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A practical definition of pin site infection

Florian A. Frank [a,b], David Stubbs [a], Jamie Y. Ferguson [a], Martin McNally [a,*]

[a] Bone Infection Unit, Nuffield Orthopaedic Centre, Oxford University Hospitals, Oxford, United Kingdom of Great Britain and Northern Ireland, UK
[b] Musculoskeletal Infections Center (ZMSI), University Hospital Basel, Basel, Switzerland

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ABSTRACT

Pin Site Infection (PSI) is the most common complication of external fixation treatment. Several classifications and diagnostic approaches have been used with reported incidences varying widely from 1 to 100 %. The quality of the existing literature is limited by the absence of a definition. This renders comparing literature and developing evidence-based algorithms for prevention, diagnostics, and treatment difficult to impossible. Similar problems were identified with prosthetic joint infection (PJI) and fracture-related infection (FRI) in recent years, resulting in new, validated definitions.

PSI is complicated by the complexity of the issue. Numerous factors in PSI need consideration. Factors may be related to the patient, the surgical technique, the pin-bone interface, the pin-skin interface, the choice of external fixation device and/or the material used and its properties. Reliably diagnosing PSI is one of the most pressing issues.

New definitions for FRI or PJI have diagnostic criteria which can be either confirmatory or suggestive. Any positive finding of a confirmatory criterion constitutes an infection. Although PSI resembles PJI and FRI, distinct differences are present. The skin is never closed, and bacterial colonization is inevitable along the treatment duration. The external fixator is only temporarily in place; thus, the goal of all measures is to continue the external fixator until the intended indication is reached.

This paper proposes the principles of a definition of PSI. This definition is not designed to guide any treatment of PSI. Its purpose is to create common ground for clinical investigations and publishing further research.

Introduction

Pin Site Infection (PSI) is recognized as the most common complication of external fixation treatment. Several classifications and diagnostic approaches have been used with reported incidences varying widely from 1 to 100 % [1–5]. A Pin Site Consensus Group was established in Cape Town, South Africa in 2018 [6]. Following a modified Delphi approach, several systematic reviews on Pin Site Infections were published [2,7–14] which had one common denominator – a definition on pin site infection was lacking and thus, the published literature lacks high-quality and is hard to interpret. To raise the quality of published research and to facilitate comparison between investigations for pin site infection, a pragmatic definition is needed. Our understanding of pin site infection and knowledge about the true incidence are impaired by the absence of a definition [15].

Lacking a definition for PSI resembles the situation with PJI and FRI in the past. The recent definition of FRI [16] led to numerous studies of high quality on this subject being published. Even though Pin Site Infections resemble some features of FRI (temporary implant placement, possible suppression until metalwork removal), there are several distinct differences. The situation with PSI is different to FRI as pins will cross the skin barrier, leaving the deep tissue vulnerable to bacteria living on the skin. Bacterial colonisation of the tract is inevitable and soft tissue cover of the 'implant' cannot be achieved. Furthermore, most infections start superficially at the level of the skin [17] and can be resolved with antibiotic treatment and local wound care. This scenario is relatively benign and usually no further surgical treatment is necessary. However, extension of a superficial pin site infection to the bone may produce bone lysis with pin loosening, compromising fixator stability. These more severe pin infections can require surgery for pin removal and replacement or rarely revision of the whole external fixator construct.

This paper proposes a definition of infected pin sites for all transcutaneous skeletal fixation pins (pins and fine wires used for external fixation, transcutaneous fixation and skeletal traction). A pin site is considered to consist of all tissue in contact with the pin. This includes the skin, the underlying soft tissue as well as the bone; and in the rare

* Corresponding author.
E-mail address: martin.mcnally@ouh.nhs.uk (M. McNally).

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case of a pin being inserted into a joint, the joint itself too. In the definitions for PJI and FRI, consensus was reached that a combination of clinical, laboratory and radiological features are needed to confirm or exclude the presence of infection [16,18]. Diagnostic tests were divided into highly specific tests, which can confirm an infection, or sensitive tests which may suggest infection, but may be positive in other conditions (lower specificity). This approach has delivered clinically useful definitions which have been validated and applied in clinical studies [19–22]. These principles can be applied to PSI with confirmatory signs establishing the diagnosis of PSI, but suggestive criteria needing further investigation.

