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Diagnostic Criteria and Treatment of Acute and Chronic Periprosthetic Joint Infection of Total Ankle Arthroplasty

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Abstract

Background: Prosthetic joint infection (PJI) after total ankle arthroplasty (TAA) is a serious complication that results in significant consequences to the patient and threatens the survival of the ankle replacement. PJI in TAA may require debridement, placement of antibiotic spacer, revision arthroplasty, conversion to arthrodesis, or potentially below the knee amputation. While the practice of TAA has gained popularity in recent years, there is some minimal data regarding wound complications in acute or chronic PJI of TAA. However, of the limited studies that describe complications of PJI of TAA, even fewer studies describe the criteria used in diagnosing PJI. This review will cover the current available literature regarding total ankle arthroplasty infection and will propose a model for treatment options for acute and chronic PJI in TAA.

Methods: A review of the current literature was conducted to identify clinical investigations in which prosthetic joint infections occurred in total ankle arthroplasty with associated clinical findings, radiographic imaging, and functional outcomes. The electronic databases for all peer-reviewed published works available through January 31, 2018, of the Cochrane Library, PubMed MEDLINE, and Google Scholar were explored using the following search terms and Boolean operators: "total ankle replacement" OR "total ankle arthroplasty" AND "periprosthetic joint infection" AND "diagnosis" OR "diagnostic criteria." An article was considered eligible for inclusion if it concerned diagnostic criteria of acute or chronic periprosthetic joint infection of total ankle arthroplasty regardless of the number of patients treated, type of TAA utilized, conclusion, or level of evidence of study.

Results: No studies were found in the review of the literature describing criteria for diagnosing PJI specific to TAA.

Conclusions: Literature describing the diagnosis and treatment of PJI in TAA is entirely reliant on the literature surrounding knee and hip arthroplasty. Because of the limited volume of total ankle arthroplasty in comparison to knee and hip arthroplasty, no studies to our knowledge exist describing diagnostic criteria specific to total ankle arthroplasty with associated reliability. Large multicenter trials may be required to obtain the volume necessary to accurately describe diagnostic criteria of PJI specific to TAA.

Level of Evidence: Level III, systematic review.

Keywords: total ankle arthroplasty, total ankle replacement, infected total ankle arthroplasty, periprosthetic ankle infection, diagnosis of total ankle arthroplasty infection

Introduction

Prosthetic joint infection (PJI) after total ankle arthroplasty (TAA) is an unfortunate and serious complication that results in significant consequences to the patient and threatens the survival of the ankle replacement. Of all those who undergo TAA, it is estimated that 4% had a diagnosis of, or had undergone a procedure for, PJI.[2] A total ankle infection may require debridement, placement of antibiotic spacer,

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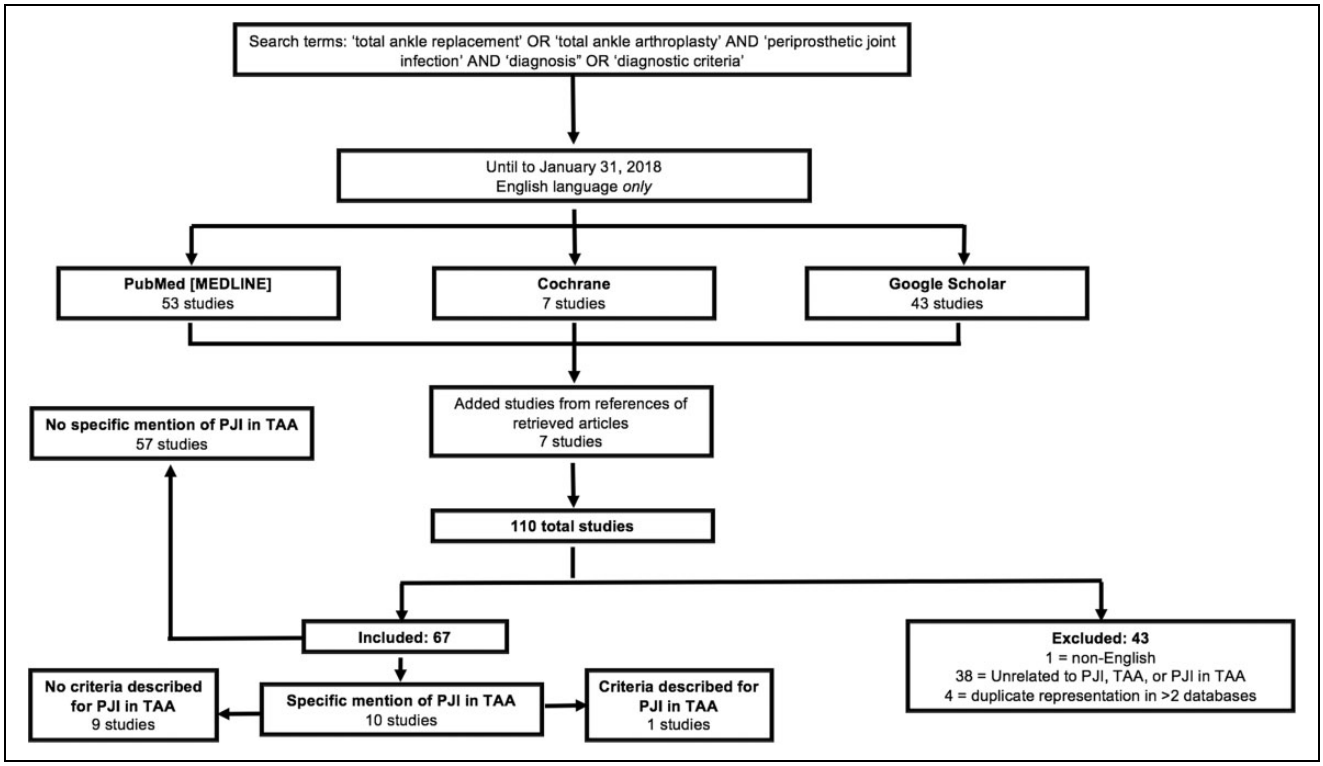

