

Metaphyseal osteomyelitis in children: how often does MRI-documented joint effusion or epiphyseal extension of edema indicate coexisting septic arthritis?

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Abstract

Background Joint effusions identified by MRI may accompany osteomyelitis and determining whether the joint effusion is septic or reactive has important implications on patient care.

Objective Determine the incidence of epiphyseal marrow edema, joint effusions, perisynovial edema and epiphyseal non-enhancement in the setting of pediatric metaphyseal osteomyelitis and whether this may be used to predict coexisting septic arthritis.

Materials and methods Following IRB approval, we retrospectively evaluated children who underwent MRI and orthopedic surgical consultation for suspected musculoskeletal infection between January 2011 and September 2013. Criteria for inclusion in the study were microbiologically/pathologically proven infection, MRI prior to surgical intervention, long bone involvement and age 0–18 years. MRI exams were independently reviewed by two faculty pediatric radiologists to confirm the presence of appendicular metaphyseal osteomyelitis, to evaluate extent of edema, to determine subjective presence of a joint effusion and to assess perisynovial edema and epiphyseal non-enhancement. Any discrepant readings were reviewed in consensus. Charts and operative notes were reviewed to confirm the diagnosis of osteomyelitis and septic arthritis.

Results One hundred and three joints with metaphyseal osteomyelitis were identified (mean age: 7.1 years; M:F 1.3:1), of whom 53% (55/103) had joint effusions, and of those, 75%

(41/55) had surgically confirmed septic arthritis. The incidence of coexisting septic arthritis was 40% in the setting of epiphyseal edema, 74% in epiphyseal edema and effusion, 75% with perisynovial edema, 76% with epiphyseal non-enhancement and 77% when all four variables were present. Of these, the only statistically significant variable, however, was the presence of a joint effusion with a *P*-value of <0.0001 via Fisher exact test. Statistical significance for coexisting septic arthritis was also encountered when cases were subdivided into intra-articular vs. extra-articular metaphyses (*P*-value = 0.0499). No statistically significant difference was found between patients younger than 24 months and those older than 24 months.

Conclusion Patients with joint effusions identified by MRI, in the setting of metaphyseal osteomyelitis, should be presumed to have septic arthritis until proven otherwise. Epiphyseal extension of edema, perisynovial edema and epiphyseal non-enhancement in the setting of metaphyseal osteomyelitis are not helpful predictors in differentiating reactive and pyogenic joint effusions. Osteomyelitis at a site with an intra-articular metaphyses, however, is more likely to have concurrent septic arthritis.

Keywords Children · Infection · Joint effusion · Magnetic resonance imaging · Osteomyelitis · Septic arthritis

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Introduction

MRI characteristics of complications of osteomyelitis, including surgically significant bone, subperiosteal and soft-tissue abscesses are well described. MRI is an important early tool to determine location and extent of infection as well as assist

with preoperative planning when surgically significant complications of osteomyelitis are identified [1–3]. One quandary regarding MRI is whether the presence of joint effusion, in the setting of nearby metaphyseal osteomyelitis, represents an innocuous, non-pyogenic reactive effusion or concurrent septic arthritis. This distinction is important because septic arthritis requires specific surgical irrigation and debridement of the joint compared with isolated osteomyelitis. In non-complicated osteomyelitis, management more commonly includes medical rather than surgical treatment. Therefore, knowing whether an effusion is reactive or pyogenic is important to optimize patient care [1, 4–7].

Several studies investigating MRI predictors of septic arthritis have shown considerable overlap of imaging features of pyogenic and non-pyogenic joint effusions [8, 9]. In pediatric and adult patients, MR findings of synovial thickening, perisynovial and bone marrow edema and enhancement and the lack of contralateral joint effusions favor septic arthritis rather than transient synovitis, but there is overlap of findings in pyogenic and non-pyogenic causes of a joint effusion [8, 9].

In our experience, when nearby osteomyelitis is present, not all cases of a coexisting joint effusion have represented pyogenic septic arthritis. To our knowledge, no study has addressed whether the extent of nearby osteomyelitis identified by MRI may help predict septic arthritis. Therefore, the purpose of this study was to determine the incidence of concomitant septic arthritis in the setting of appendicular metaphyseal osteomyelitis in children and whether epiphyseal extent of edema may help predict when a nearby joint effusion actually represents coexisting septic arthritis. Additionally, previously investigated characteristics of perisynovial edema and epiphyseal non-enhancement were evaluated.

