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QUESTION 3: What is the definition of a sinus tract?

RECOMMENDATION: A sinus tract has the following characteristics: (1) it is an abnormal channel through the soft tissues that allows communication between a joint prosthesis and the outside environment, known or presumed to be colonized by bacteria and (2) its presence may be confirmed with direct visualization of an underlying prosthesis, evidence of communication with fistulogram, ultrasound, computed tomography (CT) or magnetic resonance imaging (MRI).

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 97%, Disagree: 2%, Abstain: 1% (Unanimous, Strongest Consensus)

RATIONALE

The presence of a sinus tract communicating with a total joint arthroplasty (TJA) is one of the two major criteria for the diagnosis of periprosthetic joint infection (PJI) proposed by the Musculoskeletal Infection Society (MSIS) and the International Consensus Meeting [1]. Therefore, consistently defining what constitutes a sinus tract in this context has significant implications for the appropriate diagnosis and treatment of PJI. Interestingly, there is a paucity of information in the arthroplasty literature that defines the characteristics of a periprosthetic sinus tract. Many investigations discuss the presence and subsequent surgical management of sinus tracts in the setting of knee and hip arthroplasty but do not provide consistent or detailed descriptions of the cutaneous pathology. Given the lack of information and evidence, it is important to develop a comprehensive and standardized method for characterizing a soft tissue sinus tract surrounding a total joint prosthesis.

A sinus tract (latin: hollow, cavity) is an abnormal channel connecting a cavity lined with granulation tissue to an epithelial surface [2]. Although a fistula and a sinus tract are technically separate entities, with the former representing an abnormal connecting channel between two epithelialized cavities specifically, [2] they are frequently grouped together.

Given the relationship between infection and the development of sinus tracts and vice versa, it is not surprising that there exists a rich accounting of draining wounds and sinus tracts throughout medical history. In fact, a likely description of a draining sinus tract, secondary to chronic shoulder infection and osteomyelitis, is included in the Edwin-Smith Papyrus [3], the oldest surgical treatise in existence. Centuries later, Hippocrates [4] would provide various descriptions of sinus tracts and fistulae and extensive options for remedies, including topical, oral and surgical.

However, perhaps the most important of the historical treatments of sinus tracts comes from the 1686 *Chirurgical Treatises* of Richard Wiseman [5]. In his chapter titled “On Fistulae,” which appears in the appendix to his treatise on gunshot wounds, Wiseman describes a fistula as a sinuous ulcer, which has actively been draining for at least two to three months. He associates the draining sinus fistula with a “long pipe of skin” and the presence of “callus” which has been “hastened by the transpiration and resolution of the thin and subtill humours.” Like Hippocrates, Wiseman advocated for treatment with either medications or surgical debridement. Of note, Wiseman specifically commented upon the particular difficulty of curing sinus tracts associated with joints.

Since Wiseman, there have been numerous additional descriptions of sinus tracts associated with bones and joints. However, one of particular interest to the field of arthroplasty dates from the early 1700s [6]. Johanne Daniele Schlichting describes a case report from 1730 of a 14-year-old girl suffering from disability due to a hip infection associated with a large draining sinus tract. Schlichting also describes his method of treatment including removal of the femoral head and in doing so provided the first report of a proximal femoral resection in the medical literature. Throughout surgical history, a sinus tract has been pathognomonic for deep infection. The same is true in TJA, but the terms of the definition have not been established.

Sinus tracts are currently synonymous with PJI [7]. Fistulas in TJA have been noted to form connections between the prosthesis and vascular channels [8], the ureter [9], bladder [10,11], colon [12], rectum [13] and vagina [7], and are clearly a risk for the development of PJI when associated with bacterially-colonized cavities. Additionally, there is little information differentiating a communication that originates from inside the joint versus outside the joint.

There has been a significant amount of effort spent on determining the yield of culture samples from sinus tracts and fistulas originating from or terminating at joint arthroplasties [8,13–20]. Although this has provided insight as to the utility of sinus content cultures in the diagnosis of the responsible pathogens, it has not further assisted in defining the pathology. For the purposes of PJI diagnosis, we suggest that sinus tracts and fistulas communicating with bacterially-colonized areas should be grouped together, regardless of origin from within the joint or without, in order to fulfill the major criterion for the diagnosis of PJI.

The majority of information regarding the definition of a sinus tract in the presence of musculoskeletal infection has been studied in the context of osteomyelitis. There are multiple classification systems for sinus tracts, with varying degrees of focus on associated soft tissue compromise. The Cierny-Mader classification is perhaps the most commonly-referenced system, and involves categorical divisions staged by combining anatomic class (I: medullary, II: superficial, III: localized and IV: diffuse) and host physiologic class (A: normal immune function, B: local or systemic immune compromise and C: treatment worse than disease) [21]. A sinus tract leading to exposed bone is the hallmark of Stage II (superficial) osteomyelitis and occurs on a continuum with Stage III and IV disease. Although further details of sinus tract characteristics aside from direct contact with osseous structures are not included, treatment with thorough debridement is consistently advocated [21,22]. Conceptually similar to the anatomic class used by Cierny and Mader, Ger proposed a classification system in 1984 that focused on the wound, separating simple sinus, chronic superficial ulcer, multiple sinuses and multiple skin-lined sinuses [16]. Similarly, these pathologic conduits tunneled directly to bone. Currently, no analogous method is used to characterize sinus tracts associated with PJI. However, a patent channel through soft tissue connecting the outside environment directly to a total joint prosthesis should be considered a sinus tract.

