeral contractures and joint and bone deformities resulting in pain and worsening functional disability. de Joode et al. reported that lengthening the clavicle can reduce pain by allowing the scapula and peri-scapular muscles to return to a more anatomical position. The technique is promising, as the first seven cases reported with a median follow-up of 42 months showed a significant reduction in pain [16].

Waltenspül et al. compared the long-term results of arthroscopic Bankart and open Latarjet procedures in adolescents. They reported 57% failure rate in the Bankart group and 6% in the open Latarjet group although patients without recurrence had comparable functional outcome scores. The authors strongly recommend considering the open Latarjet procedure as the first option in adolescents with anterior glenoid-humeral instability [17].

Dai et al. assessed the risk factors for redislocation in surgically treated chronic Monteggia fracture. They found that reconstruction of the annular ligament or fixation of the radio-capitellar joint did not prevent redislocation, as it occurred in 16.1% of cases. The authors found that age, time from injury to surgery, and radial osteotomy were risk factors for recurrent dislocations of the radio-capitellar joint. However, these findings need to be confirmed by larger studies [18].

## Hip

Femoroacetabular impingement (FAI) in adolescents and young adults can be the result of a sequela of childhood hip disease or an aspheric anterior-lateral head-neck junction. This leads to shear stress on the anterior–superior acetabulum resulting in chondral delamination and labrum detachment or laceration. Fukasa et al. [19] pair-matched 157 adolescents with FAI who underwent arthroscopic treatment to adult controls with a median postoperative follow-up of 8.9 and 6.6 years, respectively. They found that hip arthroscopy for FAI in adolescents performed using a physal-sparing approach is safe and effective, and it yields superior clinical outcomes compared to adults. Particularly, adolescents showed better functional scores and lower rate of revision surgery (9% versus 11%) compared to adults despite similar or lower baseline scores. Arciero et al. in their systematic review of adolescent undergoing hip arthroscopy reported favourable post-operative outcome, high rates of return to sport, and a low complication rate [20].

The treatment and long-term evolution of congenital hip dislocation and Legg-Calvé-Perthes disease (LPCD) remain debated among specialists. In their retrospective diagnostic accuracy study, Yu et al. evaluated the performance of hip

medial ultrasound and anterior–posterior radiographs for determining the quality of hip reduction in patients with congenital hip dislocation managed by closed reduction and spica cast immobilization. Ultrasound showed excellent sensitivity, specificity, positive predictive value, and negative predictive value with perfect inter- and intra-observer correlation to determine the quality of reduction. Moreover, ultrasound had higher specificity (95% versus 68%) and positive predictive value (50% versus 7%) than plain radiographs. Yu et al. recommended the use of ultrasound to monitor reduction in patients < 24 months of age managed by closed reduction and spica cast immobilization [21].

Kołodziejczyk et al. evaluated the hips of adolescents who had or had not been operated on during infancy for congenital hip dislocation and the hips of adults with congenital hip dislocation during infancy who had not undergone previous surgery; they concluded that surgical treatment of congenital hip dislocation during infancy has a beneficial effect on the outcome of periacetabular osteotomies performed in adolescence and early adulthood. Particularly, Kołodziejczyk et al. highlighted that the correction of radiological parameters and clinical outcome of periacetabular osteotomies were better in patients with congenital hip dislocation undergoing surgery during infancy [22].

To investigate the potential benefit of using prolonged non-weight-bearing (PNWB) as a treatment option for early-stage LCPD, Peck et al. retrospectively reviewed a series of patients with Waldenström stage 1A, 1B, and 2A aged between six and 12 years at disease onset. They found that patients with more than 6 months PNWB had better femoral head shape and congruency than those managed by simple symptomatic treatment at two year follow-up [23]. Using a web-based platform, Mcguire et al. collected 1182 responses to a questionnaire from patients of 45 different countries who developed LPCD in childhood. They found that 40% of respondents had undergone at least one surgical procedure during childhood while 22% and 30% underwent at least one total hip replacement and any type of surgery, respectively [24].

