Original Clinical Article

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Synovial fluid cell counts and its role in the diagnosis of paediatric septic arthritis

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Abstract

Purpose Clinical presentation of paediatric septic arthritis (SA) can be similar to other joint pathologies. Despite potential for infection in all major joints, most diagnostic criteria are based on values from the hip. This study identifies the best joint aspirate values in diagnosing SA in all joints.

Methods In all, 166 patients who underwent 172 joint aspirations at the authors' institution between 01 September 2004 and 01 September 2014 were retrospectively identified. Recorded measures included age, sex, duration of symptoms, fever history, weight-bearing status, aspiration results, serum results and antibiotic administration. Patients were placed in the following four categories: 'culture confirmed SA' (C-SA), 'suspected SA' (S-SA), 'Other' and 'Other-rheumatologic' (Other-R), a subcategory of 'Other'.

Results Most common sites of aspiration were the knee (55%) and hip (29%). Diagnostic grouping was as follows: C-SA = 44, S-SA = 45, Other = 83 (Other-R = 21). Fever and non-weight-bearing prior to admission were useful predictors of SA, though in C-SA patients, 21% did not have a fever and 23% could weight bear at the time of admission. Aspirate white blood cell (WBC) count was significantly greater in both C-SA (92 000 cells/hpf) and S-SA (54 000) than in Other (10 000) and Other-R (18 000) patients. The percentage of polymorphonuclear (%PMN) was also significantly greater in C-SA (81.1%) and S-SA (80.9%) than in Other (57.9%) and Other-R (63.3%).

Conclusion Joint aspirate values, especially %PMN, are valuable in diagnosing SA. Additionally, antibiotics pre-aspiration did not affect %PMN, facilitating subsequent diagnosis of infection. Lastly, while aspirate WBC count was a valuable indicator of SA, this finding is not as definitive as previous research suggests.

Level of Evidence: IV Case Series

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Introduction

Septic arthritis (SA) in the paediatric population can be a diagnostic challenge, as its clinical presentation can be similar to other joint pathologies. Children affected by these conditions may present with swelling and warmth in the affected joint with pain, fever, restricted range of movement and/or refusal to bear weight as predominant symptoms.[1] However, these findings are non-specific, making it difficult to establish a definitive diagnosis on clinical presentation alone. This is further complicated when treating infants and neonates in whom refusal to feed, crying and discomfort with joint manipulation (e.g. change of diaper) limits thorough evaluation. Despite these challenges, a prompt and accurate diagnosis is imperative to initiate treatment and prevent chondral damage or other sequelae such as avascular necrosis, osteomyelitis, joint dislocation, destruction of the epiphyseal plate, acute fulminate disease and death.[2]

Over the past few decades, clinical prediction algorithms guiding diagnosis have been proposed. Kocher et al[3] reported on four diagnostic criteria (history of fever, non-weight bearing, white blood cell (WBC) count >12 000 cells/mL and erythrocyte sedimentation rate (ESR) > 40 mL/h) to distinguish SA from transient synovitis. More recently authors have supported supplanting the ESR with the C reactive protein (CRP).[4-7] Alternate algorithms have been proposed by Luhmann et al[8] and Caird et al,[6] however, neither of these guidelines include an analysis of a joint aspirate. Most of these studies have focused on differentiating SA involving the hip from

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transient synovitis, though most joint infections do not occur in the hip.

When infection is suspected, joint aspiration is a critical component of evaluation. The presence of bacteria is diagnostic of SA, while a WBC count above 50 K/hpf upon microscopic examination of joint fluid aspirate is suggestive of SA, though it may be seen in other settings, such as inflammatory arthritis.[6,9] One recent study looking at WBC counts in joint aspirates demonstrated that those aspirates with WBC counts between 25 K to 50 K were still most likely to be SA.[10] While these data are very useful, there are relatively few studies in the literature describing the use of the percentage of polymorphonuclear (%PMN) cells from a joint aspirate in aiding with the diagnosis of SA. Some studies have used the cutoff of $\geq$ 90% PMNs to be indicative of SA, however, to our knowledge this cutoff was established in the literature by Ward et al[11] in 1960 without formalized repeated evaluation for its validity.

