Symposium

POSI
IJPO

Sequelae of Paediatric Musculoskeletal Infections

Prateek Behera MS Ortho[1], Vikas Gupta MS Ortho[2], Shubhangi Gupta MS Ortho[3]

Abstract

Musculoskeletal infections (MskI) are one of the leading causes of morbidity in children. In neonates and infants, they can result in deaths, too, if timely treatment is not initiated. Of the several factors contributing to the development of sequelae, late presentation, delay in diagnosis, and failure in initiation of appropriate treatment are considered important. Chronic osteomyelitis is often a continuation of untreated or incompletely treated osteomyelitis. The management of chronic osteomyelitis rests on the pillars of extensive surgical debridement and appropriate antibiotic therapy. The diseased bones might get fractured and need to be supported till union, which invariably happens inappropriately treated patients. In young children, osteomyelitis and septic arthritis tend to be frequently present concomitantly, and the infection can result in the destruction of the epiphysis, too. These children with damaged epiphysis have poor outcomes despite best of the efforts to restore function. Physis can also be involved in MskI, resulting in formation of physeal bar that can result in growth arrest. This bar can result in a shortened limb, angular deformity, or both. Management of these conditions includes physeal bar excision wherever suitable or correction of angular deformity by osteotomies. Length can be gained concomitantly using ring external fixators.

Keywords: Musculoskeletal infections, Osteomyelitis, Sequelae, Growth arrest, Physeal bar

Dr. Prateek Behera

Dr. Vikas Gupta

Dr. Shubhangi Gupta

Address of Correspondence
Dr. Prateek Behera
Department of Orthopaedics, AIIMS Bhopal, Madhya Pradesh.
E-mail: pbehera15@outlook.com

[1]Department of Orthopaedics, AIIMS Bhopal, Madhya Pradesh.
[2]Department of Orthopaedics, Central Institute of Orthopaedics, VMMC and Safdarjung Hospital, New Delhi
[3]University of North Dakota, USA

DOI- https://doi.org/10.13107/ijpo.2023.v09.i03.159

Introduction

The term "sequela," that has been derived from "sequel," is often used to describe a pathological condition arising from any disease or injury. This term thus refers to conditions that occur because of any index event, such as a disease or injury [1]. Musculoskeletal infections (MskI) in children can affect the bones, joints, and surrounding muscles. The incidence of MskI in children is around 10-25 per 1,00,000 children in developed countries [2]. Increased awareness amongst clinicians, availability of reliable investigations, and availability of antibiotics and surgical facilities have contributed to timely diagnosis and treatment of children with MskI, especially in countries with good penetration of healthcare services. However, the same cannot be said for most developing countries, and it is not uncommon to see atypical complications and sequelae in these countries [3, 4]. While many factors can contribute to this aspect of MskI, one pertinent aspect might be the absence of treatment guidelines. Recently, the Indian Academy of Paediatrics has developed a consensus statement on MskI in children [5].

Submitted: 26/08/2023; Reviewed: 22/09/2023; Accepted: 29/10/2023; Published: 10/12/2023

The pathophysiological aspect of MskI

The metaphyseal area of long bones, with its hairpin loop arrangement of blood vessels, is the usual site for the initial lodgement of bacteria. An inadequate response of host defenses, mainly due to a lack of macrophages, promotes the establishment of infection. Timely identification and initiation of appropriate treatment helps in controlling the infection. However, that is not the case with every infection, and the collected purulent material, instead of staying contained, moves out along the path of least resistance to adjacent areas [6–9]. The path of least resistance varies. In infants and children up to 18 months of age, the infection can spread to the epiphysis. Outward spread towards the periosteum is a common mode of spread and results in the purulent material getting collected in the subperiosteal space. Such a spread can, at times, result in pan diaphyseal osteomyelitis too [7]. Additionally, involvement of the metaphysis near the physeal plate predisposes to an involvement of the physis too. The involved physeal region can lead to formation of a physeal bar. The location and size of the physeal bar determines the sequelae that the limb would finally land up in, i.e., whether it would be a short limb or, a limb with angular deformity, or both. In children who have infective arthritis, it is the synovium that is primarily involved. The organisms get lodged in the small vessels of the synovium and stimulate the host defense responses, resulting in release of many proteolytic enzymes. These enzymes are released by both the bacteria and the child's immune response. Consequently there occurs an excessive secretion of synovial fluid, resulting in a joint effusion, which is often the first sign of an infective process. This effusion generates pressure within the closed compartment of the joint that is harmful to the local blood supply. At times, the intracapsular pressure can result in subluxation and dislocation of the joint. Furthermore, proteolytic enzymes can destroy the articular cartilage too [2, 7, 10]. The epiphysis is often destroyed if the infection has occurred in the neonatal period (Fig. 1).