Zhi et al. performed a systematic review and meta-analysis to estimate the incidence of total hip arthroplasty (THA) in patients with LCPD treated conservatively or surgically and to identify the factors influencing the incidence of THA in this patients' population. They found that the older the patient's age at disease onset and longer the follow-up, the higher the incidence of THA. Particularly, the incidence of THA increased dramatically after 40 years of follow-up, regardless of treatment modality. Interestingly, they pointed out the Stulberg classification is not a good predictor of the incidence of THA in patients with LPCD who have reached skeletal maturity [25]. On the other hand, Huhnstock et al. reported that the modified Stulberg classification applied at five year follow-up is a significant predictor of unsatisfactory long-term outcome in patients with LCPD [26]

## Knee and sports medicine

Ling et al. used data from 291 patients to develop a multivariate model based on individual risk factors for recurrence after a first episode of lateral patellar dislocation with the aim of reducing the long-term risk of patellofemoral arthritis. They identified age, history of contralateral patellar dislocation, skeletal immaturity, lateral patellar inclination, tibial tubercle-to-trochlear groove distance, Insall-Salvati ratio, and trochlear dysplasia as the most significant risk factors for recurrence. In contrast, gender, mechanism of injury, Caton-Deschamps ratio, sulcus angle, tilt angle, and facet ratio were not found to be risk factors for redislocation [27].

Lins et al. reviewed children and adolescents treated with lateral discoid meniscus rim preservation surgery at an average follow-up of 19.5 years. They found that nearly half of the patients who underwent surgery for lateral discoid meniscus rim preservation required subsequent ipsilateral knee surgery, although two-thirds were satisfied with the overall surgical outcome [28].

A systematic review and meta-analysis by Pagliuzzi et al. compared anterior cruciate ligament reconstruction by partial transphyseal, complete transphyseal, and physeal-sparing techniques and found comparable outcomes. The approach using a physeal-sparing technique achieved better results in terms of knee stability than the approaches using the partial and complete transphyseal techniques, but this did not result in a significant difference in subjective and objective clinical scores. In addition, no significant difference was found between the three techniques with regard to recurrence, growth disturbance, and axial deviation. However, the authors believe that the physeal-sparing technique should remain the preferred approach in a young population in order to ensure restoration of knee stability [29].

Using the Swedish National Knee Ligament Registry, Thorolfsson et al. found that following anterior cruciate ligament reconstruction, adolescents had lower knee injury and osteoarthritis scores than young adults at two, five and ten years of follow-up. One possible explanation is that adolescents, and paediatric patients in general, tend to resume physical activities, even intense ones, earlier than young adults. The results of this study give realistic information regarding the long-term outcomes of anterior cruciate ligament reconstruction [30].

## Foot and ankle

Owoeye et al. investigated the association between severe sport-related ankle sprain (SAS) and health-related outcomes during the first 15 years after the index injury in patients < 18 years of age. They found that those with a history of severe SAS had more pain, reduced self-rated function, reduced sport participation, and poorer ankle-related

quality of life compared to uninjured controls regardless of gender and time from initial injury. They suggested that ankle sprains should not be viewed and managed as a minor condition. In particular, they stressed out primary prevention of ankle sprains, and secondary prevention of chronic ankle instability and post-traumatic osteoarthritis have to be considered [31].

Lucchesi et al. studied the morpho-anatomical characteristics of too-long anterior calcaneal process (TLACP). They found that all feet diagnosed with TLACP had a calcaneonavicular distance < 5 mm. They also introduced a new classification system based on the anatomy of the TLACP: type 1, absence of TLACP; type 2, triangular TLACP; type 3, rectangular TLACP; type 4, coalition [32].

Wartelle et al. investigated the association between TLACP and osteochondral lesions of the talus (OLT). The TLACP is responsible of sub- and mid-tarsal stiffness and can lead to the development of OLT which can be aggravated by recurrent sprains. They found that the relative risk of having TLACP was three times higher in the OLT group than in the control group. Indeed, 86% of the feet with OLT had a calcaneonavicular distance < 5 mm, and half of them were symptomatic [33].

Fibrin glue contains separately packaged human fibrinogen and human thrombin and is used to create a fibrin clot for haemostasis as well as for cartilage repair and wound healing. Swonger et al. reported the use of fibrin glue as interposition tissue in tarsal coalition resections was not significantly different compared to fat graft interposition in terms of rate of recurrence and wound complication [34].

There are no clinical practice guidelines for the treatment of clubfoot in preterm infants. Scalan et al. retrospectively reviewed 26 preterm infants (46 feet) born at < 37 weeks of gestation with clubfoot who were treated at term. They found that at one year follow-up they had comparable outcome, number of casts, tenotomy, and recurrence rates to those born at term [35].

Monforte et al. compared the clinical outcome of children with idiopathic clubfoot managed by the Ponseti method using plaster of Paris versus semirigid fiberglass. At 5-year follow up, they found that semirigid fiberglass (more expensive and with slightly less moldability) and plaster of Paris have similar clinical outcome and rate of recurrence [36].

To date, brachymetatarsia has not been critically analyzed, and there is no consensus on the timing and method of bone lengthening. Lamm et al. introduced a comprehensive classification system for brachymetatarsia that allows accurate diagnosis of the deformity and provides an algorithm for surgical treatment [37].

