

Musculoskeletal infection in children

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Purpose of review

Musculoskeletal infection in children is evolutionary. The emergence of new causative organisms, the development of antibiotic resistance among common organisms and an increased incidence of unusual clinical presentations of infection contribute to this evolution. Early, accurate diagnosis and prompt initiation of appropriate treatment remain central principles in the evaluation and treatment of acute orthopedic infections. This review summarizes the recent literature regarding musculoskeletal infection in children.

Recent findings

Kingella kingae has been identified as a causative organism of septic arthritis and osteomyelitis in children between the ages of 6 months and 2 years. Improved culture techniques allow more reliable detection of this gram-negative coccobacillus, which is otherwise difficult to isolate. There is a rising incidence of community-acquired methicillin-resistant *Staphylococcus aureus* as the cause of invasive musculoskeletal infection in children. Specific genetically encoded virulence factors may play a role in the occurrence of complications of chronic osteomyelitis and deep venous thrombosis in some children. The differentiation of septic arthritis from transient synovitis may be facilitated by an evidence-based clinical prediction algorithm. Variation of population characteristics from region to region may limit the application of such guidelines in general practice. Careful clinical judgment remains necessary.

Summary

Improved methods of evaluation of musculoskeletal infection including culture techniques for isolating *Kingella kingae*, genetic mapping of community-acquired methicillin-resistant *S. aureus* virulence factors, and magnetic resonance imaging to evaluate pelvic pyomyositis may lead to more accurate diagnosis and early administration of appropriate treatment for invasive musculoskeletal infections in children.

Keywords

children, musculoskeletal infection, osteomyelitis, pyomyositis, septic arthritis

Abbreviations

MRI	magnetic resonance imaging
MRSA	methicillin-resistant <i>Staphylococcus aureus</i>
pvl	Panton-Valentine leukocidin

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Introduction

Invasive infection of the musculoskeletal system in children is most commonly caused by *Staphylococcus aureus* and manifests as osteomyelitis, septic arthritis, and pyomyositis. Other causative organisms seem to have a proclivity for specific age groups, which may be a consequence of the timing of increased exposure to these bacteria in daycare and day school settings and the loss of passively acquired immunity. Little has changed in the past four decades regarding the principles of evaluation and treatment of musculoskeletal infection. Early recognition and prompt treatment are effective in resolving infection and preventing sequelae in most children with these conditions.

Recent literature, however, offers hope that clinical and basic research may improve our ability to recognize and treat musculoskeletal infection and its consequences. Clinical practice guidelines along with careful clinical judgment may enhance our ability to differentiate between septic arthritis and transient synovitis [1•]. Analysis of the genetic composition of bacteria may help us identify virulence factors predisposing to adverse outcomes that may enhance our vigilance in their presence [2•]. Finally, improved methods of bacterial isolation may allow a more accurate detection of causative organisms that might otherwise elude recognition [3•].

Osteomyelitis

Acute hematogenous osteomyelitis in children is most commonly caused by *S. aureus* (70–90% of cases) [4•]. The most common location of involvement is the metaphyseal region of long bones, with the lower extremities more commonly affected than the upper extremities [5•]. The diagnosis is usually made on the basis of elevated laboratory indices consistent with infection along with a suggestive clinical history. Plain radiographs may demonstrate deep soft tissue swelling, and bone scintigraphy often reveals increased uptake on all three phases in the area of involvement. Other locations of osteomyelitis, which may be difficult to identify and often result in diagnostic delay, include the spine, pelvis, or foot. Magnetic resonance imaging (MRI) is considered the most useful supplemental

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study in these locations and in any child with osteomyelitis who is not responding to appropriate antibiotic treatment because it allows a thorough delineation of the anatomic and spatial extent of the infection and may detect abscesses that require surgical drainage (Fig. 1). Whenever osteomyelitis is suspected on the basis of the clinical, radiographic, and laboratory evaluations, consideration should be given to performing an aspiration of the subperiosteal space and the metaphyseal bone at the site of maximum tenderness in an attempt to isolate the causative organism. In many instances, this may be the only means of positive identification of the organism, which confirms the diagnosis and guides the choice of antibiotic.

