ISSN: 3065-758X
Review Article

Journal of Infectious Diseases and Viruses Research

Periprosthetic Knee Infection: A Diagnostic and Surgical Challenge

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Submitted: 03 March 2025 **Accepted:** 10 March 2025 **Published:** 17 March 2025

https://doi.org/10.63620/MKJIDVR.2025.1032

Citation: *Spinarelli, A., Conserva, V., Palmiotto, F., & Porcelli, G. (2025). Periprosthetic Knee Infection: A Diagnostic and Surgical Challenge. J of Infec Dise and Vir Res, 4(2), 01-07.*

Abstract

Periprosthetic joint infection (PJI) is one of the major complications resulting from the implantation of a joint prosthesis. Staphylococci are responsible for more than 50% of prosthetic infections, about 20% can be polymicrobial, 15% are gram-negative and about 10% of cultures are negative. The complete eradication of the infection is extremely difficult. For a correct treatment is first of all useful to perform a clinical staging based on the anatomical location of the infection and on the immune characteristics of the host. However, regardless the area of infection, the role of the surgeon is crucial, firstly in terms of timing and secondly in assessing the degree of invasiveness of the infected and necrotic tissues required. The goal of the treatment must be to eradicate the infection ensuring the maximum functional result.

Keywords: TKA, Infection, PJI

Introduction

Periprosthetic joint infection (PJI) represents one of the most significant complications following joint prosthesis implantation. The incidence of infection after a primary implant is estimated to be between 1% and 2%, increasing to approximately 4% in revision surgeries [1-3]. Currently, there is no universally accepted definition of PJI. Clinically, it can manifest in various forms, and classical signs of infection-such as fever, leukocytosis, or local inflammatory symptoms-may be absent, making diagnosis particularly challenging. However, the inability to identify a pathogen does not exclude the diagnosis.

Staphylococci are responsible for over 50% of prosthetic infections, while approximately 20% of cases are polymicrobial, 15% involve gram-negative bacteria, and about 10% yield negative cultures. Research has demonstrated that the pathogens responsible for PJI vary depending on the time of onset in relation to the surgical procedure [4-7]. In particular, infections occurring within the first four weeks postoperatively (early infections) are typically caused by highly virulent microorganisms, such as Staphylococcus aureus. In contrast, infections that develop beyond three months post-surgery are often due to low- virulence organisms, including coagulase-negative Staphylococcus, Propionibacterium acnes, and Enterococci.

The incidence of infections is highest during the first two years following surgery. This is attributed to the increased vascularization of peri-implant tissues, which facilitates the hematogenous spread of bacteria [8]. One of the main challenges in eradicating PJI is the presence of biofilm—a structured microbial community embedded within a self-produced extracellular matrix. This biofilm confers a significant survival advantage to bacteria, rendering them up to 1000 times more resistant to antibiotic treatment and capable of evading the host's immune response [9].

A comprehensive discussion on the most relevant aspects of prosthetic infections took place at the International Consensus Meeting in Philadelphia in 2018, providing updated recommendations based on the latest scientific evidence.

For effective treatment, an initial clinical staging is essential, considering both the anatomical location of the infection and the immune status of the patient. Regardless of the affected area, the surgeon's role is pivotal, particularly in determining the appropriate timing and extent of surgical intervention necessary for debridement and removal of necrotic tissue. The success of surgical management directly influences recurrence rates, postoperative complications, and overall patient outcomes, includ-

ing the stability of bone structures and restoration of joint and muscular function.

Despite the significance of PJI, few studies have addressed the management of exposed prostheses. Available evidence suggests that in most cases, prompt and adequate soft tissue coverage plays a crucial role in prosthesis salvage [10]. Skin complications following knee arthroplasty are relatively common, though they do not always result in prosthetic exposure. In cases where the prosthesis becomes exposed, primary closure via simple suturing is usually ineffective. Instead, early intervention with vascularized soft tissue reconstruction is required to promote wound healing and preserve the prosthesis.