Materials and methods

Patient selection

Following IRB approval, retrospective review was performed of all patients who underwent orthopedic consult for musculoskeletal infections and had MRI between January 2011 and September 2013 at an urban, tertiary care children's hospital. The orthopedic surgeons at our institution maintain a comprehensive spreadsheet of all patients on which they are consulted. Each entry was reviewed for relevance to osteoarticular infections and cross-checked in the picture archiving system (PACS) (Phillips iSite, Foster City, CA, USA) for MRI. In addition, a separate PACS search was performed using Primordial© keyword search solution (Primordial Design Inc., San Mateo, CA, USA) to include all MRI studies performed for musculoskeletal infection in the same time period. Criteria for inclusion in the study were as follows: (a) MRI prior to surgical intervention, (b) infection involving the

metaphysis of a long bone, (c) no medical comorbidities (sickle cell, immunosuppression, etc.) or history of direct inoculation osteomyelitis, (d) acute infection confirmed with microbiology and/or surgical pathology, and (e) patient age between 0 and 18 years. This resulted in a study population of 103 joints in 97 patients.

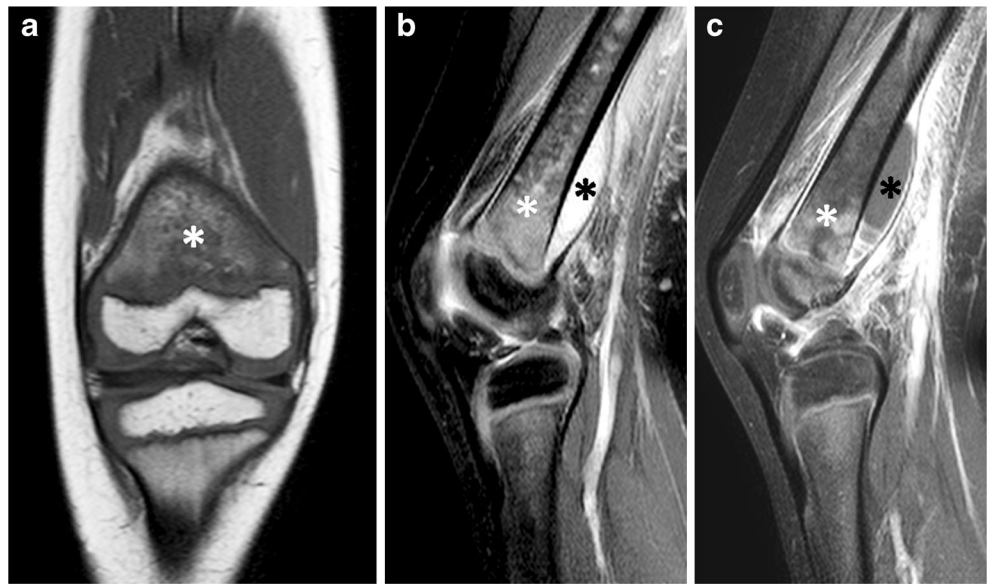
Imaging technique

All 103 joints were imaged using a 1.5-T or 3.0-T Achieva MR system (Philips Healthcare, Best, The Netherlands). On the basis of age and body size, a quadrature-body, XL Torso (Philips Healthcare) or cardiac coil was used for the region of interest. Imaging was then focused with a smaller field of view at the location of signal abnormality and the following sequences were obtained: T1-weighted coronal or axial, fluid sensitive (short tau inversion recovery [STIR], T2-weighted fat-saturated, or proton density fat-saturated) coronal and axial, and T1-weighted fat-saturated contrast-enhanced (0.1 mmol/kg IV gadopentetate dimeglumine [Magnevist, Bayer HealthCare, Whippany, NJ, USA]) sequences in two or three planes with fat suppression.