Osteomyelitis in the foot most commonly presents as hematogenous calcaneal osteomyelitis (Fig. 2). Foot puncture wounds rarely result in deep infections, including osteomyelitis. *Pseudomonas aeruginosa* is commonly identified as the causative organism in these infections. Toothpick puncture wounds have been reported to lead to delayed onset of osteomyelitis because plain radiographs failed to recognize the retained foreign body [6•]. Imaging with ultrasound or MRI proved useful in identifying the toothpick remnants in one series, leading to adequate debridement [6•].

Children usually present within a few days of the onset of symptoms, which typically include fever, pain, swelling, and limited use of the extremity. For most children, prompt diagnosis and rapid treatment with an appropriate antibiotic are the essential elements to avoid complications [4•]. Sequential parenteral-oral antibiotic treatment with a semisynthetic penicillin or a first-generation cephalosporin for 4 to 6 weeks is effective treatment for most children with uncomplicated infections. Occasionally, surgical intervention and more specific antibiotic treatment, possibly of longer duration, are needed to treat advanced stages of infection or unusual organisms. Surgical debridement is usually needed whenever plain radiographs or MRI have confirmed the presence of an intraosseous or subperiosteal abscess; however, subperiosteal collections of 2 to 3 mm have been noted to spontaneously resolve

following antibiotic treatment alone. The Cierny-Mader classification is useful in defining the anatomic stages and the physiologic class of the host, which may help to guide treatment in complicated cases [5•].

Chronic osteomyelitis is most commonly identified in the aftermath of the treatment of acute hematogenous osteomyelitis. Hallmarks of the condition include dead bone (sequestrum) surrounded by reactive new bone (involucrum). Children with chronic osteomyelitis have frequently undergone numerous surgical procedures and prolonged antibiotic treatment in an effort to eradicate their infections. At some point, the lack of blood supply to the area of infection results in the need for consideration of reconstructive surgical options in many of these children. Often this becomes imminent in the face of pathologic fractures that may surface during limited activities. Various methods of delayed reconstruction have been reported, including debridement, tissue transfer, bone grafting, and external fixation. A recent review indicated successful treatment of pediatric patients with tibial defects by use of the Ilizarov bone transport [7••]. The 30 patients in that series underwent 97 procedures, and their hospital stays ranged from 2 weeks to 18 months (average 4.7 months). Overall, 80% of these children had good outcomes with this form of treatment [7••].

Septic arthritis

Bacterial infection of joints typically occurs in children under the age of 5 years. Most commonly a child will present with limited use of an extremity. Physical examination often demonstrates an irritable joint with painful, limited range of motion. In superficial joints, such as the knee, elbow, or ankle, a joint effusion may be palpable or visible on plain radiographs. Deep joints, such as the hip or shoulder, may require ultrasound to determine the presence of intraarticular fluid (Fig. 3). The identification of a joint effusion in the presence of elevated infectious laboratory indices often leads to joint aspiration for inspection of the joint fluid with Gram stain, cultures, and white blood cell count. White blood cell counts greater than 50 000 cells/ml

Figure 1. Magnetic resonance images of distal femoral osteomyelitis.

(a) Subperiosteal abscess as seen on an axial short tau inversion recovery (STIR) sequence.
(b) Post-gadolinium T2-weighted image.

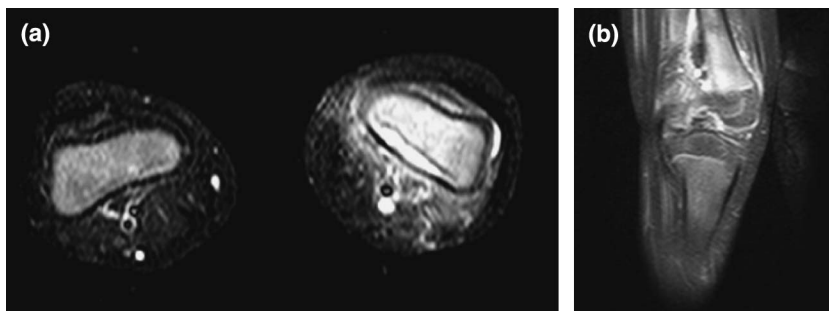


Figure 2. Magnetic resonance images of hematogenous calcaneal osteomyelitis.