Among the various reconstructive options, the gastrocnemius muscle flap is considered the gold standard due to its simplicity, reliability, and safety. When combined with appropriate local and systemic antibiotic therapy, this technique provides durable soft tissue coverage and can be performed in a single-stage procedure. Additionally, it is associated with low morbidity and minimal residual scarring, making early intervention particularly advantageous [11-13]. Further benefits of the gastrocnemius muscle flap include early mobilization, reduced hospital stays, and lower rates of arthrodesis, ultimately leading to better functional outcomes for patients [11].

Diagnosis of Periprosthetic Joint Infection (PJI)

Diagnosing PJI remains one of the most challenging aspects of managing patients with joint replacements, despite the development of increasingly refined criteria and scoring systems over the years. A correct diagnosis is critical not only for determining the presence of infection but also for selecting the most appropriate treatment strategy to ensure successful outcomes [14].

Evolution of Diagnostic Criteria

In 2011, the Musculoskeletal Infection Society (MSIS) introduced standardized criteria for PJI diagnosis. These criteria underwent further refinement during the 2013 International Consensus Meeting (ICM). More recently, both national and international working groups have striven to establish robust and standardized protocols for diagnosing suspected PJI. In 2018, a new evidence-based PJI definition was published, which, upon external validation, demonstrated improved performance in diagnosing hip and knee PJIs. Continuing this trend toward standardization, the European Joint Infection Society (EBJIS) released a practical, three-level diagnostic guide for clinicians at the end of 2020 [15-18].

Clinical Presentation and Initial Evaluation

The diagnosis of PJI can sometimes be straightforward. For example, the presence of a communicating fistula or obvious prosthetic exposure is sufficient to classify the joint as infected. In more occult cases, although local signs of infection and systemic symptoms such as fever may raise suspicion, pain remains the most prevalent and significant symptom-reported in over 90% of cases.

The initial workup for suspected PJI typically includes:

- **Radiographic Assessment:** Standard X-rays in two projections are used to evaluate prosthesis stability, looking for signs such as loosening or the presence of radiolucent lines indicative of osteolysis.
- **Blood Tests:** Laboratory markers such as C-reactive protein (CRP), D-dimers, and the erythrocyte sedimentation rate (ESR) are measured. However, it is important to note that recent studies have reported a false-negative rate of approximately 20% for CRP and ESR [19].
- **Arthrocentesis:** Joint aspiration, ideally performed in a sterile setting, is a critical diagnostic step. It is recommended that any ongoing antibiotic therapy be withheld for at least 14 days prior to the procedure to enhance test sensitivity [20]. A minimum of 2 mL of synovial fluid is advised to allow for multiple assays, including the alpha-defensin test, white blood cell (WBC) count, leukocyte esterase (LE) assay, CRP, and polymorphonuclear (PMN) cell percentage analysis.

Advanced Synovial Fluid Analysis

Among the newer diagnostic markers is alpha-defensin, an antimicrobial peptide released by neutrophils. When combined with CRP levels, alpha-defensin has significantly enhanced the diagnostic criteria for PJI. Although this test is highly accurate, its widespread use is tempered by high costs, limited utility in the immediate postoperative period, and the possibility of false positives in cases of metallosis. To mitigate these issues, Stone et al. proposed an algorithm that integrates the alpha- defensin assay with CRP measurement, thereby reducing both false positive and false negative results [21].

Another rapid diagnostic tool is the leukocyte esterase dipstick test (LET), which can be performed at the patient's bedside. A strongly positive result—indicated by a deep purple color (++), suggests a high likelihood of infection. Nevertheless, differential diagnoses, such as gout or other inflammatory arthropathies, must be considered. A meta- analysis encompassing 1,011 patients reported a sensitivity of approximately 90% and a specificity near 97% for LET [22].

For more precise results, synovial fluid samples are typically sent to the laboratory after centrifugation to remove blood contaminants. Recent studies suggest diagnostic cutoffs of 1,630 leukocytes/μL (sensitivity 83.6%, specificity 82.2%) and a PMN percentage of 60.5% (sensitivity 80.3%, specificity 77.1%). However, universally accepted cutoff values have yet to be established [23].