The main purpose of this study is to determine the best joint aspirate values, particularly %PMN, which we hypothesize is highly sensitive in diagnosing SA. A second goal is to establish such criteria which can be used to evaluate for SA in all affected joints, not just the hip, particularly since most potential joint infections do not involve the hip.

Patients and methods

An institutional review board approved retrospective review was performed of patients who underwent joint aspiration for acute joint-related symptoms at an urban tertiary paediatric centre, Children's Hospital Los Angeles, between September 2004 and September 2014. Data including age, sex, duration of symptoms, fever history, weight-bearing status, aspiration results (cell count, differential, culture, gram stain), serum results (WBC, CRP, ESR, platelet count, hematocrit count, blood culture results, gram stain), prior antibiotic administration and evidence of effusion on imaging studies were recorded. Patients were placed in the following categories: 'culture confirmed SA' (C-SA), 'suspected SA' (S-SA) and 'Other' (with subcategory 'Other-rheumatologic' (Other-R)). The category of 'suspected SA' was composed of patients without positive joint aspirate cultures who were given a discharge diagnosis of SA or SA with adjacent osteomyelitis and who underwent operative treatment for infection. This group was analyzed individually and compared with the other two groups as well as in combination with the 'confirmed SA' group compared with the 'Other' group.

Statistical analysis was performed using Stata12 (StataCorp LP, College Station, Texas) and Microsoft Excel 2010 (Microsoft, Albuquerque, New Mexico). Student's *t*-test, Mann-Whitney U and chi-squared/Fischer exact testing were used for univariate analysis of variables, with *post hoc* analysis done by Tukey's Honestly Significant Difference or Games-Howell test. Multiple regression was utilized for multivariate analysis. A p-value was significant at < 0.05.

Results

In all, 166 patients who underwent 172 joint aspirations met inclusion criteria. The most common sites of aspiration were the knee (95 aspirates, 55%) and the hip (50 aspirates, 29%) Demographic data are listed in Table 1. Diagnostic grouping was as follows: C-SA = 44, S-SA = 45, Other = 83 (Other-R = 21). The most common diagnoses in the other category were transient synovitis (n = 15) and reactive arthritis (n = 11). Mean prior duration of symptoms was 22.3 days (SD 83.9; 0 to 730).

Out of the C-SA patients, 11 had Beta-hemolytic Streptococcus (BHS), ten had methicillin-susceptible *Staphylococcus aureus* (MSSA), six had Methicillin-resistant *Staphylococcus aureus* (MRSA), five had coagulase negative *Staphylococcus* (CNS), two had *Staphylococcus aureus*, two had *Streptococcus pneumoniae* and there was one patient with each of the following: *Streptococcus pyogenes*, *Propionibacterium acnes*, *Corynebacterium*, *Enterococcus faecium*, *fusobacterium nucleatum*, *Morganella Morganni*, *Neisseria meningitidis* and CNS, BHS and MSSA and BHS and CNS. One S-SA patient had CNS and another had *Viridans streptococci*, although it was noted that both of these were likely contaminants.

Clinical and serum test values are found in Table 2. There were significant differences in the percentage of patients with a history of fever prior to admission between both the C-SA and S-SA and both Other and Other-R groups, but not between the C-SA and S-SA groups. Additionally, C-SA and S-SA patients had significantly shorter duration of symptoms prior to presentation compared with Other-R patients.

Similarly, significantly more patients in both the C-SA and S-SA groups were unable to bear weight compared

Table 1 Demographic information

Covariant	Category	Value/percentage
Mean age, yrs (SD; range)		7.9 (4.6; < 1 mth to 17.7 yrs)
Sex, % (n)	Male	60 (99/166)
	Female	40 (67/166)
Side, % (n)	Right	51 (88/172)
	Left	49 (84/172)
Location, % (n)	Hip	29 (50/172)
	Knee	55 (95/172)
	Ankle	6 (10/172)
	Shoulder	3 (6/172)
	Elbow	6 (10/172)
	First metatarsophalangeal joint	1 (1/172)

