



■ CHILDREN'S ORTHOPAEDICS

Consensus guidelines on the management of musculoskeletal infection affecting children in the UK

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Aims

The aim of this study was to determine the consensus best practice approach for the investigation and management of children (aged 0 to 15 years) in the UK with musculoskeletal infection (including septic arthritis, osteomyelitis, pyomyositis, tenosynovitis, fasciitis, and discitis). This consensus can then be used to ensure consistent, safe care for children in UK hospitals and those elsewhere with similar healthcare systems.

Methods

A Delphi approach was used to determine consensus in three core aspects of care: 1) assessment, investigation, and diagnosis; 2) treatment; and 3) service, pathways, and networks. A steering group of paediatric orthopaedic surgeons created statements which were then evaluated through a two-round Delphi survey sent to all members of the British Society for Children's Orthopaedic Surgery (BSCOS). Statements were only included ('consensus in') in the final agreed consensus if at least 75% of respondents scored the statement as critical for inclusion. Statements were discarded ('consensus out') if at least 75% of respondents scored them as not important for inclusion. Reporting these results followed the Appraisal Guidelines for Research and Evaluation.

Results

A total of 133 children's orthopaedic surgeons completed the first survey, and 109 the second. Out of 43 proposed statements included in the initial Delphi, 32 reached 'consensus in', 0 'consensus out', and 11 'no consensus'. These 11 statements were then reworded, amalgamated, or deleted before the second Delphi round of eight statements. All eight were accepted as 'consensus in', resulting in a total of 40 approved statements.

Conclusion

In the many aspects of medicine where relevant evidence is not available for clinicians to base their practice, a Delphi consensus can provide a strong body of opinion that acts as a benchmark for good quality clinical care. We would recommend clinicians managing children with musculoskeletal infection follow the guidance in the consensus statements in this article, to ensure care in all medical settings is consistent and safe.

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Introduction

Musculoskeletal infection in children may endanger life or result in long-term disability. Children can present in various ways such as a limp, limb disuse, back pain, or life-threatening sepsis.^{1,2} However, other medical conditions such as rheumatological joint disease, malignancy, and transient synovitis can mimic the symptoms and signs of musculoskeletal infection, so

careful assessment and accurate diagnosis are important.^{3,4} Infection of different tissues (septic arthritis, osteomyelitis, pyomyositis, fasciitis, tenosynovitis, spinal discitis) by different microorganisms (from an aggressive methicillin-resistant *Staphylococcus aureus* (MRSA) infection secreting Panton-Valentine leucocidin to the much less severe *Kingella kingii*) means that it is not always easy to identify which child has infection,

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where the infection is located, and what the best treatment will be.^{5,6} As not all hospitals provide the same level of care, appropriate pathways and infrastructure are needed to manage these children in the context of a network of general and specialist hospitals for each region.

In order to ensure that each child is investigated promptly in a safe and thorough manner, without overinvestigating children with low risk of serious illness, guidelines on all these aspects of care can be helpful to support clinicians and avoid geographical variability in service provision. However, basing practice on the literature is difficult. On the one hand, there have been many published studies that tend to focus on specific aspects of the management of paediatric musculoskeletal infection. On the other, there are many aspects of the entire care pathway for a child that fall between the topics where such research tends to focus. For example, the guidance document published following the 2018 International Consensus Meeting on Musculoskeletal Infection in Paediatrics states, “However, challenges still arise for paediatric orthopaedic surgeons who encounter clinical scenarios that are unique to the paediatric population, where evidence-based guidelines are sparse.”⁷ Similarly, the clinical practice guideline published in 2021 by the Paediatric Infectious Diseases Society and the Infectious Diseases Society of America on acute osteomyelitis has numerous entries entitled ‘research needs’, highlighting many of the gaps in the evidence.⁸ Where no good quality clinical studies are available (or are even practical to perform), consensus recommendations by specialist organizations are a constructive way forward.⁷⁻⁹ Consensus recommendations allow hospitals to audit and benchmark their practice against these national standards, so that clinicians can align their practice to what their profession considers reasonable and safe.¹⁰