Imaging review and data collection

MRI exams were independently reviewed by two faculty pediatric radiologists with a combined 37 years of experience (G.S.B. 28 years, J.H.K. 9 years) to confirm the presence of appendicular metaphyseal osteomyelitis, evaluate extent of edema, determine subjective presence of a joint effusion and assess perisynovial edema and epiphyseal non-enhancement. Any discrepant readings were reviewed in consensus. Imaging evidence of osteomyelitis was defined as increased fluid-sensitive signal with corresponding decreased T1 signal and abnormal enhancement (Fig. 1) with additional supportive imaging findings including bone and soft-tissue abscesses and periosteal edema. When there was isolated marrow edema only, a study was labeled as osteomyelitis when there was clinical and surgical documentation of infection. All studies from the orthopedic surgical consult list were re-reviewed by imaging and chart review to confirm final diagnosis. Extent was recorded as involving the metaphysis with or without epiphyseal extension (Fig. 2). Subjective determination of a joint effusion was documented as present or not present. When applicable, the ipsilateral, non-involved joint or contralateral joint was used as a reference (Fig. 2). Positive perisynovial edema was defined as greater than 50% circumferential pericapsular edema-like signal. Positive epiphyseal non-enhancement was documented as present when there was either focal or diffuse non-enhancement of the epiphyseal cartilage and/or ossification center on postcontrast imaging (Fig. 3). The variable of epiphyseal extension of edema and epiphyseal non-enhancement could both be positive when fluid-sensitive sequences show epiphyseal edema but

Fig. 1 Isolated metaphyseal osteomyelitis without septic arthritis in a 4-year, 5-month-old girl presenting with limping, fever and knee swelling. Coronal T1 (a), sagittal proton density fat saturation (b), and postcontrast sagittal T1 proton density fat saturation (c) MRI sequences demonstrate distal femoral metaphyseal osteomyelitis (*white asterisk*), no epiphyseal extension of marrow edema and no effusion, but a large subperiosteal abscess (*black asterisk*)



postcontrast images demonstrate non-enhancing foci. Measurements for synovial thickness were not evaluated because there are no known normative standards for measurements to determine pathology in children that account for different appendicular joint locations, relative size of effusion, and differing ages and size of children. Chart and operative notes were reviewed to confirm the diagnosis of osteomyelitis with or without septic arthritis, at which time additional parameters (i.e. age, gender, etc.) were recorded. Joint effusion was considered septic based on laboratory evaluation, including an organism present on culture or Gram stain of synovial aspirate, a synovial fluid cell count of >20,000 white blood cells per cubic millimeter, or the presence of grossly purulent material in the joint at the time of surgery. Diagnosis of osteomyelitis was based on clinical examination, laboratory studies and culture of bone aspiration

with supportive MRI and/or surgical findings. When there was discrepancy between imaging and clinical diagnosis, imaging was re-reviewed, and surgical and microbiological diagnosis was taken as the reference diagnosis.

Results

General

Ninety-seven children with metaphyseal long bone osteomyelitis were identified with a total of 103 joints. The average patient age was 7.1 years with standard deviation of 4.6 years. The median was 7 years with a minimum age of 1 month and maximum age of 15.4 years. The lower quartile was 2.8 years

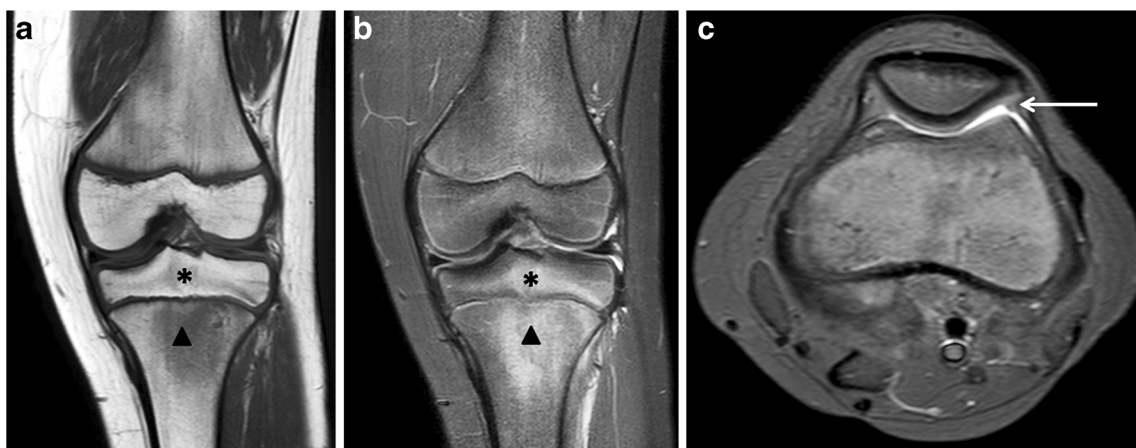


Fig. 2 Metaphyseal osteomyelitis with marrow edema extending to the epiphysis without coexisting septic arthritis in a 10-year, 5-month-old boy presenting with left knee pain for 5 days, no trauma, and elevated erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). Coronal T1 (a), coronal STIR (b) and axial STIR (c) MRI sequences