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Table 2 Non-aspirate data

Lab value	Mean C-SA; SD; range	Mean S-SA; SD; range	Mean Other; SD; range	Mean Other-R; SD; range	Significant differences
Blood WBC count (K/uL)	14.1; 6.6; 0.1 to 32.4	11.1; 5.2; 0.74 to 29.04	10.8; 4.1; 1.27 to 25.06	10.4; 3.7; 5.77 to 18.93	C-SA vs Other (p = 0.02; CI 0.5 to 5.5); C-SA vs Other-R (p = 0.001; CI 1.3 to 5.3)
CRP (mg/dL)	13.6; 10.8; 0.5 to 43.7	7.8; 5.9; 1.1 to 22.8	4.9; 6.5; 0.5 to 37.4	4.9; 5.7; 0.5 to 20.4	C-SA vs S-SA (p = 0.002; CI 2.1 to 9.5); C-SA vs Other (p < 0.0001; CI 5.5 to 11.8); C-SA vs Other-R (p = 0.004; CI 2.9 to 14.3); S-SA vs Other (p = 0.02; CI 0.5 to 5.2)
ESR (mm/hr)	62.3; 39.9; 7 to 150	56.6; 33.1; 2 to 119	41.2; 35.2; 0 to 145	58.8; 45.4; 0 to 145	C-SA vs Other (p = 0.005; CI 6.5 to 35.6); S-SA vs Other (p = 0.02; CI 2.0 to 28.7)
Platelet (x 10^3/ microliter)	293.6; 125.6; 51 to 614	295.8; 132.6; 31 to 629	339.2; 118.4; 107 to 610	379.6; 109.2; 227 to 580	C-SA vs Other (p = 0.05; CI 0.1 to 91.2); C-SA vs Other-R (p = 0.01; CI 16.6 to 155.4); S-SA vs Other-R (p = 0.02; CI -11.4 to 156.2)
Haematocrit (%)	32.3; 6.7; 0.3 to 45.4	33.7; 6.2; 0.4 to 42.6	35.4; 4.4; 19.6 to 45.3	34.7; 4.2; 21.3 to 39.4	C-SA vs Other (p = 0.004; CI = 1.0 to 5.1)
Fever history (% of patients)	79	63	41	43	C-SA vs Other (p < 0.001); C-SA vs Other-R (p = 0.0001); S-SA vs Other (p = 0.02); S-SA vs Other-R (p = 0.03)
Inability to weight bear on admission (% of patients)	77	83	49	29	C-SA vs Other (p = 0.01); C-SA vs Other-R (p = 0.001); S-SA vs Other (p = 0.001); S-SA vs Other-R (p < 0.001)
Prior duration of symptoms (days)	6.1; 5.8; 0 to 30	7.4; 18.4; 0 to 120	30.3; 99.7; 0 to 730	67.1; 164.8; 0 to 730	C-SA vs Other-R (p = 0.02); S-SA vs Other-R (p = 0.02)

C-SA, culture confirmed septic arthritis; S-SA, suspected septic arthritis; Other-R, Other-rheumatologic; WBC, white blood cell; CI, confidence interval; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate;

with the Other and Other-R groups. There was no significant difference between inability to bear weight in the C-SA and S-SA groups.

Joint aspirate cell count and differential data are included in Table 3. Mean aspirate WBC counts for all groups were 43 000 SD 91 000 cell/hpf. Aspirate WBC counts were significantly higher in both the C-SA and S-SA groups than in the Other and Other-R groups. Aspirate WBC counts of C-SA and S-SA patients were not significantly different (p = 0.12). Additionally, no difference was found in aspirate WBC counts of C-SA and S-SA patients who received antibiotics prior to aspiration *versus* those who did not (p = 0.39; confidence interval (CI) -76643 to 30765).

For all patients, mean joint aspirate %PMN was 70% (SD 27%). Mean %PMN for C-SA (81%; SD 20%; 16% to 98%) and S-SA (81%; SD 20%; 8% to 97%) were both significantly higher than in Other and Other-R groups. When C-SA and S-SA were combined (81%; SD 21%; 8% to 98%) the aggregate mean was also significantly higher than both Other (p < 0.0001; CI 16.8 to 33.0) and Other-R (p = 0.001; CI 7.5 to 27.8). No difference was found in %PMN of patients who received antibiotics prior to aspiration *versus* those who did not (p = 0.97; CI -9.0 to 9.4). A lack of correlation was found between duration of symptoms and %PMN.

Discussion

The current study focuses on the importance of synovial WBC count and the differentiation of SA from other causes of irritable joints in children. Many algorithmic approaches to diagnose SA, including methods by Kocher et al[3] and Caird et al,[6] focus on differentiating SA of the hip from transient synovitis. However, unlike previous diagnostic criteria, the current study takes into account aspirate values of six different joints instead of one.