Microbiological Culture and Histopathology

Swab cultures, while sometimes used, are known to yield a high rate of false positives. Consequently, the gold standard for diagnosing PJI remains bacterial cultures. These cultures should be incubated in a microbiology laboratory for at least 14 days, and the isolation of the same microorganism in at least two separate cultures is considered confirmatory evidence of infection. In 2018, an international meeting held in Philadelphia resulted in the development of a scoring system based on these diagnostic tools. Compared to the MSIS criteria, this new system demonstrated a sensitivity of 97.7% and a specificity of 99.5%, greatly facilitating preoperative diagnosis.

In complex cases where the diagnosis remains ambiguous, a periprosthetic tissue biopsy can be invaluable. Performed under CT or ultrasound guidance, this procedure allows for the col-

lection of tissue samples for both histopathological examination and culture. The detection of inflammatory cell infiltrates, coupled with positive culture results, strongly supports the diagnosis of PJI.

Emerging Techniques: Next-Generation Sequencing

The final frontier in PJI diagnosis is the application of next-generation sequencing (NGS). This cutting-edge genetic sequencing technique is rapidly becoming more cost-effective and faster than traditional methods. NGS is highly sensitive-capable of detecting bacterial DNA even in cases where traditional cultures might fail. Although this approach is promising, research into its clinical application is still in its early stages [24, 25].

Table 1:

Major criteria (at least one of the following)	Decision
2 positive cultures of the same organism	Infected
Sinus tract with evidence of communication to the joint or visualization of the prosthesis	

Table 2: New scoring system definition for PJI (Philadelphia ICM 2018). Caution is required in several conditions, like adverse local tissue reaction, crystal deposition disease, slow growing organisms, etc. CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; LE, leukocyte esterase; PMN, polymorphonuclear; WBC, white blood cell.

Preoperative Diagnosis	Minor criteria		Score	Decision
	Serum	Elevated CRP or D-Dimer	2	6 Infected
		Elevated ESR	1	
		Elevated synovial WBC count or LE	3	
	Synovial	Positive alpha-defensin	3	2-5 Possibly Infecteda
		Elevated synovial PMN (%)	2	
		Elevated synovial CRP	1	0-1 Not Infected

Intraoperative Diagnosis	Inconclusive pre-op score or dry tap	Score	Decision
	Preoperative score	-	6 Infected
	Positive histology	3	
	Positive purulence	3	4-5 Inconclusiveb
	Single positive culture	2	3 Not Infected

Treatment of Knee Prosthesis Infections: An Integrated, Multimodal Approach

The treatment of infections in knee prostheses requires a comprehensive approach that considers multiple factors. These include the timing of the infection (early, delayed, or late onset), the condition of the soft tissues, the extent and clarity of the infectious process (including the functionality of the extensor mechanism), the patient's comorbidities, laboratory inflammatory markers, microbiological data (including identification of the causative agent and its antibiotic sensitivities), the stability of the implant, as well as the patient's functional expectations and needs. Ultimately, the goal is to eradicate the infection while preserving or restoring the maximum possible function of the joint. Treatment may involve antibiotic therapy alone or in conjunction with one or more surgical interventions [26, 27].

Antibiotic Therapy

Antibiotic treatment is one of the two cornerstones of managing prosthetic joint infections. Its use must be carefully tailored to the clinical scenario:

Limited Role in Isolated Surgical Wound Infections

In cases where the infection is limited solely to the surgical wound, antibiotic therapy may be the treatment of choice if there is no need for surgical intervention.

Challenges with Biofilm-Associated Infections

When the infection extends beyond the superficial wound, the presence of a bacterial biofilm on the prosthetic implant significantly reduces the efficacy of antibiotics administered alone. In these situations, antibiotic therapy is generally reserved for specific conditions, such as:

- Patients at high operative risk or those with significant comorbidities.
- Patients with a stable, mechanically sound prosthesis.
- Infections caused by low-virulence microorganisms that are sensitive to oral antibiotics.
- Patients who are medically stable, without signs of an acute, ongoing septic process [28].
- Targeted versus Broad-Spectrum Antibiotics:

When culture results are available, treatment should be tailored to the identified organism with a specific antibiotic regimen. In contrast, broad-spectrum antibiotics are indicated for patients

with acute knee infections exhibiting signs of sepsis, pending culture results [29].