demonstrate proximal tibial metaphyseal osteomyelitis (*black arrowhead*) with marrow edema that extends to the epiphysis (*black asterisk*) and a physiological amount of fluid in the joint, i.e. no joint effusion (*white arrow*)

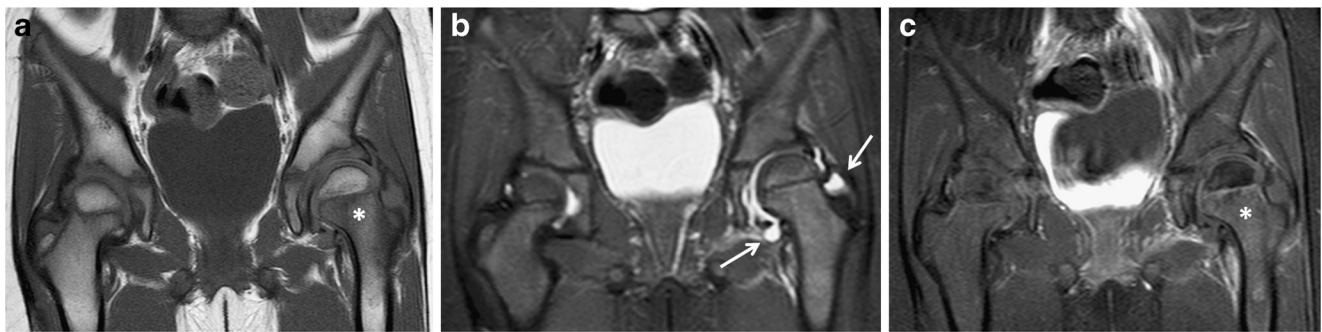


Fig. 3 Metaphyseal osteomyelitis of the proximal femur with hip effusion surgically proven as concurrent septic arthritis in a 4-year, 1-month-old girl presenting with poorly localized left lower extremity pain for roughly 1 week, fever and inability to bear weight. Coronal T1 (a), coronal STIR (b) and postcontrast coronal T1 fat saturation (c) MRI images demonstrate left proximal femoral metaphyseal heterogeneous

low T1, increased STIR signal and heterogeneous enhancement (white asterisks) of the marrow consistent with early osteomyelitis with a joint effusion (white arrows). The decreased enhancement of the left femoral capital epiphysis is an example of what was recorded as positive for the variable of epiphyseal non-enhancement

and the upper quartile was 10.7 years; therefore, 50% of the children were between the ages of approximately 3 and 11 years. Fifty-six percent of the patients were male, while 44 were female for a 1.3:1 male-to-female ratio. Distribution of metaphyseal osteomyelitis in the appendicular skeleton is presented in Table 1 with 34% occurring around the knee, 36% around the ankle, 16% at the hip, 6% at the shoulder, 4% at the wrist and 3% around the elbow. The overall incidence of coexisting septic arthritis in the setting of metaphyseal osteomyelitis irrespective of extent of edema, presence of joint effusion, perisynovial edema or epiphyseal non-enhancement or age was 40% (41/103).

Intra- vs. extra-articular metaphyses

At sites where the metaphysis is intra-articular (proximal femur, proximal radius, distal fibula and proximal humerus), the rate of coexisting septic arthritis was 55% (17/31) (Table 2). When joints were divided between those with intra-articular metaphyses and those with extra-articular metaphyses, a statistically significant positive relationship was identified between those with intra-articular metaphyses and coexisting septic arthritis (P -value = 0.0499).