Figure 1. PRISMA (Preferred Reported Items for Systematic Reviews and Meta-Analyses) flow diagram.

revision arthroplasty, conversion to arthrodesis, or potentially below-knee amputation. Although the practice of TAA has gained popularity in recent years,[24] there is a paucity of data describing wound complications of acute or chronic PJI of TA, with limited studies describing the criteria used in diagnosing PJI, prompting this topical review.

The purpose of this topical review is to critically examine the most recent literature regarding PJI in TAA to offer surgeons more meaningful criteria in diagnosing acute and chronic periprosthetic joint infection of total ankle arthroplasty. Furthermore, we provide our institution's procedures, diagnosis algorithm, and treatment options for acute and chronic PJI in TAA as performed at our tertiary care center based on the available literature.

Materials and Methods

A current review of the literature was conducted to identify clinical investigations in which periprosthetic joint infections occurred in the context of TAA with associated clinical findings, radiographic imaging, and functional outcomes. The electronic databases for all peer-reviewed published works available through January 31, 2018, of the Cochrane Library, PubMed MEDLINE, and Google Scholar were explored using the following search terms and Boolean operators: "total ankle replacement" OR "total ankle arthroplasty" AND "periprosthetic joint infection" AND "diagnosis" OR "diagnostic criteria." Moreover, an examination of works cited of all included articles in this review were investigated to detect more studies. An article was considered eligible for inclusion if it concerned diagnostic criteria of acute or chronic periprosthetic joint infection of total ankle arthroplasty.

Results

A total of 110 studies were found from the original Boolean search; 53 from MEDLINE, 43 from Google Scholar, 7 from Cochrane, and 7 from references of retrieved articles. A descriptive algorithm of included and excluded articles for this literature review are depicted in Figure 1. Only 1 ($n = 1$) article by Alrashidi et al offers a descriptive algorithm for characterizing PJI in TAA; however, the pathways are derived from previously described literature specific to knee and hip arthroplasty.[1]

Discussion

This review of current literature fails to reveal a specific set of accepted criteria for diagnosis of an acute or chronic periprosthetic joint infection in total ankle arthroplasty.

The current literature reveals extremely limited data on PJI in TAA. Of the 10 studies that reference diagnosis of PJI in TAA, only 1 study by Alrashidi et al references a diagnostic algorithm used to classify patients with prosthetic ankle infections.[1] Alrashidi et al appear to invoke laboratory threshold measurements described by the International Consensus Group on Periprosthetic Joint Infection in their proposed diagnostic diagram, which is apparently derived from

literature specific to knee and hip arthroplasty.[1,17,18] Our review of the current literature failed to identify any clinical study or publication that had referenced use or perspective on the diagnostic algorithm submitted by Alrashidi et al.[1] These authors present clinically useful data in their diagnostic algorithm including presence of a sinus tract, cell count and differential from synovial aspiration, culture from synovial aspiration, nuclear imaging studies, and histologic frozen sections; however, no sensitivities or specificities of these results have been described in determining PJI specific to TAA. The trend of referencing hip and knee arthroplasty data in the work-up of PJI in TAA was common in the articles we reviewed.[3,15,23,25,26]

Other mention of PJI in TAA in our literature search did not specifically describe the criteria used to reach that diagnosis,[2,6,7,10,21,22,27] leaving no definitive criteria for defining this medical condition.