Figure 1: The left proximal humeral epiphysis is not visible in this 4-year-old child who had suffered from neonatal septic arthritis of the shoulder.

The pathophysiological aspect of the development of Sequelae

For children who have MskI but are treated appropriately, the results are satisfactory, with almost no major short-term or long-term complications and sequelae. However, complications do occur in many patients, and development of sequalae is not uncommon. The factors predisposing a child to these complications are enumerated below[2, 7].

1. Delay in diagnosis and initiation of treatment: This can be considered the most important factor from an Indian perspective. In developing countries, even though the healthcare facilities have improved over the years, still, delays in presentation and in initiation of appropriate treatment are not uncommon (Fig. 2).

Figure 2: A paediatric specialist failed to refer this patient in a timely manner to an Orthopaedic specialist resulting in the destruction of the capital epiphysis of the femur on both sides. The right hip is dislocated too.

2. Incomplete or inappropriate treatment: At times, even when MskI has been diagnosed early, appropriate treatment in the form of administration of suitable antibiotics by correct route, dose, and duration, as well as timely surgical intervention, is not done. This results in an increase in the possibility of development of complications and sequelae.

3. Predisposed patients: Patients with low immune status, like neonates, children with immunodeficiency states, and those with diseases like Type 1 diabetes mellitus and sickle cell

disease, are predisposed to develop MskI and have a greater tendency for developing sequelae.

4. Highly virulent and Atypical organisms: Infections caused by atypical organisms like Brucella, Burkholderia pseudomallei, M bovis, etc., are often not diagnosed well in time and can result in complications and sequelae [11].

Chronic Osteomyelitis

Chronic osteomyelitis can be considered a continuation of acute osteomyelitis that has failed to resolve completely [2, 12–14]. Classically, it may present with periods of quiescence of variable duration. Its occurrence, type, severity, and prognosis are multifactorial. Chronic osteomyelitis has a waxing and waning course and can persist for life. While the persistence of infection is just one aspect of chronic MskI, the condition can be associated with the occurrence of pathological fracture, joint stiffness, and physeal injury. The management of these complications is challenging. Once suspected on clinical grounds, further imaging studies in in the form of plain radiographs in two orthogonal views must be obtained. Obtaining CT and MRI is decided on a case-to-case basis. Laboratory investigations, including total and differential leukocyte counts, ESR, and CRP, must be obtained. The management is planned with the following aims:

1. Control of infection: This must be the priority while treating any patient of MskI. Radical debridement of the infected tissues is recommended (Fig. 3). Deep samples are sent for cultures and sensitivity testing. Superficial swabs must not be used, as the possibility of growing contaminants is high. Organism-specific antibiotics result in an increased possibility of controlling infection and hence the treatment must be switched from empirical antibiotics to specific antibiotics once the culture-sensitivity report is available. A few surgeons use antibiotic bone cement for local delivery of specific antibiotics. Recently, the use of bioabsorbable antibiotic drug delivery vehicles like calcium sulfate, tricalcium phosphate, morselized cancellous bone, etc., has shown promising results. The commonly accepted duration of antibiotic administration is 6 weeks although there is a recent trend of using them for shorter duration too. Blood counts, ESR, and CRP are obtained during treatment to judge the effectiveness of the treatment [15].