Effusions (reactive vs. pyogenic)

Of the 103 sites of osteomyelitis, 55 (53%) had coexisting joint effusions. Of these, 25% (14/55) were reactive/non-pyogenic while 75% (41/55) represented coexisting septic arthritis (pyogenic effusion) (Tables 2 and 3). No cases of coexisting septic arthritis were identified that did not have MR identified effusion. Mean age at which the effusion was reactive was 5.5 years (standard deviation 5.3) versus 7.4 years (standard deviation 4.7) when the effusion was pyogenic. Using a Wilcoxon rank test, the difference in age was not statistically significant with a P -value of 0.2160. Additionally, presence of effusion and the relationship with coexisting

septic arthritis were divided in the age groups younger than 24 months and older than 24 months because of differences in vascular anatomy (Table 3). In the category of patients younger than 24 months, 69% of effusions (9/13) represented coexisting septic arthritis rather than reactive effusions. The overall rate of coexisting septic arthritis in this age group was 43% (9/21). In the category of patients older than 24 months, 76% (32/42) of effusions represented concurrent septic arthritis. Using Fisher exact test, there was no statistically significant difference between the two age groups in predicting whether an effusion represented coexisting septic arthritis versus reactive effusion with a P -value of 0.7188.

The incidence of effusion and septic arthritis was also analyzed by joint location and summarized in Table 1.

Extent of marrow edema

When evaluating extent of bone marrow edema, 29% (30/103) of cases demonstrated edema-like signal in the metaphysis only, while the remainder, 71% (73/103), demonstrated extension of signal into the epiphysis (Table 2). When edema extended to the epiphysis, 40% (29/73) of cases represented coexisting septic arthritis. When edema was present in the metaphysis only, 40% (12/30) of cases represented coexisting septic arthritis. When epiphyseal edema was present, 53% (39/73) of cases also demonstrated joint effusion and of these 74% (29/39) represented coexisting septic arthritis. Forty-seven percent (34/73) of patients with epiphyseal edema did not have effusions. When marrow edema was present in the metaphysis only, 53% (16/30) demonstrated joint effusions of which 75% (12/16) represented coexisting septic arthritis. No effusion was present in 47% (14/30) of the cases with only metaphyseal marrow edema. In summary, there was no statistically significant difference in the presence of epiphyseal edema or the presence of effusion and epiphyseal edema in predicting coexisting septic arthritis via Fisher exact test with a P -value of 1 and 1, respectively (Tables 2 and 3). In

Table 1 Summary of joint location, age, gender, presence of joint effusion, coexisting septic arthritis, perisynovial edema, epiphyseal non-enhancement, organism cultured and source

Location	N	Average age (Y)	M/F	+ Joint effusion (%)	+ Coexisting septic arthritis (%)	+ Perisynovial edema (%) ^b	+ Epiphyseal non-enhancement (%) ^b	Organism	Source ^c
Metatarsals	2	10.3	1/1	50 (1/2)	0 (0/1)	100 (1/1)	0 (0/1)	100% MSSA	50% bone 50% SP abscess
Distal fibula ^a	9	4.7	3.5/1	67 (6/9)	33 (2/6)	50 (3/6)	0 (0/6)	22% MRSA 56% MSSA 11% Group A Strep 11% Strep pyogenes	22% joint 56% bone 22% blood
Distal tibia	28	7.7	1/1.3	43 (12/28)	75 (9/12)	92 (11/12)	25 (3/12)	43% MRSA 43% MSSA 3.6% Group A strep 3.6% Salmonella Group C 7.1% NOI	32% joint 50% bone 11% SP abscess 7% blood
Proximal fibula	4	8.4	3/1	0	0	N/A (no effusion)	N/A (no effusion)	50% MRSA 50% MSSA	75% bone 25% blood
Proximal tibia	11	8.2	1.2/1	45 (5/11)	60 (3/5)	100 (5/5)	80 (4/5)	55% MRSA 36% MSSA 9% Group A strep	27% joint 46% bone 9% SP abscess 18% blood
Distal femur	20	6.0	1/1.2	60 (12/20)	83 (10/12)	100 (12/12)	17 (2/12)	35% MRSA 50% MSSA	30% joint 30% bone
Proximal femur ^a	16	7.3	4.3/1	75 (12/16)	92 (11/12)	75 (9/12)	58 (7/12)	5% Group A strep 5% Salmonella Group B 5% no micro	20% SP abscess 15% blood 5% no culture
Distal radius	4	10.1	1/1	0 (0/4)	0 (0/0)	N/A (no effusions)	N/A (no effusions)	12.5% MRSA 75% MSSA 12.5% NOI	37.5% joint 37.5% bone 25% blood
Proximal ulna	1	7	1/0	100 (1/1)	100 (1/1)	100 (1/1)	0 (0/0)	75% MRSA 25% Strep intermedius	50% bone 50% SP abscess
Distal humerus	2	8.1	1/1	100 (2/2)	50 (1/2)	100 (2/2)	0 (0/2)	100% MSSA	100% SP abscess & blood
Proximal humerus ^a	6	5	1/1	67 (4/6)	100 (4/4)	100 (4/4)	25 (1/4) 25 (1/4) N/A [no gad]	50% Group A strep 50% NOI 50% MRSA 33% MSSA 17% Group B strep	joint 33% joint 17% bone 17% abscess 33% blood