Gurhan et al. reported that electrocauterization of the matrix in addition to the wedge resection of the toe-nail does not affect recurrence rate and clinical outcomes in adults with ingrown toe-nails although it decreases significantly

the recurrence rate in adolescents. They also recommend to complete the matricectomy with electrocoagulation in younger patients [38].

## Spine

In children with early-onset idiopathic scoliosis, serial casting performed before 18 months of age reduces the risk of curve progression. Fedorak et al. conducted a retrospective study of 134 children with early-onset scoliosis (mean curve: 50.4°; mean follow-up: 5.2 years) and found outcome was worse the later the cast treatment was started. They also reported 75% of children aged < 18 months at the beginning of treatment had a residual curve < 15° at the last follow-up visit. This percentage decreased with advancing age to 23% in the group of children aged four years at the beginning of cast treatment [39]. However, Flynn et al. tempered the findings of Fedorak et al. by pointing out that some of their patients had only six months of age and 11° of scoliosis at the beginning of treatment. Simple observation could have led to a “cure” in many of the cases reported by Fedorak et al. Flynn et al. also pointed out the fact that such treatment required an average of eight general anaesthetics whose effects on children’s brain development are still unknown [40].

Skeletal maturity status is a reliable indicator of the risk of curve progression in patients with adolescent idiopathic scoliosis (AIS). There is currently no system to assess bone age on spine radiographs, and currently used measures of skeletal maturity rely on additional radiographs (hand, elbow and pelvis). Cheung et al. developed a proximal femur maturity index that assesses skeletal maturity in AIS patients without additional radiographs because it is based on the appearance of the proximal femur (femoral head, greater trochanter, and triradiate cartilage) which is visible in full spine anterior–posterior radiographs [41].

Based on the recommendation of the International Society for Orthopedic and Rehabilitative Treatment of Scoliosis (SOSORT) suggesting sport activities in AIS patients treated by full-time brace, Negrini et al. conducted the first in-depth prospective study designed to test the effect of sports activity on patients with AIS managed by full-time thoracolumbar brace. The study showed that regular sports activity increases the odds of deformity reduction  $\geq 5^\circ$  at 18-month follow-up, and the odds of improvement increased with the frequency of sport activity [42].

Zapata et al. found that the progression of curves between 15° and 19° was comparable to that of curves between 20° and 24°, with no significant differences between Risser 0 and Risser 1. Therefore they suggested a paradigm shift in the treatment of mild AIS in favor of a more interventional attitude with brace [43].

Lenz et al., in order to develop patient-specific algorithms to predict individual risk of curvature progression in AIS

patients, summarized individual and radiological risk factors by a systematic literature review of 8255 patients. Patient-related risk factors for deformity progression were age at diagnosis < 13 years, family history, bone mineral status (< 110 mg/cm<sup>3</sup> in quantitative CT), and a growth velocity of 7–8 cm/year. Radiologic risk factors were skeletal maturity (Risser < 1 or Sanders Maturity Scale < 5), curve magnitude, and thoracic location (single or double curve) [44].

In recent years, CT navigation has improved the accuracy of pedicle screw placement during paediatric spinal deformity surgery. Baldwin et al., in a meta-analysis of 13 studies, found that intra-operative navigation allows more accurate pedicle screw placement than non-navigated techniques while blood losses were comparable [45]. However, the duration of surgery was on average about half an hour longer in cases with navigation than in those without; similarly, the effective radiation dose was higher with navigation, although not statistically significant. These findings are now shared by several studies and allow us to predict that navigation systems will soon enter the routine practice of pediatric spinal deformity surgery [46, 47]. Meanwhile, Swany et al. reported 0.4% revision surgery rate due to screw malpositioning in 2435 patients with AIS with freehand or fluoroscopy-assisted pedicle screw placement [48].

Data on growth modulation by anterior vertebral body tethering (AVBT) for the treatment of progressive scoliosis in skeletally immature patients continue to emerge, allowing the indications to be refined. Newton et al. reviewed 237 patients with thoracic scoliosis undergoing AVBT and compared them to 237 patients undergoing posterior spinal fusion (PSF). The AVBT group was younger, had a smaller thoracic curve ( $48^\circ \pm 9^\circ$  versus  $53^\circ \pm 8^\circ$ ), and had a lower initial correction ( $41\% \pm 16\%$  versus  $70\% \pm 11\%$ ). After a mean follow-up of 2.2 years, 76% of patients in the AVBT group had a residual curve of < 35°, compared with 97.4% in the PSF group. A total of 16% of patients treated with AVBT required subsequent surgery, compared with 1.3% in the PSF group; in addition, another 4 cases (1.3%) in the AVBT group had a residual curve of > 50° that might have required revision or conversion to PSF [49]. Catanzano et al. evaluated the response of lumbar curves following correction by AVBT of thoracic curves. Although immediate reduction of the lumbar curve was observed after AVBT of the thoracic curve, further correction was observed only in 54% of patients with continuing improvement of the thoracic curve. Furthermore, when considering all patients, only a 30% improvement in lumbar curve was observed two years after the index procedure on the thoracic spine [50].