Some features are pathognomonic for pin site infection, others are less specific and could be present in patients with inflamed pins and wires without an infection. In most other bone and joint infections, fluid draining from the bone or implant is regarded as confirmatory of an infection. In the case of pin site infection this is not necessarily true, particularly in the short period after pin placement. As the pins and wires are inserted through the skin, there is always a communication between the skin and the bone, which is never closed. Fluid can be present around the pin due to mechanical irritation close to joints or moving muscles/tendons. This, together with other specific features of transcutaneous pins make design of a definition more difficult.

Definition

In principle, a healthy pin should be pain-free, surrounded by normal skin, and have no discharge (Fig. 1).

In concordance with PJI and FRI definitions, diagnostic criteria for PSI can be either confirmatory or suggestive [16,18]. Criteria can be clinical, radiological or laboratory based. Any positive confirmatory sign constitutes infection. The presence of several suggestive signs increases the likelihood of infection.

Confirmatory criteria

Clinical

1. Skin breakdown with visible bone.
2. Painful, purulent drainage from the pin site (Fig. 2).

Radiological

1. Ring sequestrum on plain radiographs under a wet pin site [23].
2. Progressive bone lysis around a pin, under a wet pin site.

Laboratory

1. Aspiration of subcutaneous fluid collections around the pin with positive microbiological culture of a virulent organism (such as *Staphylococcus aureus, Staphylococcus lugdunensis,* Beta-haemolytic Streptococci*, Streptococcus anginosus* group*, Enterococci* spp.*,* Enterobacterales*, Pseudomonas aeruginosa*, Anaerobic Gram-negative rods and *Candida* spp. but not including skin commensals or common contaminants such as Coagulase-negative staphylococci or *Cutibacterium acnes* [24].(Fig. 3)
2. Aspirate from effusion of a joint in close proximity to an external fixator, demonstrating a virulent organism (as above), thus confirming septic arthritis.

Suggestive criteria

Clinical

1. Local pain, particularly new pain in a previously pain-free pin.
2. Persistent or increasing drainage of fluid (wet pin site).
3. Spreading erythema (Fig. 4).
4. Pin loosening (Fig. 5a and b)
5. Systemic upset, fevers, pyrexia without other cause
6. New onset joint effusion in joints adjacent to pins and wires placed in proximity to joints. Be aware PSI of pins and wires close to a joint can cause septic arthritis – infection per continuitatem.

Radiological

1. Lysis around pins or wires (Fig. 5a and b).
2. Subcutaneous fluid collection in keeping with a possible abscess.
3. Radiological signs of a sequestrum under a dry pin.

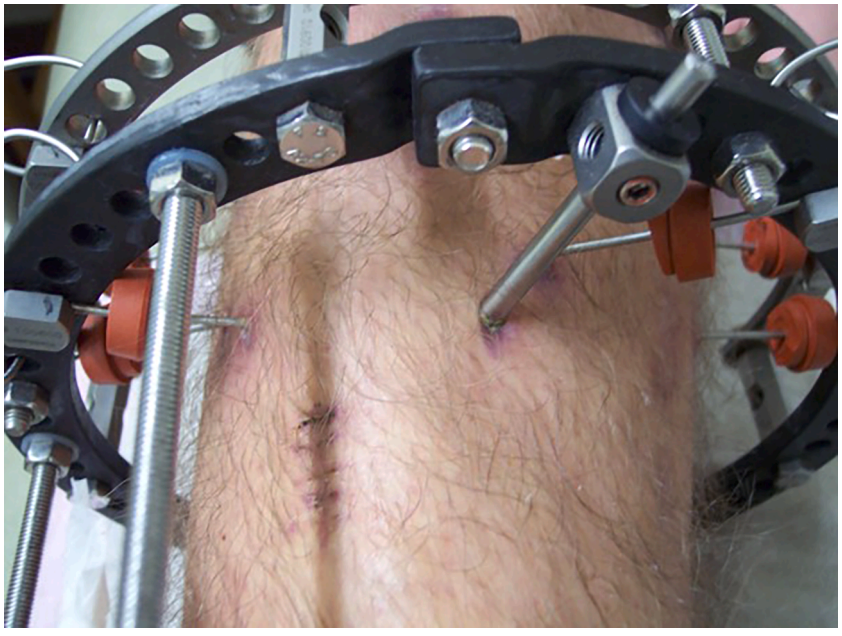

Fig. 1. These tensioned wires and half pin show the normal appearance of healthy pin sites. The surrounding skin is normal up to the pin-skin interface. There is minimal erythema and no discharge.