MRSA Methicillin-resistant *Staphylococcus aureus*, MSSA Methicillin-sensitive *Staphylococcus aureus*, NOI No organism isolated, SP abscess Subperiosteal abscess, N/A Not applicable, [no gad] No gadolinium, i.e. no intravenous contrast, F female, M male, N number of patients, Y years

^a Locations where the metaphysis is intra-articular. There were no cases in the proximal radius, which also has an intra-articular metaphysis

^b Percentage of cases that are positive (perisynovial edema, non-epiphyseal enhancement) when a joint effusion was identified

^c If coexisting septic arthritis, first choice for location for organism was joint; if osteomyelitis, first choice for location for organism was bone, second was subperiosteal abscess and third was blood. If location was not from primary choice, additional clinical parameters detailed in [Materials and methods](#) sections confirmed diagnosis of uncomplicated osteomyelitis versus coexisting septic arthritis

Table 2 Incidence of multiple variables in the setting of metaphyseal osteomyelitis with presence of coexisting septic arthritis ($n=103$)

Variable	Total (%)	Number of coexisting septic arthritis (%)	P-value via Fisher exact test
Joint effusion			
Yes	55 (53%)	41 (75%)	<0.0001
No	48 (47%)	0 (0%)	
Epiphyseal edema			
Yes	73 (71%)	29 (40%)	1.0000
No	30 (30%)	12 (40%)	
Intra-articular metaphysis			
Yes	31 (30%)	17 (55%)	0.0499
No	72 (70%)	24 (33%)	
Age group			
<24 months	21 (20%)	9 (43%)	0.8053
≥24 months	82 (80%)	32 (39%)	

the context of children younger than 24 months, 67% (14/21) demonstrated epiphyseal extension of edema of which 57% (8/14) were confirmed as coexisting septic arthritis. In children older than 24 months, 72% (59/82) demonstrated epiphyseal extension of edema of which 36% (21/59) represented coexisting septic arthritis. The proportions of coexisting septic arthritis in these two age categories when epiphyseal edema was present is not statistically significant by a Fisher exact test but does suggest a trend with a P-value of 0.2234.

Organism cultured

In regard to the rate of organism recovery in the setting of musculoskeletal infection, bacteria were cultured in 94% (97/103) of cases. Ninety percent were caused by *Staphylococcus aureus*. Methicillin-resistant *Staphylococcus aureus*

Table 3 Incidence of coexisting septic arthritis when there is metaphyseal osteomyelitis and a joint effusion present ($n=55$) with the presence of the following additional variables

Variable	Total (%)	Number of coexisting septic arthritis (%)	P-value via Fisher exact test
Epiphyseal edema			
Yes	39 (71%)	29 (74%)	1.0000
No	16 (29%)	12 (75%)	
Perisynovial edema			
Yes	48 (87%)	36 (75%)	1.0000
No	7 (13%)	5 (71%)	
Epiphyseal non-enhancement			
Yes	17 (32%) ^a	13 (76%)	1.0000
No	36 (68%) ^a	27 (75%)	
Age group			
<24 months	13 (24%)	9 (69%)	0.7188
≥24 months	42 (76%)	32 (76%)	

^a Two missing values, denominator of the percentage was 51

(MRSA) represented 36% (37/103) of the total infections and 41% (17/41) of the coexisting septic arthritis cases. Methicillin-sensitive *Staphylococcus aureus* (MSSA) represented 49% (50/103) of the total infections and 51% (21/41) of the coexisting septic arthritis cases. The type of bacteria cultured by joint location and source of sample (joint, bone, blood, etc.) is provided in Table 1.