Management of PJI in TAA

The current literature has no diagnostic criteria specific to PJI of TAA. The current algorithm and treatment strategies are extrapolated from data pertaining to hip and knee arthroplasty literature and although these do not specifically pertain to TAA PJI, they may offer insight into diagnosis and management. The authors offer insight into our current practice of treating PJI in TAA seen regularly at our tertiary care center.

Management of PJI in TAA first requires evaluating the patient for systemic sepsis. Sepsis is defined as a systemic response to infection with at least 2 systemic inflammatory response syndrome (SIRS) criteria in the setting of a known infection. SIRS criteria as described by Bone et al include: (1) temperature >38°C or <36°C; (2) heart rate >90 beats per minute; (3) respiratory rate >20 breaths per minute or $Paco_2$ <32 mm Hg; and (4) white blood cell count >12 000/mm^3.[4] Patients meeting criteria for sepsis secondary to PJI of TAA should be evaluated and treated emergently.

Septic patients secondary to PJI in TAA receive close monitoring in the surgical intensive care unit where appropriate resuscitation may be promptly performed. Infectious bacterial load is urgently reduced through explantation and surgical debridement. In cases of life-threatening septic shock or rapidly worsening infection, emergent amputation may be required. Following debridement, progress of bacterial eradication is monitored through trending inflammatory markers. Both erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels are obtained at time of presentation. CRP is then evaluated every 48 hours during inpatient treatment to monitor progress of infection while ESR is evaluated again 1 to 2 weeks later given the vastly different half-lives of these acute phase reactants. CRP has been shown to normalize within 7 days of infection eradication while ESR may take 22 days.[8,20] Blood cultures are drawn in all febrile patients at time of presentation to assess for bacteremia while synovial fluid and tissue cultures are obtained intraoperatively for intravenous antibiotic selection at time of surgical debridement. After the patient is medically stable, repeat irrigation and debridement may be performed with insertion of an antibiotic cement spacer and the patient may be managed similarly to a non-septic patient with TAA PJI as noted below.

Patients not in septic shock who present with acute PJI in TAA (<4 weeks from index procedure) require operative irrigation and debridement, intraoperative cultures, and polyethylene spacer exchange. Culture specific antibiotics are selected and inflammatory markers (eg, ESR and CRP) are trended through hospitalization and subsequent follow up to ensure eradication of infection as noted previously.

Patients who are not in septic shock who present with a chronic PJI in TAA (>4 weeks from index procedure) typically require initial management with arthroplasty explantation, antibiotic cement spacer placement, and culture-specific parenteral antibiotics.[11] Following TAA explantation and infection eradication, definitive cement spacer salvage procedure, revision TAA, or arthrodesis may be used for definitive treatment. In severe circumstances, below knee amputation may also be necessary.[11] Treatment with a cement spacer may limit functional capacity in comparison to revision TAA or arthrodesis; however, this method is proven as a viable salvage option. Lee et al investigated outcomes of a series of 16 patients who underwent definitive ankle cement arthroplasty for intractable infection, nonunion, large bone defects, and tumors. Average AOFAS scores improved from 39 to 70 using this technique with an average spacer retainment of 39 months (range, 14-100 months).[13]

Staged revision TAA is another definitive treatment option for TAA PJI. Revision TAA and arthrodesis are both options that should be discussed with patients as both treatment options rely heavily on patient functional status, postoperative goals, and surgeon experience. In the setting of normalized serum inflammatory markers, negative aspiration and/or cultures, and absence of symptoms, it has been recommended that revision TAA be considered if there is adequate soft tissue envelope, bone stock, preoperative range of motion, and patient compliance.[11] Concerns of inadequate bone stock, however, may be overcome with the use of staged Ilizarov distraction osteogenesis to correct limb length discrepancies followed by revision TAA. This may provide revision arthroplasty options to patients with significant bone stock deficits or deformities. Deficits in preoperative range of motion have historically played a role in choosing definitive arthrodesis over revision arthroplasty in TAA PJI as previously described.[16] In the setting of primary TAA performed on stiff ankles with limited preoperative range of motion, evidence exists demonstrating significant improvements in gait in patients with stiff ankles who underwent TAA.[5] No research to our knowledge has been done to assess gait function in patients with stiff ankles revised for TAA PJI; however, these findings suggest that preoperative ankle stiffness is not a contraindication to

revision TAA for PJI. Revision TAA for stiff ankles following PJI is our institutional preference over conversion to arthrodesis with the goal of optimizing gait function.