The Delphi method, first developed in the 1950s and 1960s, is an interactive way for a panel of experts to reach consensus when forecasting in any field from business, the military, or healthcare.¹¹ This has the advantage that a large number of individuals can contribute anonymously, without the process being dominated by a few individuals who may have particularly strong views on a topic.¹²⁻¹⁴ In 2011, a review of the use of Delphi in healthcare provided guidance to the optimal rigorous approach for medical publications,¹⁵ and where applicable, we have followed their recommendations. The AGREE II reporting checklist has become the internationally accepted standard for the evaluation of the methodological quality of clinical practice guidelines,¹⁶ and we have also followed their approach.

Methods

The British Society for Children’s Orthopaedic Surgery (BSCOS) identified the need to update their guidance on the management of children with musculoskeletal infection, originally published in 2013.¹⁷ The target users for these guidelines are not just those working in paediatric orthopaedics, but all those who assess and treat children with musculoskeletal infection in healthcare settings. These include orthopaedic surgeons dealing with general emergency attendances, as well as practitioners in emergency medicine, paediatrics, infectious disease, and microbiology. All BSCOS members with a special interest in musculoskeletal infection were invited to volunteer

to take part in a steering group, and 12 agreed to participate. They were all consultant paediatric orthopaedic surgeons, from a mixture of university teaching hospitals and district general hospitals in England, Scotland, and Wales. Following consultation and synthesis of the recent published scientific literature on musculoskeletal infection in children, a series of six online meetings were held between October 2020 and June 2021. Consensus statements were created and chosen in order to provide guidance on the full pathway from arrival in the hospital emergency department to discharge from clinic. The consensus statements were put together to cover practice on what was felt to be the most important aspects of the following three areas of management: 1) assessment, investigation, and diagnosis, covering how to assess a child with symptoms and signs that might indicate musculoskeletal infection; 2) treatment, where infection has been identified; and 3) service, pathways, and networks, covering aspects of integrated networking that are necessary to ensure a well-balanced service is provided in each region. This includes shared care, advice from specialists to generalists, and transfer of sick patients to higher-level centres.

Before sending out our statements for Delphi assessment, they were shared with the executive committee of the British Paediatric Allergy, Immunity and Infection Group of the Royal College of Paediatrics and Child Health (RCPCH), whose feedback was incorporated into the statements.

Following the same approach employed by BSCOS to create best practice guidelines for the management of children with clubfoot,^{18,19} we set up an online anonymized Delphi survey with invitations sent to all members of the society. We gathered not only their responses to the proposed statements, but also data on their place of work (regional centre or non-specialist unit) and the number of children they tend to treat for musculoskeletal infection in a typical year. Following GRADE guidelines,²⁰ each participant was asked to score every statement from 1 to 9, with 1 to 3 indicating ‘not important for inclusion’, 4 to 6 indicating ‘important but not critical’, and 7 to 9 indicating ‘critical for inclusion’. If they did not approve of a statement, the respondents could submit a comment as to which aspect of the statement they disagreed with (qualitative feedback). Any statements where over 75% of respondents graded ‘critical for inclusion’ were accepted at that stage for the final guidance (‘consensus in’). Any statements where over 75% graded ‘not important for inclusion’ were excluded from the final guidance (‘consensus out’), where 75% cut-off is standard for Delphi consensus. For further details, see Supplementary Table i. Those responses that fell between the criteria for ‘consensus in’ and ‘consensus out’ were reassessed by the working group, incorporating the feedback comments from those completing the survey. This helped the steering group to determine which aspect of a statement prevented respondents from strongly agreeing with it, and so allowing the statement to be reworded. These revised statements were then sent to the BSCOS membership for the second-round Delphi process, where the same criteria for inclusion were applied. On this occasion, if any statements did not meet the inclusion criteria (over 75% grading ‘critical for inclusion’), they were discarded.

Table I. The final agreed consensus statements.