The current consecutive series of 172 joint aspirates (in 166 patients) from a tertiary paediatric centre evaluates all patients with joint aspirate being diagnosed for possible SA. In this study, only 29% of aspirates for suspected SA had hip involvement, and the most common site was the knee (95 aspirates, 55%). The criteria proposed for the hip cannot necessarily be extrapolated to cases of potential SA in other joints.

Despite its routine use in the work-up of patients with suspected SA, there is little research on the predictability of synovial values in diagnosing SA. Synovial results from joint aspiration are valuable in determining whether to proceed with irrigation and debridement for potential SA. Pääkkönen[12] suggests that children with acute symptoms with elevated CRP (> 2.0 mg/dL) or ESR (> 20 mm/hour) should have an aspiration to detect infection.

The dogma has been that synovial PMN differential > 90% indicates SA in children. This study demonstrates that this belief does not appear to reflect the reality of SA in a series of 172 consecutive joint aspirations. In the current study, mean %PMN in joint aspirates in both the C-SA and S-SA groups were approximately 81%, well below the 90% threshold typically cited, despite these values being significantly greater in both the C-SA and S-SA groups from Other (58%) and Other-R (63%). In fact, one patient in the C-SA group had a %PMN of only 16%. While Mistry

Table 3 Joint aspirate data

Lab value	Mean C-SA; SD; range	Mean S-SA; SD; range	Mean Other; SD; range	Mean Other-R; SD; range	Significant differences
Aspirate WBC count (cell/hpf)	92 000; 152 000; 13 to 939 240	54 000; 62 000; 105 to 236 800	10 000; 17 000; 0 to 82 500	18 000; 24 000; 280 to 82 500	C-SA vs Other (p < 0.0001; CI 32 000 to 137 000); C-SA vs Other-R (p = 0.03; CI 7000 to 141 000); S-SA vs Other (p < 0.0001; CI 30 000 to 58 000); S-SA vs Other-R (p = 0.01; CI 8000 to 64 000)
%PMN	81.1; 20.4; 16 to 98	80.9; 20.4; 8 to 97	57.9; 28.8; 0 to 95	63.3; 24.8; 8 to 91	C-SA vs Other (p < 0.0001; CI 13.5 to 32.9); C-SA vs Other-R (p = 0.003; CI 6.2 to 29.4); S-SA vs Other (p < 0.0001; CI 13.4 to 32.5); S-SA vs Other-R (p = 0.004; CI 6.0 to 29.1)
%Lymphocytes	7.5; 12.8; 0 to 71	7.2; 12.6; 0 to 72	14.5; 15.5; 0 to 68	15.1; 17.7; 0 to 68	C-SA vs Other (p = 0.017; CI 1.1 to 11.6); C-SA vs Other-R (p = 0.05; CI 0.1 to 15.9); S-SA vs Other (p = 0.002; CI 3.0 to 13.0); SA vs Other-R (p = 0.01; CI 2.2 to 16.9)
%Monocytes	9.7; 11.5; 0 to 69	12.0; 15.6; 1 to 79	24.5; 24.6; 0 to 91	18.6; 16.9; 2 to 55	C-SA vs Other (p < 0.001; CI 6.9 to 22.6); C-SA vs Other-R (p = 0.02; CI 1.7 to 16.1); S-SA vs Other (p = 0.003; CI 4.3 to 20.5)

C-SA, culture confirmed septic arthritis; S-SA, suspected septic arthritis; Other-R, Other-rheumatologic; WBC, white blood cell; CI, confidence interval; %PMN, % polymorphonuclear cells

et al[13] were unable to differentiate SA from acute rheumatic fever using %PMN and Aupiais et al[9] did not find a difference in %PMN between patients with SA, juvenile idiopathic arthritis and no diagnosis, %PMN was a reliable diagnostic differentiator between SA and other rheumatological pathology in the current study.[9,13] These values support findings by Pääkkönen[12] who stated that > 75% PMN is indicative of SA. As noted earlier, there were some %PMN values in the C-SA group as low as 16%.