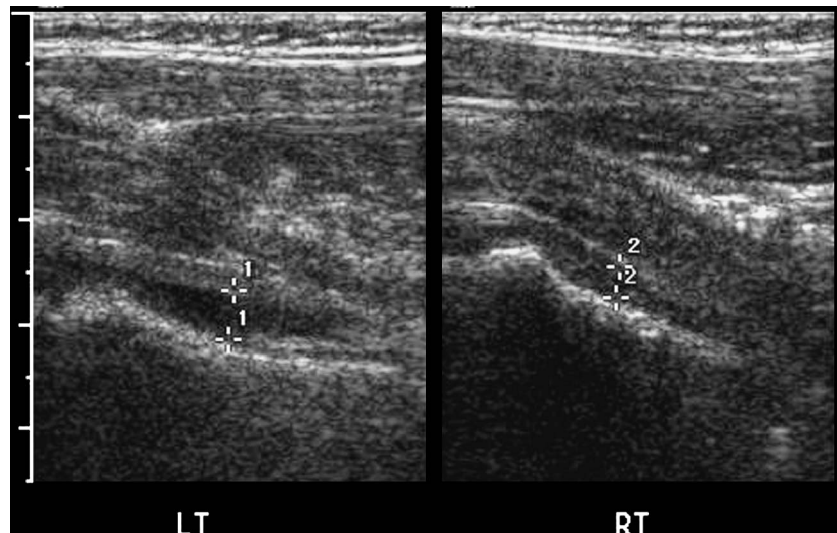


Marrow enhancement of the posterior tuberosity of the calcaneus is seen on axial short tau inversion recovery (STIR) (a) and coronal STIR (b) sequences.

with a predominance of polymorphonuclear leukocytes are suggestive of infection, whereas cell counts under 15 000 cells/ml are suggestive of inflammation. The differential diagnosis of joint inflammation includes transient synovitis and reactive arthritis, most commonly post-streptococcal reactive arthritis, and juvenile rheumatoid arthritis. Bacterial infections of the pelvic region, such as pyomyositis, iliopsoas bursitis, and pelvic osteomyelitis, may sometimes be difficult to differentiate from septic arthritis of the hip and require more elaborate studies such as MRI to enable the correct diagnosis to be made without unnecessary delay [8,9].

Figure 3. Ultrasound image of hip.

Ultrasound image of hip demonstrating increased joint space, as measured from the femoral neck to the joint capsule, of the left hip compared with the right.



Because of the importance of differentiating transient inflammation of the hip, which merely requires observation and antiinflammatory medication, from septic arthritis, which requires joint drainage and antibiotics, researchers have studied the differences between these two conditions in children. Kocher *et al.* [10] initially conducted a retrospective review using multiple regression analysis and identified four risk factors that correlated positively with the presence of infection. They included (1) fever above 38.5° Celsius, (2) non-weight-bearing, (3) elevated erythrocyte sedimentation rate greater than 40 mm/h, and (4) elevated white blood cell count greater than 12 000 cells/ml. In the presence of zero of four predictors, the incidence of septic arthritis was 0.2% in the population studied, whereas when all four predictors were present, the incidence of septic arthritis was 99.6% [10]. A subsequent prospective validation study conducted at the same tertiary children's medical center found that the clinical prediction rule was less precise [11]. In this study, Kocher *et al.* [11] found that a child with zero predictors had a 2% chance of having septic arthritis, whereas a child with all four predictors had a 93% chance of hip sepsis. Luhmann *et al.* [11], however, using the same clinical prediction rule at a different tertiary center, found that the presence of all four independent predictors in their patient population had a probability of septic arthritis of only 59%. These findings at both institutions demonstrate the continued necessity of careful clinical judgment and close clinical follow-up if observation is pursued. Luhmann *et al.* [11] continue to recommend ultrasound and hip aspiration whenever a joint effusion is identified.

The treatment of septic arthritis involves some form of joint decompression along with the administration of appropriate empiric and specific antibiotic therapy for 3 to

4 weeks. Methods of joint decompression may include arthrotomy, arthroscopy, or serial joint aspiration. Many surgeons still prefer arthrotomy for hip sepsis because this joint is difficult to approach arthroscopically and the sequelae for inadequate joint decompression of the hip may be devastating. A recent study, however, has shown favorable outcomes by treating septic arthritis of the hip with repeated ultrasound-guided aspirations [12•]. In this study, children underwent a mean number of 3.6 aspirations, and 75% resumed walking after 24 hours [12•]. It is important to bear in mind, however, that these cases represent uncomplicated hip sepsis that was identified early in its course. Contiguous osteomyelitis of the proximal femur associated with septic arthritis continues to have a poor prognosis when treatment is delayed. Aggressive open surgical decompression may be the best means of ameliorating the adverse consequences seen under these circumstances.