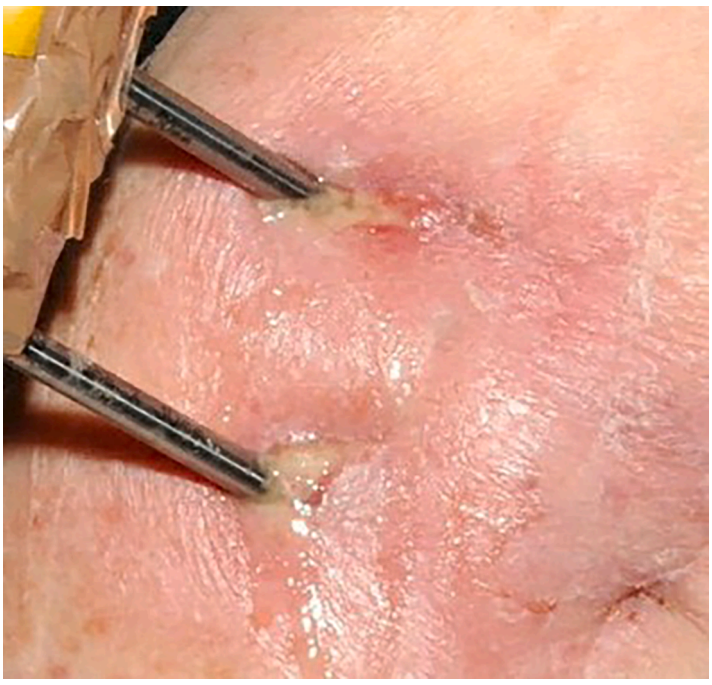

Fig. 2. These half pins became progressively painful over several days with increasing purulent discharge. At review, the skin had spreading erythema, discharge of thick pus and pain on stressing the pins, confirming the infection.

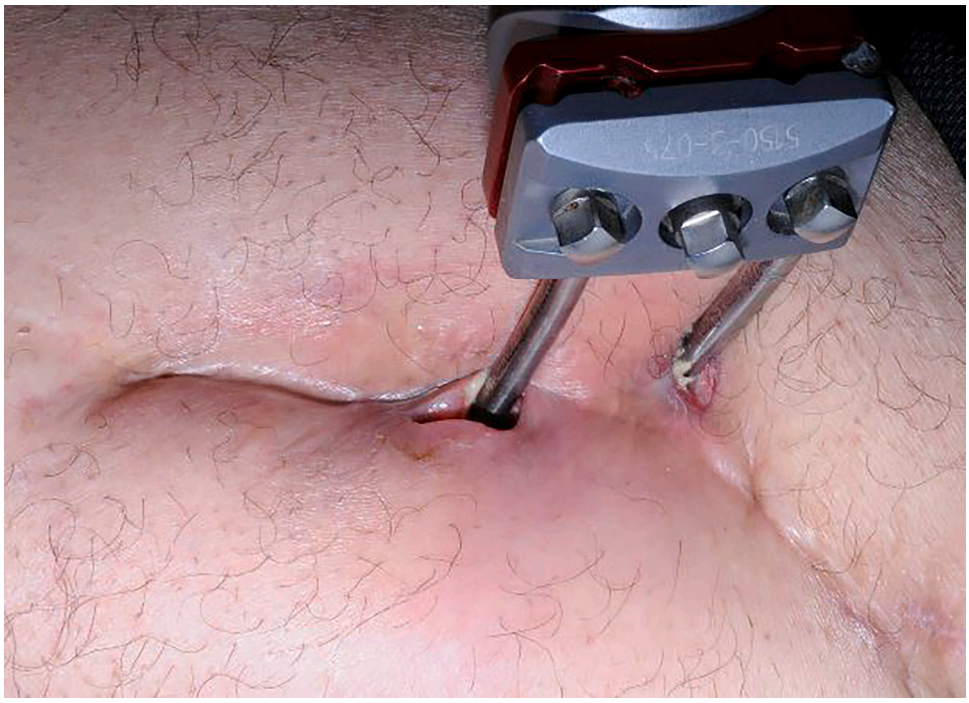

Fig. 3. These painful half pins developed a swelling around the pins. Aspiration of the subcutaneous fluid grew *Staph. Aureus,* confirming the presence of infection around the pin.