Chronicity of drainage and of associated symptoms is an important consideration. Although it has been noted that postoperative wound drainage lasting longer than five to seven days is unlikely to remit without intervention [14], differentiating between simple prolonged postoperative drainage and early sinus tract formation is difficult. Galat et al. [15], reviewed the records of over 17,000 primary total knee arthroplasties and identified a 5.3% to 6.0% risk of deep infection in knees with persistent wound drainage within a 30-day postoperative time frame. However, "surgeon judgment" rather than objective testing played a significant role in the diagnosis of deep infection in many cases and may have skewed results. Another series of over 11,000 arthroplasty procedures identified 300 patients who developed wound drainage lasting > 48 hours following surgery [17]. Although persistent wound drainage was noted to cease in the majority of patients between postoperative days 2 to 4, 28% continued to drain and underwent further surgery. Surgical debridement was adequate to resolve the wound issues in the majority of cases but 20% required additional intervention in the form of two-stage exchange, resection arthroplasty or antibiotic suppression. In this series, the mean interval between the onset of drainage and surgical treatment was 10 days in patients who required further intervention.

Other studies have suggested that drainage of greater than 5 days imparts a 12.5-times risk of developing infection [23] and each day of continued drainage increases the risk of wound infection by 42% in hips and 29% in knees [24]. However, these studies do not subdivide the portion of superficial wound infections that progress to true PJI. In addition, surgery on a draining wound performed following 12 days of continuous drainage was noted to yield positive cultures in only 25% of cases [25]. While the distinction between persistent wound drainage and a developed sinus tract is not defined in the acute setting following surgery, there is likely a time after which persistent drainage should be deemed a sinus tract. Currently, there is no evidence to guide us, to our knowledge, in understanding this distinction. Regardless of the definition, persistent drainage in any form is clearly concerning for PJI.

There is a strong association between chronically-draining wound sinus tracts and deep infection of prosthetic hip and knee joints [26]. However, it is important to draw a distinction between the presence of a sinus tract *de facto* as a diagnostic criterion for PJI and the utility of sinus tract cultures in guiding infection treatment. Wound sinus cultures for osteomyelitis have notoriously low sensitivity and specificity [20,27,28]. The same has proven true for deep prosthetic joint infection. Two studies have been conducted to determine the correlation between superficial cultures from wounds or draining sinus tracts and a deep pathogen in the setting of prosthetic joint infection. Cune et al. evaluated the usefulness of wound culture results in the treatment of acute postoperative prosthetic joint infection. They found 80.3% agreement between superficial and deep surgical cultures in this setting with high sensitivity and specificity for *Staphylococcus aureus* and gram-negative bacilli [29]. Tetreault et al. performed a similar analysis comparing superficial and deep cultures in patients with deep prosthetic joint infection. Their results showed a 47.3% concordance between superficial and deep cultures, and in 41.8% of cases, the superficial organism wound has guided therapy with a different antibiotic than deep cultures [30]. There is likely a gradient of organisms within a sinus tract community, but the biology of the sinus tract microenvironment has not yet been studied. Therefore, although the presence of a sinus tract should be considered equivalent to a deep prosthetic joint infection, cultures of the fluid cannot be relied upon to guide treatment.

In general, for the diagnosis of PJI, a sinus tract should demonstrate clear communication between the prosthesis and a non-sterile environment. The most obvious method is to directly visualize the underlying prosthesis through the lumen of the sinus or directly access the prosthesis with a sterile probe. However, to corroborate physical exam findings or evaluate a suspicious channel, various imaging methodologies may be utilized to confirm the presence of a true sinus tract that communicates with a TJA. Conventional radiography may be helpful in identifying areas concerning for infection with a sinus tract in combination with subcutaneous or intraarticular gas. However, plain X-rays may be negative in more than 50% of cases and may be of minimal diagnostic utility in acute infection [31]. Instead, conventional X-ray with the addition of arthrography or fistulography may drastically increase the diagnostic yield by illuminating infectious channels and accumulations [32,33]. Traditionally, more advanced imaging modalities such as CT and MRI were believed to be of limited use in evaluating the soft tissues immediately around a total joint prosthesis due to large amounts of metal artifact and image distortion. Recent developments, including metal artifact reduction sequence (MARS) MRI and three-dimensional reconstruction, allow for a much more detailed evaluation of periarticular structures and the presence of sinus tracts. However, given the dynamic nature of soft tissues and underlying infection, imaging studies may not provide sufficient evidence to verify the existence of a sinus tract as these may fluctuate in their patency and extent. Therefore, imaging modalities should not solely be relied upon for the identification of a sinus communicating with a joint prosthesis.

In summary, an established sinus tract or fistulous connection between a deep prosthetic joint and another space known to be colonized with pathogenic microorganisms should be considered tantamount to deep prosthetic infection. Although the literature does not provide clear guidelines regarding the time at which a draining wound becomes a sinus tract, it is clear that prolonged drainage from an arthroplasty wound increases the likelihood that deep infection will occur. While literature does not support the use of superficial sinus cultures to guide treatment of deep PJI, clinicians should rely on the presence of a sinus to justify surgical treatment. Therefore, any suspected connection between a deep prosthetic joint and an area colonized by pathogenic microorganisms should be considered seriously and evaluated thoroughly.

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