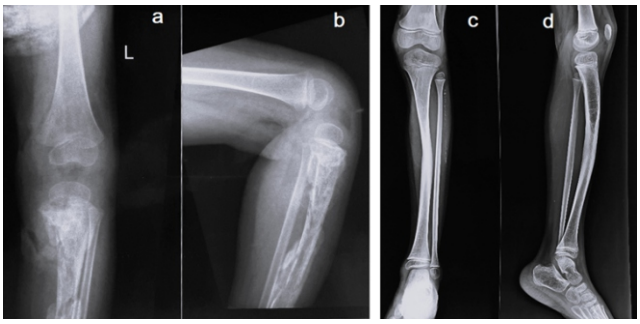

Figure 3: Chronic osteomyelitis affecting the whole of the left tibia of a 1 year old child (a, b) she was treated by extensive debridement followed by antibiotic therapy for 4 weeks. At 5 years follow up the bone has become near normal c, d)

2. Skeletal stabilization: While many patients undergoing debridement do not have a obvious fracture, a lot of patients do have a pathological fracture through the diseased bone or develop an iatrogenic fracture during the surgical procedure. In these cases, stabilization of the bone using an external fixator is often considered as the preferred treatment modality. Several patients can have gap non-union. A circular Ilizarov-type device or modular monorail system can be used to achieve union across the fracture/ non-union site (Fig. 4). The addition of stability aids in control of infection [16].

Figure 4: An 8 years old boy presented with 6 months history of discharging sinus on the right tibia (a,b). He underwent debridement, Ilizarov frame application and bone transport. 3 years after the frame removal (c,d) he is pain free with near normal limb function.

3. Bone defect/Gap non-union: In patients of chronic osteomyelitis frequently a bone defect (gap) is seen. This might result from resorption of bone by the pathological process itself or, at times, is the consequence of surgical debridement performed to control infection. This resulting gap non-union can be addressed by autologous bone graft, bone transport, or the Masquelet technique. Appropriate stabilization with implants or external fixator is necessary to allow for healing to occur [17].

4. Soft tissue problems: Frequently, repeated debridement results in a loss of skin and soft tissues. At this juncture, reconstructive procedures with support from the plastic

surgery team are required.

5. Nutritional and other measures: Patients with chronic MSkI usually are undernourished. Appropriate dietary nutrients, in addition to supplementation during treatment, are recommended.

Sequelae of Infective Arthritis of Joints

Infective (Septic) arthritis of various joints is not uncommon. Frequently, the hematogenous seeding of infection occurs in the joints either directly by the involvement of the synovium or results from spread from the metaphyseal region of the bones affected by osteomyelitis. In the absence of appropriate treatment, acute bacterial septic arthritis can result in articular cartilage damage and joint destruction. Avascular necrosis can be seen as a potential complication of septic arthritis of the hip. Septic arthritis in children can potentially result in physeal injury and growth arrest causing a leg-length discrepancy and/or angular deformity. The destruction of articular cartilage can result in contractures across the joint or, in some cases, where the portion of the epiphysis is itself damaged; even instability (excessive laxity) can be a consequence (Fig. 5). Choi et al. have presented an extensive review of the pattern of destruction of the hip joint along with the treatment options for neonates and young children who have had the misfortune of septic arthritis [18]. Depending on the pattern of destruction of the femoral head and the available bony structures for reconstruction, management is offered to the patients that can range from serial lengthening, open reduction of the hip, and trochanteric osteotomy.

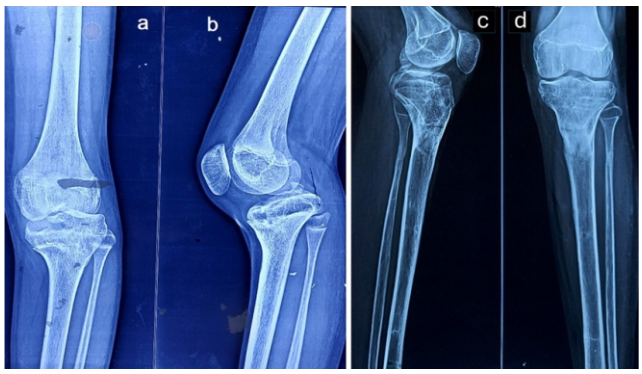

Figure 5: A 14 years old boy presented with history of osteomyelitis when he was 9 years old. At presentation he had a varus and recurvatum deformity and a short tibia resulting from proximal tibial physeal bar (a,b). He underwent an oblique plane deformity correction and simultaneous lengthening using Ilizarov ring fixator. At one year post surgery he has near normal function of the affected limb, (c, d)