Laboratory

1. Elevated serum inflammatory markers (serum white blood cell count (WBC) and C-reactive protein) are non-specific. Persistent elevation or incremental increase should trigger the suspicion for infection, in the absence of other causes.

   A wet pin site is defined as any fluid discharge from a pin site. If this discharge is painful and purulent (frank pus), this constitutes a confirmatory sign of pin infection. If it is not painful, non-purulent (clear, thin fluid) or sero-sanguinous, this is suggestive of infection and merits further observation or investigation.

   It can be difficult to distinguish the clinical appearance of the early stages of infected pins (Fig. 2) from overgranulation of tissue around a foreign body in the skin (Fig. 6). However, overgranulating pins are usually pain-free and the surrounding skin is normal, without erythema.

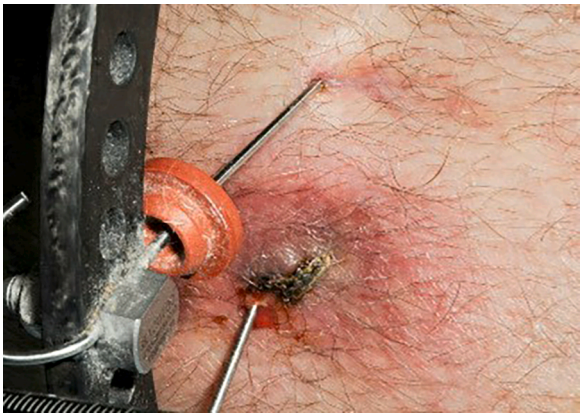

Fig. 4. The upper wire in this fixator is healthy but the lower wire is surrounded by erythema. There is a little clear discharge and no pain. This is suggestive of infection but does not confirm it. The patient should be closely observed and advised to contact the treating team if the pin becomes painful or discharges pus.

If an overgranulating pin becomes painful or starts to discharge fluid, or causes surrounding skin changes, this would suggest an infection. If the painful discharge is purulent, this confirms infection.

Application of the PSI definition in clinical practice

Patients with external fixators, skeletal traction or transcutaneous fixation pins should be reviewed regularly during treatment. At each visit, the pin-skin interface should be inspected for signs of erythema, wound breakdown with exposed bone, discharge or local fluid collections. Patients should be questioned about pin site pain, systemic upset or changes in adjacent joints (new swelling, reduced range of motion, pain). Pins or wires should be tested clinically for loosening and plain radiographs inspected for bone lysis around the pin or ring sequestra. This includes checking if the frame construct is still firmly anchored to the bone without any signs of translational movement or instability.

Subcutaneous fluid collections may be aspirated directly or under ultrasound control (see below).

Discussion

This definition is designed to serve as a descriptive common ground and is based on previously validated principles in PJI and FRI. The proposal is pragmatic as it includes only widely recognized features and tests (clinical, plain radiology and basic laboratory assays). It does not overcomplicate matters and should be easily applicable in daily practice and for future investigations (Table 1).

One principle of the definition was to include pin sites in all bones, of all durations of implantation and for all indications. There is no evidence from the literature that pin infection has different mechanisms of origin or development in any specific bone or site. It is clear, that the incidence of pin infection is affected by the site of the pin, host factors and duration but this is not the subject of this definition [1,7,14,25]. Therefore, we did not add any subdivision to the definition.

The intention of this publication is to provide a clinically useful definition of PSI for standardization of upcoming studies. The definition does not classify infections or give any degree of severity and is thus not designed to guide treatment decisions. Future data, collected prospectively, should be used to validate this definition.