- Role of Multidisciplinary Oversight:

The choice, dosing, and duration of antibiotic therapy should be determined in collaboration with infectious disease specialists, medical microbiologists, and virologists. Postoperative protocols must be established to monitor the patient's response and to determine the appropriate route and duration of antibiotic administration.

Surgical Treatment

In many cases, surgical intervention is required alongside antibiotic therapy. The choice of surgical technique depends on factors such as implant exposure, the extent of infection, implant stability, and patient- related factors. Surgical options range from joint preservation procedures to salvage operations:

DAIR (Debridement, Antibiotic Therapy, and Implant Retention) and DAPRI (Debridement, Antibiotic Therapy, Partial Replacement, and Implant Retention)

DAIR Approach

For early infections, debridement and irrigation with antiseptic solutions—performed without removing the implant—are typically recommended. This is appropriate in cases where:

- Radiographs do not show signs of implant loosening or heterotopic bone formation (which would suggest a chronic process).
- The prosthetic implant appears mechanically stable, a fact that should be confirmed intraoperatively.

Procedure Details

- Infected tissue is thoroughly removed and sent for culture.
- Placement of drains can help evacuate postoperative seroma or hematoma.
- Local delivery of antibiotics via antibiotic beads, in conjunction with systemic therapy, may enhance infection control.
- Replacement of modular components (if present) is advised when they are identified as potential sources of persistent infection [28, 30].

Advantages of DAIR

- It is less invasive than complete prosthesis removal.
- It is associated with a lower risk of surgical complications.
- It generally involves lower overall costs.

Limitations of DAIR

- There is a risk of persistent or recurrent infection.
- The approach may fail if the infection is chronic or if the implant is unstable.

DAPRI Approach

DAPRI builds upon the DAIR concept by including the replacement of selected modular components of the implant:

Key Elements:

- **Debridement:** As in DAIR, meticulous removal of infected tissue is performed.
- **Antibiotic Management:** Similar to DAIR, with an emphasis on prolonged and targeted antibiotic therapy.
- **Prosthesis Retention with Partial Replacement:** The technique involves replacing modular components (e.g., the polyethylene liner) while retaining well-fixed parts of the implant. This reduces the bacterial load and the risk of re-infection without subjecting the patient to the morbidity of a full revision.

Advantages of DAPRI

- Improved infection control compared to DAIR alone.
- Preservation of the implant structure, reducing overall surgical invasiveness.
- Lower risk of postoperative instability.

Limitations of DAPRI

- It is a more complex and technically demanding procedure.
- Successful outcomes depend on an accurate intraoperative assessment of the implant's stability.

Two-Stage Revision

The two-stage revision is considered the gold standard for chronic or complex infections, especially those associated with implant mobilization or virulent pathogens such as MRSA.

First Stage

- Removal of the prosthetic implant and all foreign materials.
- Aggressive debridement of necrotic tissue.
- Placement of an antibiotic-loaded spacer that aids in maintaining limb alignment, preserves partial joint mobility, and allows local antibiotic release.

Second Stage

- Once infection eradication is confirmed (often by clinical, laboratory, and sometimes histological parameters), the spacer is removed.
- A new prosthesis is implanted [28, 30].

Single-Stage Revision

A single-stage revision may be appropriate for select patients:

- When the causative organism is known and sensitive to antibiotics.
- When no abscesses or significant collections are present.
- In patients who are not immunocompromised and show no radiological evidence of implant loosening or ongoing osteitis.
- Patients must typically receive preoperative antibiotic therapy (usually for 2–3 weeks) to reduce the infectious load prior to surgery [28, 31].

This procedure involves

- Complete removal of the infected implant and any foreign materials.
- Immediate implantation of a new prosthesis in the same surgical session.
- It is especially indicated when there is good soft tissue coverage and minimal to moderate bone loss.

Rescue Operations

For some patients, re-implantation of a prosthesis may not be feasible. In such cases, salvage procedures are considered to

manage the infection and maintain limb function. These include:

Arthrodesis

Arthrodesis is indicated when other reconstructive options have failed or are not feasible—such as in cases of extensive bone loss, compromised soft tissues, or infections with highly virulent organisms.