With the aim of studying the optimal lowest instrumented vertebra (LIV) in the treatment of Scheuermann’s kyphosis, Xu et al. demonstrated that a shorter fusion that stops at the Stable Sagittal Vertebra (SSV)-1 results in clinical outcomes comparable to a fusion that extends to the SSV without

increasing the risk of distal junctional kyphosis (DJK). They also showed that in patients with a preoperative difference between LIV and posterior vertical line  $< -37.35$  mm, extending the fusion to the SSV is an acceptable alternative to prevent DJK [51].

## Neuro orthopaedics

Tell us et al. reviewed the results of 3311 orthopedic procedures in 3305 individuals with cerebral palsy (CP) followed up to the age of 25 years from the CPUP (Uppf ljningsprogram f r cerebral pares) surveillance program and the Swedish National Patient Register. Ankle and foot surgery was predominant as the first surgery in GMFCS I-II patients, hip and femur surgery in GMFCS IV-V patients, while spine surgery was mainly performed in GMFCS IV-V patients. Overall, it was found that the risk of undergoing first orthopaedic surgical treatment increased with increasing GMFCS level, and it was performed at a younger age in children with a higher GMFCS level [52].

Ahmed et al. compared the outcome of subtalar arthroereisis with calcaneal lengthening in the management of flatfeet in ambulatory children with spastic cerebral palsy. Although both procedures are valid surgical options, they found that subtalar arthroereisis may be particularly appropriate for patients undergoing single-event multilevel surgery [53].

Minaie et al. evaluated the rate and risk factors for failure of hip reconstruction in 179 patients with CP with at least two years of follow-up. Overall, they found a 13.1% failure rate of hip reconstruction; age  $< 6$  years and migration percentage  $> 70\%$  at index procedure were risk factors for failure. On the other hand, correction of acetabular dysplasia at time of hip reconstruction surgery in patients with acetabular index  $> 25^\circ$  protected against subsequent failure [54].

Asma et al. reviewed 163 patients with spastic and hypertonic non-ambulatory CP with a mean follow-up of 4.8 years after triradiate cartilage closure. They found that hip migration rate and pelvic obliquity were independent risk factors for long-term poor outcome in 22.1% of cases. They also found a reduced survival rate in male patients and in patients without previous reconstructive surgery. They concluded that patients with risk factors for poor outcome and with migration percentage  $\geq 35\%$  at triradiate cartilage closure should undergo continuous radiographic monitoring for late hip displacement [55].

Despite a significant rate of postoperative complications (55.4% with at least one complication), Miller et al. found that patients with non-ambulatory CP had a mild and significant improvement in the mean score of the Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD) 2 years after spinal arthrodesis. The improvement was found in all domains of the CPHILD questionnaire, suggesting that spinal fusion can potentially benefit

these patients in various ways. Among all patients, 36.3% reported significant improvement in CPCHILD scores ( $> 10$  points) two years after surgery. These patients tended to have lower preoperative health-related quality of life, suggesting the possibility of greater room for improvement after surgery. A lower score in the comfort, emotion, and behaviour domain of the CPCHILD questionnaire was predictive of significant improvement after surgery. Radiographic parameters of deformity or curve correction, on the other hand, were not associated with significant improvement after surgery [56].

## Tumour and tumour-like lesions

Syv nen et al. performed a randomized clinical trial to compare unicameral bone cyst recurrence after intralesional curettage and filling with morselized allograft ( $n = 26$ ) versus bioactive glass ( $n = 25$ ). They found that the two materials had comparable recurrence rate (46% and 40%, respectively) and similar rate of complications regardless of the histology of the cyst, unicameral or aneurismal [57].

Lin et al. investigated the outcomes of spica cast ( $n = 9$ ) versus internal fixation ( $n = 5$ ) in children with pathologic proximal femur fractures due to benign bone tumors. They reported prolonged time to union, 64% of revision surgery, 71% complication rate, and 78% failure rate of initial conservative management. They concluded that children with pathologic proximal femur fractures should be managed by internal fixation [58].