Diagnostic criteria

This definition consists of diagnostic criteria (signs, symptoms and tests) which are widely described in the literature. In suspected pin infection, it is important to understand that some of these are not specific to PSI and may be due to other conditions. This is the basis of the suggestive criteria category. When suggestive criteria are present, they should be considered in the whole patient context, including other concurrent disease. For example, a raised C-reactive protein in a patient with rheumatoid arthritis and a single red, painless pin site, is unlikely to have PSI. However, a raised CRP with fever, new pin pain and no other medical cause should be taken as highly suggestive of early PSI.

The relationship between pin infection and loosening is complex. Mechanical loosening can predispose to infection, but deep infection will also loosen pins. In PJI it has been shown that pain and early

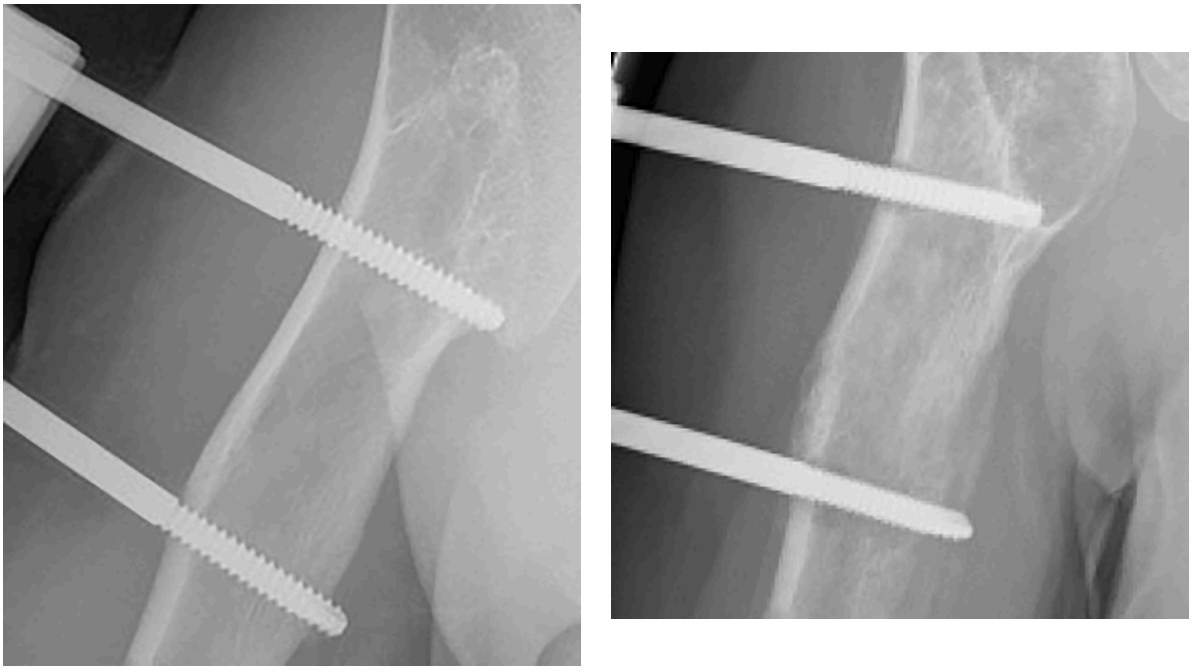

Fig. 5. (a) Well fixed pins in the proximal humerus, 2 weeks after placement. (b) At 6 weeks, there is obvious bone lysis around both pins. Clinically the pins were loose. This is highly suggestive of infection but can be due to mechanical loosening alone.