Sequelae of physeal involvement in MskI

The physis is responsible for growth of bones in the children. This is possible by the presence of germinal cells in the physis. Involvement in the process of MskI can result in a disruption of the physeal structure causing the loss of germinal cells and that of the pattern of physeal arrangements. Additionally, like fracture healing, blood vessels reach the hypertrophic zone of the physis during the infection and its healing process, too, and then an ossification response is stimulated, resulting in the formation of a localized bony bridge. The effect of a bony bar varies depending on its location and size. A centrally located large bar will stop the growth of the entire physis, resulting in shortened bone. This can then lead to limb length discrepancy or, at times, joint incongruity if it involves any one of a pair of bones (forearm bones or leg bones). If the bar is located eccentrically, growth stops at the region around the bar, but the rest of the physis continues to grow, resulting in a progressive angular deformity [19]. The consequence of this phenomenon would be the development of limb shortening, angular deformity, and/or both, depending on what region and how much of the physis is involved [3]. Management of these sequelae needs proper clinical evaluation especially concerning the functional limitation that the patient is having, and imaging studies aimed at understanding and planning of reconstructive options.

Clinical evaluation– After a detailed history of the entire course of the disease, the clinician should assess for the presence of limb length discrepancy (LLD), angular deformity, or both in the overall limb and then in each segment of the limb. These are much more important in the lower limbs as the functional impact in the form of difficulty in ambulation is significant. The upper limb abnormalities are usually compensated to a certain extent by the movements at the shoulder joint. Note should be made regarding the presence of any active infection, of the condition of the skin and muscles as they tend to be often scarred from the disease process and the previous surgeries. The available range of movements of the joints must be assessed, too.

Imaging studies– Plain radiographs are the first images that should be obtained. Full length films must be obtained for planning any proposed deformity correction. Radiographs for estimation of bone age of the child must be obtained to have an idea as to whether attempts to resect the physeal bar or using growth modulation techniques can be considered as a treatment option. If the bone age is favorable (at least two years of growth remaining), then further assessment of the size and the site of the bar is performed using CT scans and MRI studies. Bars that cover >30 to 50% of the physis are unlikely to respond to bar resection and the parents must be counselled for the same

and other options weighed upon [19].

P**arental expectations**– It is not uncommon to find parents reporting varying severity of deformity and functional disability in their child consequent to a sequela of previous MskI expecting for complete restoration of function. It is important that the surgeon provides them with a realistic plan and counsels them about the expected outcome.

Management of Limb length discrepancy (LLD)– Milder degrees of LLDs (usually up to one inch) are managed well with shoe lift. However, surgical intervention, either in the form of lengthening of the short limb with or without a timed epiphysiodesis of the contralateral limb, is necessary. In children with large LLD, repeated lengthening might be needed. This can be performed with the low-cost ring fixator or mono-lateral rail fixator. Recently, the use of electromagnetic expandable intramedullary nails has come up too that are cosmetically more acceptable to the patients. However, the high cost and limited availability of these is a challenge. Gaining length of around 4-5 cm in one sitting is safe and well tolerated with minimal complications. A well timed contralateral epiphysiodesis to limit the growth of the other limb can be performed concomitantly to control the amount of lengthening needed for the affected limb.

Management of angular deformities- Similar to the management of LLD, one has to identify if the angular deformity resulting from an eccentrically located physeal bar would benefit from a bar excision in a child in whom sufficient growth is remaining. In case either the bar is too large, or the child has limited growth potential remaining, the deformity can be addressed by corrective osteotomy. A well-planned acute corrective osteotomy can be performed that can then be fixed internally. The ring fixator system can also be used to correct the deformity gradually. This permits the correction of deformities that are in more than one plane and that are associated with LLD, as the same device can be used to gain length simultaneously. Older children and adolescents tolerate the device well, which can be a preferred modality to gain correction while maintaining the limb length (Fig. 5).

Conclusion:

Complications and sequelae following MskI infections in children is not uncommon. The ideal aim of treatment for any MskI should be a control of infection and restoration of function. Decision making needs appropriate clinical examination and radiological evaluation. Treatment should be individualized for every patient, and they must be followed up for long term as many of them might need subsequent surgical procedures.

References

1. Davis CP Definition of Sequela.

https://www.rxlist.com/sequela/definition.htm. Accessed 10 May 2024

2. Dodwell, E. R. (2013). Osteomyelitis and septic arthritis in children: current concepts. Current opinion in pediatrics, 25(1), 58-63.