Staged tibiotalar arthrodesis following TAA PJI involves eradication of infection and removal of all hardware as noted above. Tibiotalar arthrodesis should be considered in severe cases of osteolysis, loss of adequate bone stock, or soft tissue envelope concerns. Arthrodesis of the subtalar joint as well in the form of tibiotalocalcaneal (TTC) fusion should be performed in the setting of severe loss of talus bone stock, severe talar component subsidence, subtalar arthritis, or clinically painful examination findings or history suggestive of subtalar pain generation. In cases of significant bone loss secondary to subsidence or osteolysis, femoral head allograft, distal tibia allograft, or tricortical iliac crest allograft or autograft may be used to restore length. Small wire circular frames may be used to supplement fusion construct stability and fusion interface compression. Additionally, staged distraction osteogenesis may be used as a separate technique to first obtain successful tibiotalar fusion while maintaining functional limb-length.[12,14]

All management options and length of proposed treatment should be thoroughly discussed with the patient and verified to align with the patient's treatment outcome goals. The mean "time in frame" technique of circular external fixator–assisted ankle arthrodesis was 197 days (range, 146-229).[14] Even patients who are candidates for this salvage procedure may prefer other treatment options because of this time commitment, and this should be discussed at length before deciding on a treatment strategy.

Institutional Recommendations

Understanding that no criteria specific to diagnosing PJI in TAA currently exists, our institution uses the recommendations set forth by the International Consensus Group on Periprosthetic Joint Infection with a minor modification. The diagnosis of infection made with the presence of 1 major criteria or at least 3 of 5 minor criteria as previously discussed is utilized; however, a more conservative threshold is used for the criteria of aspirated synovial fluid white blood cell (WBC) count and percentage polymorphonuclear neutrophil (%PMN) values.[18] Rather than using the minor criteria of synovial WBC >10 000 cells/μL and elevated synovial fluid %PMN (acute PJI: >90%; chronic PJI: >80%), we extrapolate the more conservative values described in diagnosing total knee arthroplasty PJI (WBC >1100 cells/μL, 64% PMN).[9,19] Our more conservative minor criterion is established to minimize false negatives and the destructive clinical sequela related to delayed diagnosis of TAA PJI. We recognize that this may result in an increased rate of false-positive results and subsequent morbidity related to further procedures; however, we only recommend ankle aspiration in the setting of high clinical suspicion for PJI.

If these criteria are met, we execute the following treatment algorithm (Figure 2) depending on when the index procedure was performed:

- If ≤4 weeks from index procedure:
  - Conduct irrigation and debridement and polyethylene exchange, preferably within 24-48 hours
  - Obtain intraoperative cultures and sensitivities
  - Consultation with Orthopaedic Infectious Disease for culture-specific antibiotic therapy and possible lifelong antibiotic suppression
  - Continue to monitor clinically for signs and symptoms of infection for at least 1 year
- If >4 weeks:
  - Resection of arthroplasty components, intraoperative cultures, excisional debridement and irrigation, and placement of an antibiotic-eluting cement spacer.
  - Consultation with Orthopedic Infectious Disease for culture-specific antibiotic therapy
  - Weekly monitoring of WBC, ESR, and CRP
  - Cement spacer is maintained for 6 weeks and joint aspiration is performed if weekly WBC, ESR, and CRP values normalize
  - In the setting of normalized serum markers, negative aspiration and/or cultures, and the absence of symptoms, we assume the infection is eradicated and definitive treatment in the form of arthroplasty versus arthrodesis is discussed with the patient
  - Our institutional preference is toward revision TAA in the context of adequate soft tissue envelope, bone stock, range of motion, and patient compliance—in alignment with that described by Hsu et al[11]
- Medically Unstable Patient
  - Despite the chronicity of TAA PJI, the medically unstable patient requires emergent care
  - In cases of rapidly worsening local infection, rapidly worsening and life-threatening systemic sepsis, or sepsis recalcitrant to local debridement and explantation, emergent infectious source control in the form of amputation should be performed.
  - In patients deemed medically unstable for general anesthesia who are not septic secondary to TAA PJI, arthroscopic irrigation and debridement under regional anesthesia is a viable option in place of open debridement depending on surgeon preference. Similarly, repeated bedside aspirations and needle lavage may be performed as a temporizing modality to decrease bacterial load.