Post-streptococcal reactive arthritis and acute exacerbations of juvenile rheumatoid arthritis may be difficult to differentiate from septic arthritis. A high level of clinical suspicion must be maintained in children with a known history of juvenile arthritis so that the rare episode of septic arthritis, which may still occur in these children, will not be overlooked [13•]. Children with a remote history of streptococcal infection may subsequently experience reactive arthritis. The evaluation of these children's conditions should include a throat swab for streptococcal culture and serum titers of anti-streptolysin O and anti-DNase B titers. The treatment of post-streptococcal reactive arthritis is controversial. Treatment with penicillin and antiinflammatory medication seems to be effective in ameliorating the symptoms. Lifelong prophylaxis with penicillin may be helpful in preventing carditis and rheumatic heart disease, identified as a late complication in a subset of these children [14•].

Pyomyositis

There is an increasing incidence of bacterial infection of skeletal muscle in children of temperate regions. Initially this was manifest as tropical pyomyositis, which might be found in as many as 4% of surgical admissions in tropical regions. Nontropical pyomyositis is the term used to describe the same condition found in temperate, nontropical zones. *S. aureus* accounts for more than 90% of cases of tropical pyomyositis but approximately 70% of nontropical pyomyositis. Trauma, immune compromise, and infection with viruses or parasites have been proposed as etiologic factors, but the actual pathogenesis of pyomyositis remains unknown.

Three clinical stages of pyomyositis have been recognized. The initial invasive phase, which is identified in 5% of cases, is associated with induration of the muscle without the formation of a discrete abscess and may respond to

antibiotic treatment alone. During the suppurative phase, occurring in 90% of recognized cases, children present with fever, limited use of the extremity, and demonstrable abscesses within muscle. Surgical decompression is needed to prevent progression to the late phase of the condition, which is associated with sepsis and death and occurs in 5% of cases.

Magnetic resonance imaging has proved useful in identifying pyomyositis and differentiating between the invasive and suppurative phases [8•,15•]. MRI is also useful in differentiating pyomyositis in the pelvic region from other bacterial infections that may be difficult to differentiate clinically (Fig. 4) [9•]. The use of MRI under these circumstances may help to avoid diagnostic delay and reduce the incidence of poor clinical outcomes in sequelae-prone children. MRI may also guide interventional radiology aspiration of the abscess [8•].

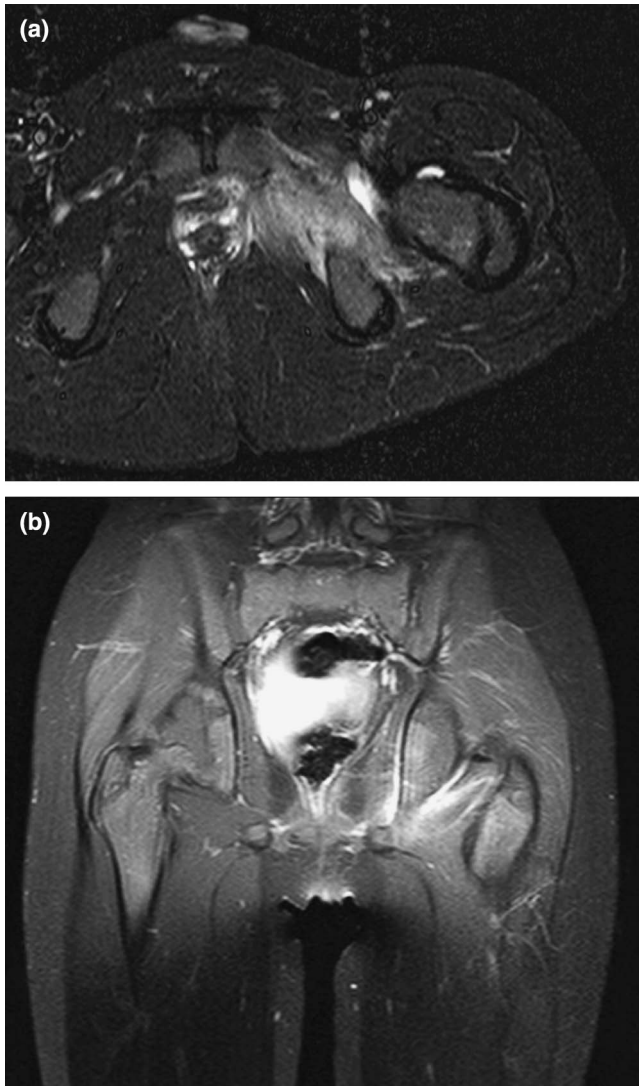
Pyomyositis is treated by surgical decompression, when indicated, and 3 to 4 weeks of appropriate sequential parenteral to oral antibiotic therapy. Children with immune compromise, including those infected with HIV, are prone to the development of pyomyositis caused by a broad spectrum of organisms, including opportunistic pathogens [16••]. Because of their immune compromise, a high level of clinical suspicion must be maintained, and aggressive surgical treatment should be exercised to provide effective treatment [16••].