A subset analysis of patients with documented joint effusions by MRI and additional variables in the setting of metaphyseal osteomyelitis ($n=55$) are shown in Table 3.

Perisynovial edema was present in 87% of patients with MRI-documented joint effusion (48/55). Of these patients, 75% (36/48) represented cases of coexisting septic arthritis. For the 7 joints without perisynovial edema, coexisting septic arthritis was present in 71% (5/7). In regard to epiphyseal non-enhancement, two studies could not be evaluated secondary to lack of intravenous contrast. Thirty-two percent (17/53) of patients with MRI-documented joint effusion demonstrated focal or diffuse epiphyseal non-enhancement. Of these patients, 76% (13/17) represented coexisting septic arthritis. When epiphyseal non-enhancement was not present, 75% (27/36) had coexisting septic arthritis. Epiphyseal extension of edema was present in 71% (39/55) of cases with effusion. When epiphyseal edema and joint effusion were present, septic arthritis was confirmed in 74% (29/39). When evaluating the above variables in the setting of positive joint effusion, none of them was statistically significant, all with a P-value of 1 using a Fisher exact test. For cases in which all variables were positive in the setting of metaphyseal osteomyelitis (combination of a joint effusion, epiphyseal edema, perisynovial edema and epiphyseal non-enhancement), the incidence of coexisting septic arthritis in the setting of metaphyseal osteomyelitis was 77% (10/13).

Discussion

Although there has been dramatic change in the prognosis and disease course in acute osteoarticular infections during the last century, acute osteoarticular infections are still a source of morbidity and even mortality, especially when concurrent septic arthritis and osteomyelitis are initially overlooked [6, 10, 11]. In our study, the presence of a coexisting joint effusion in the setting of metaphyseal osteomyelitis was found to represent concurrent septic arthritis in a majority of cases (75%) with a P-value of <0.0001. Additionally, the feature of osteomyelitis at an intra-articular metaphysis correlated positively with coexisting septic arthritis (P-value = 0.0499). The other categories of age younger than or older than 24 months, presence or lack of concurrent intra-articular (epiphyseal) edema, perisynovial edema or epiphyseal non-enhancement did not predict whether an effusion was reactive or pyogenic. Therefore, patients with metaphyseal osteomyelitis and effusion,

regardless of the above factors, should be considered high risk for septic arthritis and appropriate work-up and management should be initiated [12].

The unique vascular anatomy in the neonate has long been cited as a cause for coexistence of osteomyelitis and septic arthritis. As in most children, the route of infection is hematogenous and bacteria seed the metaphysis due to slow flow in tiny hairpin vessels [10]. However, unique to the neonatal period, the cartilaginous epiphyses (before appearance of secondary ossification centers) receive blood directly from the metaphysis, explaining the reported higher incidence of concurrent infection in this age group [13]. Additionally, the neonatal periosteum is thinner and more likely to perforate, spilling infection into the joint and adjacent soft tissues [14]. McCarthy et al. [11] quote a rate of 76% and, more recently, Montgomery et al. [6] quote a rate of 78% for concurrent septic arthritis in the setting of *neonatal* osteomyelitis. In our study population, the percent of patients younger than 2 years with coexisting septic arthritis was 44%; however, children in this age group only represented 20% of the overall population. Since the epiphysis and metaphysis have a separate blood supply beyond the neonatal period, it is postulated that rates of concomitant osteomyelitis and septic arthritis should decrease in incidence. Including *all* pediatric age groups, the reported incidence of concurrent septic arthritis and osteomyelitis is 17–33% [11, 14–20], which is lower than our rate of 40%; however, we did not investigate cases of septic arthritis only. In our study, there was no statistical difference in cases of coexisting septic arthritis in the setting of metaphyseal osteomyelitis in children younger than versus older than 2 years of age (P -value = 0.8053) (Table 2).

On MR imaging, features of pyogenic and reactive effusions have significant overlap including size of effusions, synovial thickening and perisynovial edema, and this has been previously published [8, 9, 21, 22]. We did evaluate some of these additional parameters and found that the most consistent predictor of a coexisting pyogenic arthritis was solely the presence of a joint effusion, P -value <0.0001 (Tables 2 and 3). Perisynovial edema did not help with predicting the presence of coexisting septic arthritis (P -value = 1). Also in our study, the presence of epiphyseal nonenhancement was not anymore helpful in predicting coexisting septic arthritis (P -value = 1) in contradistinction to the findings recently published by Kim et al. [23] although our study populations differed since all our patients had coexisting metaphyseal osteomyelitis and conventional postcontrast imaging was performed rather than dynamic contrast imaging.