Conclusion

Current literature is significantly limited regarding data available on PJI in the context of total ankle arthroplasty. No consensus on the specific definition of PJI in TAR with high specificity and sensitivity currently exists. Current

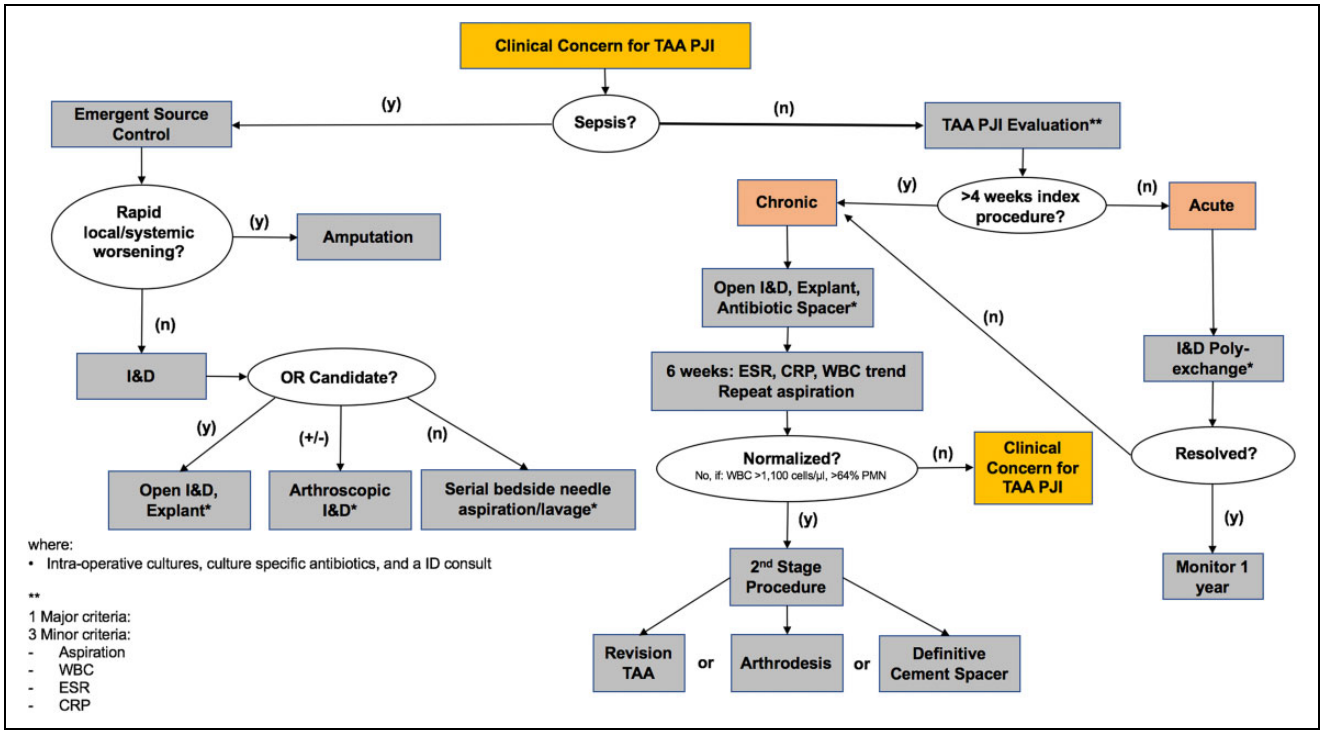

Figure 2. Management algorithm for PJI in TAA.
Abbreviations: CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; ID, infectious disease; I&D, irrigation and debridement; n, no; PJI, periprosthetic joint infection; TAA, total ankle arthroplasty; WBC, white blood count; y, yes; µL, microliter.

diagnostic algorithms rely entirely on the hip and knee arthroplasty literature, which may not accurately represent PJI specific to TAA. High-powered quality clinical studies are needed to further characterize diagnostic criteria with associated sensitivities and specificities in order to develop accurate clinical diagnostic models specific to TAA.

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