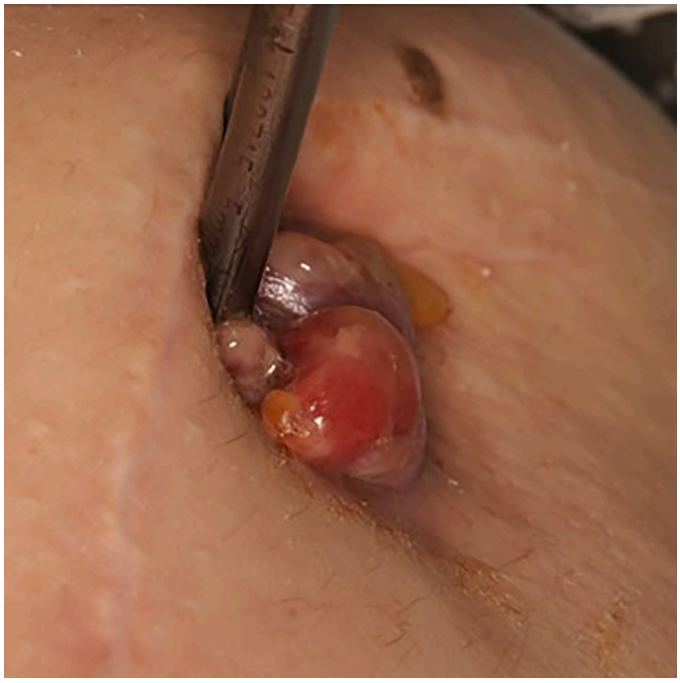

Fig. 6. A healthy stable pin with excessive granulation tissue around it. This alone is not an indication of infection.

loosening of the implant are sensitive for infection [26]. The same can be translated to PSI, but studies to define this correlation are rare. In the later stages of frame treatment, loosening is more likely to be derived from mechanical reasons but infection remains a possibility. Clasper et al. showed that fluid accumulation may be a critical factor in infection spread prior to, or with pin loosening [27].

Systemic upset with pyrexia, fevers and rigors are less frequent with isolated pin infection but can herald a serious PSI with bacteraemia. Jauregui et al. reported on several cases with limb or life-threatening pin infection resulting in toxic shock syndrome or necrotizing fasciitis [5].

In PJI and FRI, there is a major focus on establishing the microbiological and histological diagnosis with deep tissue sampling [18,28–30]. In PSI, there is rarely the opportunity to obtain clean deep tissue samples. This is only possible when the pin is removed, or the infection persists after external fixation [31]. If a loose pin is removed, deep tissue should be sent for microbiological culture, to aid diagnosis and facilitate antimicrobial therapy. It may be possible to obtain several specimens with small bone currettes.

Aspiration of subcutaneous fluid under sterile conditions provides a clean source of material for microbiological analysis but the use of superficial swabs remains controversial [32,33]. We do not advocate the use of superficial swabs. Swelling around pins which can be aspirated is not a common scenario but should be looked for. When present, aspiration is easy and provides a valuable additional test for the diagnosis of pin infection and a microbiological culture. This sample is a single specimen and so can only be regarded as diagnostic if it cultures a virulent organism, which is not a common skin commensal or laboratory contaminant[24].

Septic arthritis in a joint (as proven by culture of a virulent organism) adjacent to a pin site needs to be diagnosed early and treated aggressively as such. This joint infection can arise from haematogenous spread with bacteraemia, from a local skin or bone focus or from an adjacent pin site infection. When placing external fixator pins, care should be taken to keep pins outside the reflections of the joint capsule, but sometimes this is not possible. The development of a new joint effusion beside a possibly intracapsular pin should raise the suggestion of a septic arthritis, secondary to a pin infection. Culture of a virulent organism confirms the presence of infection. Treatment should be aimed not only at the established joint infection, but also at the potential source. This should include the adjacent pin site.

Imaging studies

Plain radiography is helpful in identifying areas of dead bone around pins [23]. The presence of a ring sequestrum (circumferential dead bone around a pin) is pathognomonic of pin infection if the overlying pin is wet and discharging fluid. This is a confirmatory sign.

More complex imaging with CT or MRI is limited by the presence of the pin or fixator in situ. These modalities are more useful with persisting infection after pin removal.

Nuclear imaging, particularly ^{18}FDG-PET-CT and SPECT-CT, have been advocated in the diagnosis of FRI and PJI [20,21], but there is no evidence which suggests that they can distinguish pin site infection from aseptic pin loosening.

Classification of PSI

More than 12 different classifications of PSI have been published and proposed. A systematic review by Iliadis in 2022 [8] showed that all are lacking validation and reproducibility, thus none is universally accepted. They concluded that the Checketts-Otterburn Classification is the most suitable classification available, with the limitation that it does depend on subjective criteria. No classification has prognostic implications.

We acknowledge that a classification which takes the prognosis and treatment implication into account is desirable. We hope that this definition will allow a start point for evaluating the severity and classification of PSI.