The potential relationship between extent of edema in the setting of osteomyelitis and presence of septic arthritis was investigated because we postulated that the proximity of marrow edema would correspond directly to the chance of having concurrent septic arthritis. Additionally, at some joints, the metaphysis is also intra-articular. These sites include the

proximal femur, proximal radius, distal fibula and proximal humerus [24]. We hypothesized that the presence of intracapsular (epiphyseal) edema and location at a joint with an intra-articular metaphysis would increase the risk of septic arthritis. Location at a joint with an intra-articular metaphysis was statistically significant (P -value = 0.0499), while presence of epiphyseal edema was not (P -value = 1), (Table 2).

Because of the significant impact on morbidity and mortality, Montgomery et al. [6] investigated parameters to improve earlier detection of coexisting osteomyelitis in the setting of septic arthritis, in which they coined the term concurrent infections. In contrast to our study, Montgomery et al. [6] started with patients with a known diagnosis of septic arthritis and looked for concurrent osteomyelitis. Our study examined patients with osteomyelitis and looked for concurrent diagnoses of septic arthritis. Additionally, our study focused on MR imaging features with clinical and surgical correlation, whereas Montgomery et al. [6] evaluated age, location, duration of symptoms, imaging performed and lab values, without documentation of whether MR was utilized during the work-up. Montgomery et al. [6] found an overall incidence of concurrent septic arthritis and osteomyelitis of 21.5%. In their study, patients were divided into four age group categories and no average age was provided. In a separate study involving 50 adult cases of septic arthritis, 33 cases of biopsy-proven septic arthritis and osteomyelitis were identified for an incidence of 66% [8]. Our study design and patient population were intrinsically different and our rate of 40% may not be directly comparable to these two previous studies.

In our study, we found a 0% incidence of surgically confirmed septic arthritis in cases with no evidence of an effusion on MRI. Therefore, in the setting of metaphyseal osteomyelitis, no MR evidence of effusion has a 100% negative predictive value for coexisting septic arthritis. This is discordant with a prior study that noted that 30% of adults with septic arthritis had no effusions identifiable by MRI [8]. In that study, the percentage included a relatively high number of small joint infections, specifically metatarsophalangeal and interphalangeal joints of the feet. When only large joints were analyzed, the rate of septic arthritis without effusion dropped to 9%, which is more in line with our study findings.

There are several limitations of this retrospective study. In terms of overall incidence, coexisting septic arthritis and osteomyelitis could be considered a matter of “what came first, the chicken or the egg?” For example, Montgomery et al. [6] published their incidence of concurrent osteomyelitis in the setting of septic arthritis (21.5%), while our incidence refers to concurrent septic arthritis in the setting of osteomyelitis (40%). Therefore, the rates cannot be directly compared. Additionally, the goal of this study was to facilitate diagnosis and management in the era when nearly all patients with suspected osteomyelitis are referred for MRI at our institution and to help answer the practical question of whether to suggest septic

arthritis when a joint effusion is present in the setting of osteomyelitis and to identify additional features such as intraosseous, subperiosteal or intra-muscular abscesses that would require surgical intervention. Another limitation is that the presence or absence of a joint effusion was made subjectively since there are no known normative values on MRI for what constitutes normal joint fluid volume versus joint effusion. Lastly, our study has a slight selection bias as four out of a total of 107 cases of osteomyelitis seen at our institution during this time period were not referred for an orthopedic consultation. These four cases were not included in the study cohort.

Conclusion

Adjacent joint effusions identified on MRI in children with appendicular osteomyelitis should be presumed to be pyogenic, and this should be conveyed to the treating surgeon to help facilitate surgical planning. However, our findings may not be applicable to the small joints of the hands and feet due to an insufficient number of cases. The presence or absence of transphyseal intra-articular epiphyseal extension of edema related to metaphyseal osteomyelitis cannot be used as a predictor of whether a joint effusion is reactive or pyogenic.

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Conflicts of interest None

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