Section 1: Assessment, Investigation, and Diagnosis

1. All children suspected to have musculoskeletal infection should be considered for joint management by orthopaedic surgeons and paediatricians, especially in cases of diagnostic uncertainty.
 2. In addition to examination of the affected limb and spine, a full systematic examination including upper respiratory tract and ears should be performed and documented by a paediatrician or other appropriate professional.
 3. In cases of cellulitis that do not settle with standard treatment, deeper infection should be considered.
 4. No single clinical algorithm for detecting MSK infection has been proven to be completely reliable, so should be considered in conjunction with history and examination.
 5. FBC, CRP, ESR and blood cultures are the minimum baseline laboratory investigations in suspected cases of MSK infection.
 6. Plain radiographs of the affected bone/joint should be performed in all cases.
 7. MRI is the gold standard second line imaging investigation if the child's condition allows.
 8. Ultrasound of the affected bone/joint should be considered when MRI is not possible.
 9. Where a joint is aspirated, the fluid should be sent to the laboratory in both plain universal culture pots and also in blood culture bottles.
 10. The majority of uncomplicated cases of osteomyelitis do not require biopsy or surgery, with biopsy reserved for cases of diagnostic uncertainty or where symptoms are not settling with treatment.
 11. Empirical intravenous antibiotics should be started immediately in any child who meets the sepsis-6 criteria, even if prior to a diagnosis of MSK infection.
 12. Antibiotics can be delayed to take adequate samples if a child's condition is stable and surgery can be performed in a timely fashion.
 13. A raised CRP or ESR in a child with an appropriate history and examination findings is suspicious for MSK infection.
 14. A normal CRP or ESR does not exclude MSK infection if early on in the disease course.
 15. Isotope bone scan should be avoided where MRI is available, to reduce radiation to children.
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Section 2: Treatment

16. In septic arthritis, urgent irrigation and drainage of the joint is the accepted standard, repeated if necessary.
 17. Osteomyelitis in bones adjacent to the joint should be considered in cases of septic arthritis.
 18. In acute haematogenous osteomyelitis, intravenous antibiotics are first line treatment, with surgical intervention indicated when response is suboptimal.
 19. Empiric antibiotics for osteomyelitis should be guided by local guidelines and the sepsis-6 pathway.
 20. In osteomyelitis a large collection of pus on imaging should be surgically drained, especially in non-responders.
 21. Every effort should be made to protect growth plates during surgery for osteomyelitis.
 22. In surgery for osteomyelitis, adjacent joint effusions should be aspirated, and joint washout performed if pus is present.
 23. In both septic arthritis and osteomyelitis, consider long line access at the earliest opportunity, particularly in the younger child.
 24. Convert to oral antibiotics when the child is clinically improving and inflammatory markers are falling.
 25. Temperature, CRP, ESR, and clinical improvement are all important to monitor response, guide treatment and exclude chronic osteomyelitis.
 26. Clinical examination and radiographic imaging are both necessary to assess medium and long term complications including fracture in osteomyelitis, joint contracture, growth arrest, hyaline cartilage loss, and Brodie Abscess formation.
 27. Total antibiotic duration should be guided with local MDT discussion, and continued at least until inflammatory markers are normal.
 28. Pyomyositis can present similarly to septic arthritis or osteomyelitis, especially around the hip, and MRI is the investigation of choice.
 29. Pyomyositis can often be treated successfully without surgery, with clinical examination and blood tests helpful for monitoring response.
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Section 3: Service, Pathways, and Networks