Causative organisms

Staphylococcus aureus remains the most common causative organism of musculoskeletal infections in all age groups. Other causative organisms seem to have a proclivity to specific age groups or in those children with a specific predisposition. Examples include the predominance of *Salmonella* infections in individuals with sickle cell disease and that of *P. aeruginosa* infections in children with late infections of the foot following puncture wounds.

Community-acquired methicillin-resistant *S. aureus* (MRSA) is responsible for an increasing percentage of invasive musculoskeletal infection. Most these bacteria remain sensitive to a variety of antibiotics, including clindamycin, trimethoprim-sulfamethoxazole, rifampin, vancomycin, and gentamicin. Clindamycin is often preferred to treat community-acquired MRSA unless macrolide-lincosamide-streptogramin B resistance is demonstrated by disk diffusion, which is performed by placing clindamycin and erythromycin discs 15 to 20 mm apart on the culture medium [2••,17]. A D-shaped zone of inhibition around the clindamycin disk, on the side of the erythromycin disk, indicates an inducible macrolide-lincosamide-streptogramin B phenotype [2••]. Bactrim and rifampin are suitable oral alternatives under this circumstance. In cases of

Figure 4. Magnetic resonance images of pelvic pyomyositis without evidence of discrete abscess.



(a) Axial short tau inversion recovery (STIR) image shows enhancement of the obturator internus and externus. (b) Post-gadolinium T2-weighted image demonstrates increased signal within the piriformis.

multi-drug-resistant nosocomial MRSA infection, vancomycin is preferred for specific therapy [18]. Because bone penetration of vancomycin is less effective than that of other antibiotics more commonly used to treat osteomyelitis, rifampin is added to enhance the effects of vancomycin as well as to address intracellular pathogens.

The presence of selected genes encoding adhesion and virulence factors may ultimately explain the differences in clinical outcomes between methicillin-sensitive and methicillin-resistant strains of *S. aureus* with respect to complications such as chronic osteomyelitis or deep venous thrombosis [19[•]]. One recent study found that the

Panton-Valentine leukocidin (pvl) and fnbB genes were more frequent in MRSA strains than in methicillin-sensitive isolates [2^{••}]. The authors reported that the pvl and fnbB genes were found in 87 and 90% of patients with MRSA and 64% of those with methicillin-susceptible *S. aureus* [2^{••}]. They also found that the pvl gene was found in 10 patients in whom chronic osteomyelitis or deep venous thrombosis developed, whereas these complications were not seen in any children who were infected with pvl-negative strains [2^{••}].

An organism that has been increasingly recognized as a cause of osteoarticular infections in children between the ages of 6 months and 4 years is *Kingella kingae*, a fastidious gram-negative coccobacillus that is difficult to identify with standard culture methods. Recent reports have suggested that identification of the organism may be enhanced by injecting joint fluid specimens into blood culture bottles and inoculating bone aspirate specimens onto blood and chocolate agar plates [3,20,21[•]]. In one study, *K. kingae* was positively identified in five of the six cases of osteomyelitis in which the specimen was inoculated immediately during surgery [3^{••}]. In comparison, when the same bone aspiration specimens were sent to the laboratory for delayed plating, the organism was identified in only one of the six cases [3^{••}].

Another organism that rarely causes joint sepsis is *Neisseria meningitidis*. In the United States, serogroup W 135 seems to predominate as the cause of extrameningeal complications [22[•]]. One report identified five children with a median age of 34 months who had infection with *N. meningitidis* W135 [22[•]]. Three had evidence of septic arthritis, and the others had uveitis, pericarditis, or a persistent inflammatory syndrome [22[•]].