Just as importantly, %PMN values in synovial aspirates were not impacted by the administration of antibiotics before the aspirate. The assumption that %PMN will be impacted by the administration of antibiotics was not true in this series. Knowing that antibiotic administration will not affect the %PMN evaluation of a joint aspiration is extremely useful information for the clinician and can help bolster a diagnosis of infection in the face of a negative gram stain.

Previous research has identified synovial WBC counts as an algorithmic factor in diagnosing SA. Heyworth et al[10] analyzed synovial fluid of hip aspirations and found 73% of patients with synovial WBC counts > 50 000 cells/mm^3 were diagnosed with SA. Interestingly, Heyworth et al[10] found that the Kocher criteria accurately predict SA when patients have synovial WBC counts of > 50 000 cells/mm^3, while reliability decreases for patients with synovial WBC counts of < 50 000 cells/mm^3. They found that patients with aspirate WBC counts of ≥ 50 000 cells/mm^3 were 4.4-times more likely to be diagnosed with SA compared with patients with WBC counts < 50 000 cells/mm^3. Aupiais et al[9] found that synovial WBC counts were better at differentiating SA from juvenile idiopathic arthritis compared with non-aspirate WBC counts. In the current study, mean aspirate WBC counts were significantly higher in C-SA patients than in Other and Other-R. S-SA patients exhibited significantly higher WBC counts than in Other patients. Despite the large variance in aspirate WBC counts, mean values for C-SA (92 000 cells/mm^3) and S-SA (54 000 cells/mm^3) patients were greater than the 50 000 cells/mm^3 minimum established by Heyworth et al.[10] Additionally, these findings contradict research indicating aspirate WBC counts less than 100 000 cells/mm^3 do not constitute SA.[14] While these are valuable findings, they did not take into consideration the %PMN value which looks to be a more valuable data point in an infection work-up.

History of fever prior to admission was a risk factor of SA in the current study, as supported by previous research.[3,6,15] Significantly greater percentages of C-SA (79%) and S-SA (63%) patients, both combined and separately, had history of fever compared with patients with other rheumatologic pathology. However, unlike Kocher et al[3] who found history of fever as a factor differentiating 'true' and 'presumed' SA, C-SA and S-SA were not statistically different. This may be attributed to the different definitions of presumed SA in Kocher et al[3] and S-SA in this study.

Caird et al,[6] when specifically looking at differentiating hip SA from transient synovitis of the hip, identified CRP levels > 2.0 mg/dL as the strongest independent risk factor for SA behind prior fever. Normal CRP values at the authors' institution are 0.0 mg/dL to 0.9 mg/dL. In this study, CRP levels in C-SA (13.6 mg/dL) patients were significantly greater than in S-SA (7.8 mg/dL), (Other (4.9 mg/dL) and Other-R (4.9 mg/dL) patients, while levels in S-SA patients were significantly greater than Other patients. However, despite the significantly greater values in the C-SA and S-SA patients, CRP levels in the Other and Other-R were above the diagnostic threshold of 2 mg/dL.[6,12] Similarly, Aupiais et al[9] had mean CRP levels of 3.3 mg/dL and 3.5 mg/dL for 'no definitive diagnosis' and 'juvenile idiopathic arthritis' patients, respectively. The high CRP levels in the Other and Other-R patients bring

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into question the validity of the previously established criterion of 2.0 mg/dL.[6] Whether this is related to the realities of an urban, tertiary care facility is not clear.

The significantly larger percentages of C-SA (77%) and S-SA (83%) patients with lower extremity SA unable to bear weight upon admission compared with the Other and Other-R groups are consistent with previous research; only 29% of our patients had hip aspirates, though 91% had lower extremity involvement.[3,16] The percentage of C-SA patients unable to bear weight in this study is comparable with that of true SA patients in Kocher et al[3] and Luhmann et al[8] (76% and 74%, respectively), but is lower than that of patients in Caird et al[6] (91%). The non-significant difference in weight bearing between C-SA and S-SA patients in the current study is also supported by previous literature.[3] The inability to bear weight may be indicative of SA, although the rates are not as high as Caird et al[6] suggest, who focused only on hip SA and synovitis.