3. Belthur M V, Esparza M, Fernandes JA, Chaudhary MM (2022) Post Infective Deformities: Strategies for Limb Reconstruction. In: Belthur M V, Ranade AS, Herman MJ, Fernandes JA (eds) Pediatric Musculoskeletal Infections: Principles Practice. Springer International Publishing, Cham, pp 411–493.

4. Krzysztofiak A, Roversi M, Musolino A, et al (2022) Clinical report and predictors of sequelae of 319 cases of pediatric bacterial osteomyelitis. Sci Rep 12:1–10. https://doi.org/10.1038/s41598-022-19208-2

5. Shenoy B, Singhal T, Yewale V, et al (2024) Indian Academy of Pediatrics Consensus Statement on Diagnosis and Management of Bone and Joint Infections in Children. Indian Pediatr 61:209–218.

6. Penny JN, Spiegel DA (2014) Chronic osteomyelitis in children. Glob Orthop Caring Musculoskelet Cond Inj Austere Settings 20:315–324. https://doi.org/10.1007/978-1-4614-1578-7_31

7. Ilharreborde B (2015) Sequelae of pediatric osteoarticular infection. Orthop Traumatol Surg Res 101:S129–S137. https://doi.org/10.1016/j.otsr.2014.07.029

8. Manz N, Krieg AH, Buettcher M, et al (2020) Long-Term Outcomes of Acute Osteoarticular Infections in Children. Front Pediatr 8:1–9. https://doi.org/10.3389/fped.2020.587740

9. Montgomery NI, Epps HR (2017) Pediatric Septic Arthritis. Orthop Clin North Am 48:209–216. https://doi.org/10.1016/j.ocl.2016.12.008

10. Brown DW, Sheffer BW (2019) Pediatric Septic Arthritis: An Update. Orthop Clin North Am 50:461–470.

https://doi.org/10.1016/j.ocl.2019.05.003

11. Dashti AS, Karimi A (2013). Skeletal involvement of Brucella melitensis in children: a systematic review. Iranian journal of medical sciences. Dec;38(4):286.

12. Barakat A, Schilling WH, Sharma S, et al (2019) Chronic osteomyelitis: a review on current concepts and trends in treatment. Orthop Trauma 33:181–187. https://doi.org/10.1016/j.mporth.2019.03.005

13. Foong B, Wong KPL, Jeyanthi CJ, et al (2021) Osteomyelitis in Immunocompromised children and neonates, a case series. BMC Pediatr 21:1–7. https://doi.org/10.1186/s12887-021-03031-1

14. Panteli M, Giannoudis P V. (2016) Chronic osteomyelitis: What the surgeon needs to know. EFORT Open Rev 1:128–135.

https://doi.org/10.1302/2058-5241.1.000017

15. Pinto D, Aroojis A (2022) Chronic Hematogenous Osteomyelitis. In: Belthur M V, Ranade AS, Herman MJ, Fernandes JA (eds) Pediatric Musculoskeletal Infections: Principles Practice. Springer International Publishing, Cham, pp 321–338.

16. Padman M, Rosenfeld SB, Belthur M V (2022) Pathological Fractures with Osteomyelitis. In: Belthur M V, Ranade AS, Herman MJ, Fernandes JA (eds) Pediatric Musculoskeletal Infections: Principles Practice. Springer

International Publishing, Cham, pp 383–409.

17. Nunn T, Patwardhan S, Hosny GA (2022) Post Infective Bone Gap Management of the Lower Extremity. In: Belthur M V, Ranade AS, Herman MJ, Fernandes JA (eds) Pediatric Musculoskeletal Infections: Principles Practice. Springer International Publishing, Cham, pp 543–559.

18. Choi I-H, Cho H-C (2022) Sequelae of Septic Arthritis of the Hip and Late Reconstruction. In: Belthur M V, Ranade AS, Herman MJ, Fernandes JA (eds) Pediatric Musculoskeletal Infections: Principles {\&} Practice. Springer International Publishing, Cham, pp 495–510.

19. Eastwood DM, Gheldere A De (2011) Physeal injuries in children. Surgery 29:146–152. https://doi.org/10.1016/j.mpsur.2011.01.003

Declaration of patient consent : The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

How to Cite this Article

Behera P, Gupta V, Gupta S | Sequelae of Paediatric Musculoskeletal Infections | International Journal of Paediatric Orthopaedics | September-December 2023; 9(3): 22-27.