30. Children should be treated at their local hospital if the local expertise is sufficient for the nature of the infection present.
 31. Each child should be treated by a multidisciplinary team, with a minimum of 2 disciplines (a surgeon and a paediatrician or microbiologist) with further input from an infectious diseases team where required.
 32. Admit all children with musculoskeletal infection for initial management.
 33. Each region must agree pathways in which specialist hospitals and supra-regional centres support district general hospitals in managing children with bone and joint infections (see definitions below).
 34. Complex cases should be transferred promptly to specialist centres.
 35. The receiving team in the specialist centre should be defined – paediatrician, or paediatric orthopaedic surgeon, or both.
 36. Clinicians managing children with MSK infection at local hospitals should have a low threshold for discussing cases with a specialist unit.
 37. If a child is well enough for discharge, but cannot be converted to orals and requires long term IV antibiotics for their treatment, then there should be provision for IV treatment as an outpatient or in the community.
 38. Consider repatriation of complex cases from a specialist hospital to their local hospital when treatment plan is finalized.
 39. Each child should have a discharge plan including dates, location and duration of outpatient appointments according to predicted complications.
 40. Follow-up should be under an interested specialist who anticipates bone fragility in osteomyelitis, monitors growth, and can manage consequences of growth disturbance and joint damage.
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Definitions

Local hospital: interested general orthopaedic surgeon and paediatrician/microbiologist. Paediatric inpatient beds.

Specialist hospital: interested paediatric orthopaedic surgeon and interested paediatrician/microbiologist. May be limited by anaesthetic provision and out of hours radiology provision.

Supraregional centre: team of paediatric orthopaedic surgeons, specialist infectious disease paediatricians, and anaesthetic/paediatric critical care support. Able to provide seven days a week specialist care.

FBC, full blood count; IV, intravenous; MDT, multidisciplinary team; MSK, musculoskeletal.

Table II. The three consensus statements included in the first Delphi but not included in the second Delphi.**Section 1: Assessment, Investigation, and Diagnosis**

12. Antibiotics for septic arthritis or osteomyelitis should not be delayed in order to obtain specimens from the site of infection.

17. An echocardiogram should be considered in conjunction with the paediatricians in children with persistent pyrexia, with or without signs of endocarditis.

Section 3: Service, Pathways, and Networks

38. A nationally accepted proforma for referral that enshrines the agreed criteria for diagnosis and initial management would be desirable based on the statements above.

Results

Overall, 146 of the 243 BSCOS members responded to the initial Delphi survey; a breakdown of the number of children they tend to treat with musculoskeletal infection in a typical year is given in Supplementary Tables ii and iv. In total, 62% (n = 91) worked in a regional specialist centre, and 38% (n = 55) in a non-specialist centre. Of this group of 146, nine then excluded themselves as they did not treat children with musculoskeletal infection, while 133 went on to complete the entire first round survey, grading each statement and giving feedback on statements they felt they could not approve as currently worded. A total of 109 respondents went on to complete the second Delphi questionnaire in full.

Out of 43 proposed statements included in the initial Delphi, 32 reached 'consensus in', 0 'consensus out', and 11 were inconclusive ('no consensus'). These 43 statements are listed in Supplementary Table iii, with 'consensus in' statements highlighted with green background and 'no consensus' with a white background. The 11 statements with a 'no consensus' vote were then reworded, amalgamated, or deleted, before the second Delphi round of eight statements (listed in Supplementary Table vi). All eight reworked statements were accepted as 'consensus in', resulting in a total of 40 approved statements. The 40 approved statements are given in Table I, and comprise the BSCOS guidelines. The three original statements that were deleted or amalgamated with others on related topics for the second Delphi are given in Table II.

Discussion

The safe investigation and treatment of children with musculoskeletal infection is clearly an important component of healthcare. While orthopaedics commonly takes the lead role in such patients, a range of specialities may also be involved. Although there have been numerous papers on particular aspects of musculoskeletal infection, such as the diagnosis and treatment of osteomyelitis and septic arthritis, some other aspects of the entire care pathway have little or no formal research base to guide clinicians in their decision-making.^{2,9} Many aspects of the investigation and management of children with suspected musculoskeletal infection cannot easily be evaluated with a randomized trial, including which specialties should be involved with their care (although there is some evidence for adults),²¹ or who should be transferred to a specialist centre and when that should happen. Similarly, good practice will differ depending upon whether the setting is a specialist children's hospital or a non-specialist district general hospital. For these reasons, our consensus agreement uses a common-sense approach that is applicable to healthcare environments of all levels. It also covers the entire timeline from initial presentation

to a healthcare professional to the long term follow-up of such children, and fills in many of the gaps not currently covered in the literature. We would therefore argue that the Delphi quality indicators included in our study have good validity and feasibility.¹⁵