Streptococcus pyogenes is a causative organism of musculoskeletal infection, including osteomyelitis in school-age children (age 4 to 10 years). This corresponds to the age of greatest exposure to group A β -hemolytic *Streptococcus*. Incidentally, this age group is also the peak age of exposure to the varicella zoster virus, which has been associated with streptococcal osteomyelitis and septic arthritis as rare secondary infectious complications [23[•],24[•]].

Conclusion

Advances in culture techniques, imaging techniques, clinical prediction algorithms, and cellular genetics have been reported in the recent literature. Although these new insights may be helpful in standardizing the evaluation and treatment of musculoskeletal infection, further research is necessary to bring about a positive influence on the natural history of these disorders. Careful clinical judgment and the prompt initiation of appropriate treatment remain as central, guiding principles whenever infection

is considered in the differential diagnosis of a child with inflammation of the spine, pelvis, or extremities.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 510).

- 1** Kocher MS, Mandiga R, Zurakowski D, *et al.* Validation of a clinical prediction rule for the differentiation between septic arthritis and transient synovitis of the hip in children. *J Bone Joint Surg Am* 2004; **86-A**:1629–1635.

This article is critical to understanding the significance of the validity of Kocher's clinical prediction rule. The authors carefully articulate the benefits and pitfalls of using multiple regression analysis in establishing treatment guidelines for a population that may differ from that originally studied.

- 2** Martinez-Aguilar G, Avalos-Mishaan A, Hulten K, *et al.* Community-acquired, methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* musculoskeletal infections in children. *Pediatr Infect Dis J* 2004; **23**:701–706.

This research offers significant insight for the direction of future research that may prove useful in the treatment of resistant strains of *S. aureus*.

- 3** Gene A, Garcia-Garcia J-J, Sala P, *et al.* Enhanced culture detection of *Kingella kingae*, a pathogen of increasing clinical importance in pediatrics. *Pediatr Infect Dis J* 2004; **23**:886–888.

Increasing physician awareness of the specific culture requirements of *K. kingae* will most likely help in identifying the true epidemiology of what was previously thought to be 'culture-negative' osteomyelitis and septic arthritis in children between the ages of 6 months and 4 years.

- 4** Darville T, Jacobs RF. Management of acute hematogenous osteomyelitis in children. *Pediatr Infect Dis J* 2004; **23**:255–257.

This article gives a general overview that may be helpful for primary care physicians and residents.

- 5** Lazzarini L, Mader JT, Calhoun JH. Osteomyelitis in long bones. *J Bone Joint Surg Am* 2004; **86-A**:2305–2318.

This article is a more detailed review of this subject by authors who have tremendous experience in the evaluation and treatment of osteomyelitis.

- 6** Imoisili MA, Bonwit AM, Bulas DI. Toothpick puncture injuries of the foot in children. *Pediatr Infect Dis J* 2004; **23**:80–82.

The awareness that a toothpick injury should prompt an early evaluation with ultrasound and/or MRI will result in fewer cases of delay in treatment and the consequences of deep invasive infection.

- 7** Yeargan SA 3rd, Nakasone CK, Shaieb MD, *et al.* Treatment of chronic osteomyelitis in children resistant to previous therapy. *J Pediatr Orthop* 2004; **24**:109–122.

The outcomes reported in this series are exceptional for a very complex problem. This is the first report in the literature to clearly spell out an aggressive early debridement strategy supplemented with a multiplane external fixator to allow bone transport into segmental defects created by infection.

- 8** Yu C-W, Hsiao J-K, Hsu C-Y, Shih TT-F. Bacterial pyomyositis: MRI and clinical correlation. *Magn Reson Imaging* 2004; **22**:1233–1241.

The differentiation between thick and thin rim enhancement may lead to an improved ability to predict which children should undergo early surgery compared with continued observation.

- 9** Wong-Chung J, Bagali M, Kaneker S. Physical signs in pyomyositis presenting as a painful hip in children: a case report and review of the literature. *J Pediatr Orthop* 2004; **13**:211–213.

Increased awareness of the various pelvic infections that may produce discrete physical finding may help physicians differentiate these conditions and avoid unnecessary procedures until appropriate imaging is available.

- 10** Kocher MS, Zurakowski D, Kasser JR. Differentiating between septic arthritis and transient synovitis of the hip in children: an evidence-based clinical prediction algorithm. *J Bone Joint Surg Am* 1999; **81**:1662–1670.