Host factors

Host factors such as systemic or local health issues have been reported to be important in classifications of PJI, osteomyelitis and FRI such as the BACH [34] or Joint-Specific BACH [35]. They have been shown to be important in the aetiology of PSI [7] but we have not identified any host factor which affects the diagnosis or definition of PSI. In patients with medical conditions which predispose to an increased risk of bone infection (diabetes, tobacco smoking, peripheral vascular disease, etc.) [36–38], the presence of any suggestive criterion for PSI should be seriously considered and further investigated.

Terminology

There is no uniform terminology in pin site infection. Pin sites can be termed pin tracts or pin tracks. There is also the issue of deep or superficial infection. We are unaware of any study with strong methodology which can accurately define these entities or distinguish them clinically or with diagnostic tests. It is therefore not possible to include these undefinable terms in a definition.

We used Pin Site Infection, as the infection can involve the whole pin area or site, not only the tract or track through which it is inserted. We recommend that this term should be used in future studies to clarify and unify the upcoming literature. This will facilitate comparison and understanding.

Limitations

There are some limitations to this definition. The literature on defining PSI is scarce and of limited quality. As such we might be missing some points which would be crucial to defining PSI. Prospective data collection and validation of this definition is needed in the future, possibly leading to revision and/or adjustments of it as the number and quality of available studies rise.

Table 1
Diagnostic Criteria for Pin Site Infection.

	Infection Unlikely	Infection Likely	Infection Confirmed
Clinical			
Clinical Features	Clean, dry pin site without pain or erythema	1) New pin site pain 2) Continuous or increasing drainage 3) Spreading erythema 4) Early pin loosening 5) Systemic upset 6) New joint effusion adjacent to pin sites	1) Wound breakdown with visible bone around the pin site 2) Painful, purulent discharge from the pin site
Microbiology			
Aspiration of local collection			Positive culture with a virulent organism[b]
Aspiration of effusion in adjacent joint			Positive culture with a virulent organism[b]
Superficial swab of pin site[b]	Positive culture of common skin commensal or laboratory contaminant	Positive culture with virulent organism[b]	
Laboratory			
C-Reactive Protein		Persistent elevation of CRP (> 10 mg/L (1 mg/dL)) without other cause	
Imaging			
Plain Radiology		1) Lysis around pins 2) Subcutaneous fluid collection 3) Ring sequestrum	1) Ring sequestrum visible under a wet pin site 2) Progressive bone loss under a wet pin site

[a]A raised C-reactive protein is only significant in the absence of any other cause for inflammation (rheumatoid disease, inflammatory bowel disease etc.). It is also unreliable in the first 2–3 weeks after surgery.
[b]Interpretation of a single positive culture from aspirations must be cautious and taken together with other evidence. Uncommon contaminants or virulent organisms (e.g. *S. aureus* or Gram negative rods) are more likely to represent infection than common contaminants or skin commensals (such as coagulase-negative staphylococci, micrococci or *Cutibacterium acnes*).

This definition does not give any advice relating to treatment. We believe that once the diagnosis of pin site infection is confirmed, treatment can be instituted, depending on the individual patient. Some clinicians may feel that pre-emptive treatment could be appropriate in high-risk patients when only suggestive criteria are fulfilled. This should be considered in the context of good antibiotic stewardship.

This definition has been designed within one institution using the best experience available combined with the most robust published studies and systematic reviews. The group has over 70 years of experience with external fixation and pin site infections, with a strong focus on diagnosis and management of bone infection. Nevertheless, a larger pool of experts or further prospective studies may allow better understanding of the diagnostic criteria.

Conclusion

A definition has two distinct purposes. Firstly, it allows clinicians to recognize the presence of the condition and secondly, it establishes a common description of that condition for future research and study projects. This proposed definition uses a previously validated model for defining bone infections to create a specific diagnostic dataset for PSI. We hope that it will allow better comparison between studies and standardization of study methods.

We strongly encourage other researchers to challenge this definition and to develop classifications which have implications for treatment of PSI.

Declaration of Competing Interest

Florian A. Frank: “This author, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.". Jamie Y. Ferguson: “This author, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article." David

Stubbs: “This author, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.". Martin McNally: “This author, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article."

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