The fact that such a large number of paediatric orthopaedic consultants in the UK support the 40 statements given in Table I, with over 75% grading every one as critical for inclusion, means that they can be relied upon as a reasonable body of opinion representing the majority of experts treating musculoskeletal infection in children. In this way these consensus guidelines vary from others that may just be put together by a small group of experts, as our process ensured external review and was open to validation from BSCOS members. If all those who treat children at hospitals follow these guidelines, then variation in approach should be reduced, and those inadvertently practising below safe standards will be elevated to a more skilled level.

As it is important to disseminate consensus guidelines widely in order for them to be adopted, after completing the Delphi process we worked with the British Orthopaedic Association to create a compact, single-page standards guide (BOAST guideline) to help support non-experts when dealing with emergencies out of hours.²² This BOAST guideline has also been approved by the executive committee of the British Paediatric Allergy, Immunity and Infection Group, RCPCH.

The consensus statements given in Table I allow hospitals across the country to audit their own practice and benchmark themselves against these agreed guidelines, perhaps on an annual basis. The consensus statements should prompt all district general hospitals to establish an agreed pathway with a more specialist hospital, to discuss complex patients and refer them promptly if required for advanced investigations (such as MRI under general anaesthetic) or specialist treatment (such as paediatric intensive care). Specialist and non-specialist centres can apply these guidelines in a manner suited to the services they provide and the level of expertise in their staff.

To ensure these guidelines remain relevant and up to date, we propose that BSCOS review the scientific literature and reassess the consensus statements in five years' time, and decide whether an update is needed. If an update is not felt to be needed we recommend that these guidelines should be refreshed with a new Delphi process in ten years' time.

The strengths of these guidelines are that they reflect the opinion and practice of over 100 paediatric orthopaedic surgeons, geographically spread right across the UK, working in both specialist and non-specialist centres, using the well-validated Delphi consensus approach, and covering all elements of the care pathway from presentation to the hospital to long-term follow-up. Not all 243 members of BSCOS completed

the Delphi survey, because not all members of BSCOS treat children with musculoskeletal infection. There are several weaknesses to these guidelines that are also worth considering. Many elements of care do not have rigorous evidence to prove that they are effective. The nature of the Delphi process means that only statements compiled by the steering group could be considered and voted upon by those completing the consensus. If the steering group had been made up of different clinicians, they might possibly have created different statements. Since paediatric orthopaedic surgeons commonly lead on the care of children with musculoskeletal infection in the UK, the consensus was created by BSCOS members, although supported with feedback from the British Paediatric Allergy, Immunity and Infection Group, RCPCH. Arguably, emergency medicine physicians, paediatricians, microbiologists, and infectious disease specialists could also have had a role in approving or rejecting these statements. Also, expert opinion is generally regarded as a lower level of evidence compared with randomized trials, cohort studies, or systematic reviews.²³ However, the expert opinion of over 100 specialists is clearly more reliable than the expert opinion of one specialist, and using the Delphi approach allows us to provide guidance on areas of care for which no randomized trial, case control study, or systematic review currently exists. Finally, while it is likely that these guidelines may be found helpful in many regions of the world, there will be variation in the degree to which they might be applicable to other countries with different healthcare settings.



Take home message

- Here we present consensus guidelines for the safe management of children with musculoskeletal infection.
- The 40 statements cover assessment, investigation, diagnosis, treatment, service, pathways, and networks.
- We recommend that UK hospitals implement these guidelines and regularly audit their practice, in order to identify and resolve any aspects that require improvement.

Supplementary material



Detailed information on the respondents to the Delphi surveys, the consensus criteria, the proposed statements, and responses to them for the first and second round.

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