ESR values in this study were significantly higher in C-SA (62.3 mm/hour) than in Other patients (41.2 mm/hour). The C-SA patients in this study exhibited higher ESR compared with values of 53.2 mm/hour and 51.6 mm/hour in previous literature.[3,13] However, the ESR value for Other patients challenges diagnostic criteria of $\geq$ 40 mm/hour for indication of SA, suggesting this value should be higher.[6,10,15] Whether this is, again, related to the realities of an urban, tertiary care centre is unclear. The higher value in Other patients is also supported by ESR in non-SA patients (40.1 mm/hour) by Heyworth et al.[10]

Significantly lower haematocrit values in SA compared with non-SA patients support the reliability of low 30% haematocrit when diagnosing SA.[10] Particularly, the C-SA (32.3%) and C-SA+S-SA (33.0%) haematocrit values are supported by research identifying < 34% haematocrit in MRSA-related SA.[14,17]

Lower aspirate %monocytes and %lymphocytes were able to differentiate between SA and non-SA patients. %Lymphocytes in C-SA (7.5%) and S-SA (7.2%) patients in the current study were below the threshold for SA patients identified by Kocher et al[3] (19.9%), supporting the validity of %lymphocyte in diagnosing SA. However, the %monocytes in C-SA (9.7%) and S-SA (12.0%) groups were above the value identified by Kocher et al[3] (6.7%), who focused on the hip. These findings represent the importance further analysis of synovial values may have in SA diagnosis.

Additionally, the presence of specific bacterial pathogens in SA patients may differentiate SA from other similar pathologies. Deanehan et al[18] found that both SA and Lyme arthritis exhibit characteristics of elevated aspirate WBC count and %neutrophils, but all patients with Lyme arthritis were positive for the Lyme immunoglobulin G and were negative for synovial fluid cultures.

There are limitations to these findings. First, the retrospective nature of this study limited the retrievable information to what was available on the patient charts. Secondly, the majority of joint aspirations in this study occurred in the hip and knee, with the remaining 16% occurring in the ankle, shoulder, elbow and first metatarsophalangeal joints. Although, the results may be more indicative of SA of the hip and knee compared with other major joints, the distribution of SA in major joints in this study is similar to that found in epidemiological studies (knee > ankle = elbow > shoulder) with the addition of the hip.[19]

Unlike previous diagnostic criteria, which did not analyze joint aspirates and/or focused on values solely from the hip, this study incorporates values from six different joints aspirations. The current study expands previous diagnostic approaches to identify SA, particularly the importance of joint aspirates of > 80% PMN in the routine algorithmic work-up. The lower values of roughly 80% PMN in this study challenge the criteria of > 90% established by Ward et al,[11] while highlighting the relevance of %PMN in SA diagnosis.[11] Additionally, the lack of difference in %PMN between patients given antibiotics or not indicates that administration does not influence synovial values. The significant differences in aspirate values between SA and non-SA patients in this study emphasize the importance of synovial tests in routine diagnosis of SA.

Clearly, no one lab value should be used out of context in patients with suspected SA. The synovial cell aspirate WBC count and differential are important assessment tools, but need to be placed in the context of the overall patient clinical presentation, physical examination and in conjunction with other laboratory values.

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COMPLIANCE WITH ETHICAL STANDARDS

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

ETHICAL STATEMENT

Ethical approval: This study has been carried out with approval from the institutional review board (IRB) at Children's Hospital Los Angeles (CHLA). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: A waiver of informed consent has been granted from the CHLA IRB as this is a retrospective study.

ICMJE CONFLICT OF INTEREST STATEMENT

RMK reports: Biomet: stock or stock options; Commission for Motion Lab Accreditation: Board or committee member; Johnson & Johnson: stock or stock options; Journal of Pediatric Orthopedics: editorial or governing board; Medtronic: stock or stock options; Pfizer: stock or stock options; Zimmer: stock or stock options.

JLP reports: American Orthopaedic Society for Sports Medicine: Board or committee member; Arthrex, Inc: paid consultant; paid presenter or speaker; research support; Ceterix, Inc.: paid consultant; Grand Rounds, Inc.: paid consultant; Pediatric Orthopaedic Society of North America: Board or committee member; Pediatric Research in Sports Medicine: Board or committee member.

All other authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

KKO: Data collection, Data analysis, Manuscript writing.
RRM: Data collection, Data analysis, Manuscript writing.
MS: Data collection.
AMB: Data collection.
AH: Data collection.
RMK: Study idea, Study design, Manuscript review.
JLP: Study idea, Study design, Manuscript review.

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