- 11** Luhmann SJ, Jones A, Schootman M, *et al.* Differentiation between septic arthritis and transient synovitis of the hip in children with clinical prediction algorithms. *J Bone Joint Surg Am* 2004; **86-A**:956–962.

The clear message from this paper is that careful clinical judgment is indispensable. We still do not have a perfect tool to predict the presence or absence of hip sepsis in all children with an irritable hip.

- 12** Givon U, Liberman B, Schindler A, *et al.* Treatment of septic arthritis of the hip joint by repeated ultrasound-guided aspirations. *J Pediatr Orthop* 2004; **24**:266–270.

This technique may be useful when children present early in the course of their infection. Close clinical follow-up is necessary to ensure appropriate response with this form of treatment.

- 13** Sauer ST, Farrell E, Geller E, Pizzutillo PD. Septic arthritis in a patient with juvenile rheumatoid arthritis. *Clin Orthop* 2004; **418**:219–221.

The authors demonstrate a disciplined approach to reaching a correct diagnosis when the primary diagnosis might otherwise overshadow joint sepsis.

- 14** Mackie SL, Keat A. Poststreptococcal reactive arthritis: what is it and how do we know? *Rheumatol* 2004; **43**:949–954.

This is a useful overview of post-streptococcal reactive arthritis. Areas of controversy are framed to help avoid overdiagnosis and overtreatment.

- 15** Scott DL, Kingsley GH. Use of imaging to assess patients with muscle disease. *Curr Opin Rheumatol* 2004; **16**:678–683.

This article is a limited and general overview of a variety of muscle diseases, including pyomyositis.

- 16** Tehranzadeh J, Ter-Oganesyan RR, Steinbach LS. Musculoskeletal disorders associated with HIV infection and AIDS: part I. Infectious musculoskeletal conditions. *Skeletal Radiol* 2004; **33**:249–259.

This is essential reading for practitioners who encounter immunocompromised children so they can be aware of the variety of causative organisms and physical manifestations of musculoskeletal infection that may be identified in these children.

- 17** Martinez-Aguilar G, Hammerman WA, Mason EO Jr, Kaplan SL. Clindamycin treatment of invasive infections caused by community-acquired, methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* in children. *Pediatr Infect Dis J* 2003; **22**:593–598.

- 18** Ish-Horowitz MR, McIntyre P, Nade S. Bone and joint infections caused by multiply resistant *Staphylococcus aureus* in a neonatal intensive care unit. *Pediatr Infect Dis J* 1992; **11**:82–87.

- 19** Yuksel H, Ozguven AA, Akil I, *et al.* Septic pulmonary emboli presenting with deep venous thrombosis secondary to acute osteomyelitis. *Pediatr Int* 2004; **46**:621–623.

The increasing incidence of these complications in children with osteomyelitis is important in the light of new research that may point to genetically driven virulence factors that may be linked to deep venous thrombosis and chronic osteomyelitis.

- 20** Osteomyelitis/septic arthritis caused by *Kingella kingae* among day care attendees—Minnesota, 2003. *MMWR Morb Mortal Wkly Rep* 2004; **53**:241–243.

- 21** *Kingella kingae* infections in children—United States, June 2001–November 2002. *MMWR Morb Mortal Wkly Rep* 2004; **53**:244.

This article comes from the Centers for Disease Control and increases our awareness of this important pathogen.

- 22** Faye A, Mariani-Kurkdjian P, Taha M-K, *et al.* Clinical features and outcome of pediatric *Neisseria meningitidis* serogroup W135 infection: a report of 5 cases. *Clin Infect Dis* 2004; **38**:1635–1637.

This article elaborates on the details of a rare cause of invasive musculoskeletal infection in young children and raises our awareness to new research that attempts to serotype bacteria that may commonly colonize the upper airways of children.

- 23** Bittmann S. Bacterial osteomyelitis after varicella infection in children. *J Bone Miner Metab* 2004; **22**:283–285.

The relation between varicella and streptococcal infections is well described in the literature. This article presents two cases that briefly reiterate the issue.

- 24** Konyves A, Deo SD, Murray JRD, *et al.* Septic arthritis of the elbow after chickenpox. *J Pediatr Orthop* 2004; **13**:114–117.

This article addresses the varicella/streptococcal relation with respect to septic arthritis. It provides a literature review, which is helpful in understanding the epidemiology.