Azoury et al. reviewed the long-term outcomes of free fibula physal transfer for pediatric proximal humerus reconstruction in children with bone tumours. They reported that such reconstruction technique preserves bone growth and provides an articular surface for motion. However, postoperative morbidity is not negligible (flap failures, fracture, avascular necrosis of the fibula head, fibular head avulsion, infection, and hardware failure) although peroneal nerve palsy following harvest is frequently transient [59]. Similar results were found by Bachy et al. for the treatment of epiphyseal defects with vascularized fibular proximal epiphyseal transfer associated to a diaphyseal segment. They reported that the vascularized fibular epiphyseal transfer can fill the bone defect, reconstruct a functional joint, and preserve growth. However, the risk of fracture persists over the long term [60].

Although in patients with traumatic myositis ossificans with pain or limited joint range of motion conservative treatment is the main treatment option, open surgery and complete resection may be considered. However, little work is available on the outcomes of this type of treatment. Pu and Su analyzed 20 patients treated by complete surgical resection of the lesion (mean follow-up: 4.9 years) and found that most patients had no recurrence and had satisfactory

functional recovery. All patients gradually started functional exercises two weeks after surgery, and the rate of recurrence was low when surgery was performed after the acute phase [61].

Shanks et al. evaluated the efficacy of surgical and non-surgical interventions in the treatment of 315 paediatric patients with wrist ganglion cysts. They found that surgical excision had the highest rates of resolution (72.8%) compared to aspiration (18.4%). Among nonsurgical options, observation had better resolution rate (44.2%) than aspiration, although it was inferior to orthotic management (54.5%). Shank et al. concluded this patients' population remains largely understudied because of the low prevalence of paediatric wrist ganglion cysts as 10% of cysts occur in patients < 20 years and only 1–2% in children < ten years of age [62].

## Infections

Alcobendas et al. and Ossurason et al. have investigated the efficacy of simplified antibiotic treatment in children with primary haematogenous osteoarticular infection [63, 64]. Alcobendas Rueda et al. compared 893 children with primary haematogenous osteoarticular infection treated by intravenous antibiotics with 64 children who received oral-only antibiotic therapy. They reported that oral-only administration of antibiotics is a safe option in children with good general condition and no underlying disease, age between six months and three years, appropriate oral tolerance, C-reactive protein < 80 mg/L, no skin lesions, no recent surgery, no cervical spondylodiscitis, and no local complications at the beginning of treatment [65].

Lansell et al. evaluated the impact of antibiotic pre-treatment on cultures in 584 children with septic arthritis and osteomyelitis. They found there were no significant differences in the odds of obtaining a positive culture in children whose blood, bone, or joint cultures had been pre-treated with antibiotics. Moreover, the duration of antibiotic administration in pre-treated cultures was also not a significant predictor of culture positivity [66].

Hamilton et al. reported that children with primary septic arthritis have lower risk of adverse outcomes than those with contiguous osteomyelitis. Particularly children with contiguous osteomyelitis had longer hospitalization, higher rate of intensive care admission, higher readmission rate, and higher complication rate. Hamilton et al. concluded that long-term adverse events in children with septic arthritis are likely due to contiguous osteomyelitis [67].

Gajewski et al. evaluated the utility of post discharge radiographic monitoring in 131 children with osteoarticular infections. They found that routine radiographs rarely alter management in the absence of other concerning signs such as recurrent fever, swelling of the extremity, or limb

deformity. They concluded that radiographs should be requested in according to clinical evolution reactively rather than routinely [68].

Loro et al. evaluated the midterm outcome and complications of vascularized fibula flap and bone transport to fill segmental bone defects secondary to chronic osteomyelitis in children in a low-resource setting. They reported favourable outcome and concluded that such procedures should be kept in mind to treat complex paediatric cases of bone and soft tissue loss, even in a low-resource setting. However, both techniques are technically difficult and lengthy procedures that are prone to complications (lower limb discrepancy, recurrence of infection, fracture) [69, 70].

## Miscellaneous

The use of new technologies must ensure the well-being of children undergoing minor orthopaedic procedures without anaesthesia.

Two randomized controlled trials including 129 and 66 children, respectively, showed that the use of virtual reality and Bedside Entertainment and Relaxation Theater during orthopaedic procedures such as K-wire removal significantly reduces fear and anxiety in patients along with excellent satisfaction rates [71, 72].

In their systematic and critical analysis review, Burkhart et al. reported that the majority of cast-room procedures to reduce fear and stress were inexpensive, readily applicable to the clinical setting, and of negligible risk to the patient [73].

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## Declarations

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**Consent to participate** Not applicable.

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