- **Procedure:** The joint is surgically fused, eliminating motion but providing a stable, pain-free limb capable of weight bearing.
- **Techniques:** Various methods (intramedullary nails, plates, or external fixators) may be used.
- **Considerations:** The success of arthrodesis can depend on the type of prosthesis previously implanted. Studies have shown variable success rates, with better outcomes following the failure of condylar prostheses compared to constrained implants [33-35].

Resection Arthroplasty

This procedure involves removing the implant and cement with thorough debridement, but without re-implanting any device. The goal is to create a "false joint" that offers a limited degree of mobility.

- **Indications:** Typically reserved for patients with low functional demands.
- **Postoperative Management:** Following surgery, the limb is immobilized for 3–6 months to allow soft tissue retraction and stabilization, which can result in a functional albeit limited range of motion [32].

Amputation

Amputation is considered a last-resort option in cases where:

- The local infection is uncontrollable despite radical surgical attempts.
- The patient's life is at risk due to systemic sepsis.
- Extensive bone loss and soft tissue compromise preclude successful wound closure.

Above-Knee Amputation

In particular, above-knee amputation may be necessary when the functionality of the extensor mechanism is irreparably lost, rendering the joint nonfunctional despite potential re-implantation [28, 34].

Management of Surgical Wound Complications

Effective management of the surgical wound is crucial in the postoperative period to prevent the development or progression of infection:

- **Hemostasis and Drainage:** After knee arthroplasty, the use of drainage systems (typically maintained for 24–48 hours) minimizes hemarthrosis. Persistent intra- articular bleeding can foster bacterial growth and may lead to wound dehiscence.
- **Wound Monitoring and Rehabilitation:** Excessive bleeding or wound dehiscence should prompt careful monitoring. A temporary pause in rehabilitation may be necessary to reduce mechanical stress on the healing wound.
- **Addressing Wound Dehiscence:** Any discontinuity in skin closure along the surgical incision can signal a potentially dangerous complication. Superficial wound dehiscence without systemic or laboratory evidence of infection can often be managed conservatively with frequent dressing changes and close follow-up to allow secondary intention healing.
- **Management of Extensive Tissue Necrosis:** In cases where a large ischemic area is identified around the surgical wound, early surgical intervention may be required. This might involve the excision of necrotic tissue followed by coverage with a skin graft, a local muscle flap, or both. Early intervention is critical to prevent further complications, including deep infections [34].

Conclusions

The identification of patient's risk factors, an adequate preoperative planning and a correct surgical execution, especially in patients already operated, an antibiotic prophylaxis and finally an early management of complications can reduce the infectious risk.

In the presence of signs and symptoms and/or laboratory test suggestive of infection, early diagnosis and aggressive treatment can make the eradication of the infection.

The most important factors to be considered when choosing the best protocol for treating a knee replacement infection include:

1. The time between surgery and the development of the infection;
2. The radiographic findings and if the bone-cement and bone-prosthesis interface is involved in the infectious process and whether the prosthesis has any mobilization findings;
3. The nature of the patient's symptoms;
4. The etiological agents involved and their sensitivity to antibiotics;
5. If replanting is possible;
6. What type of prosthesis is present and how much bone loss may be present at the time of its removal;
7. The presence of complications affecting the surgical wound and / or soft tissue;
8. The functional needs of the patient.

Considering all of this, a rational management plan can usually be found with the most appropriate treatment. Early diagnosis of the infection can ensure a less invasive surgical management; in this case, surgical debridement in association with antibiotic therapy can ensure the implant retention, especially in the presence of a low virulence infectious agent.

When these criteria is absent, the prosthesis must be removed and after debridement and local antibiotic therapy, the implant must be replaced. When the infection cannot be controlled or in presence of an important skin and soft tissues loss, arthrodesis may be the best approach. Resection arthroplasty and amputation are reserved when neither reimplantation nor arthrodesis is possible.

In summary, while the diagnosis of PJI continues to pose significant challenges, advancements in diagnostic criteria, laboratory markers, imaging techniques, and emerging molecular methods are steadily improving our ability to accurately detect and manage these infections. A comprehensive, multi-modal diagnostic

approach remains essential to ensure timely and appropriate treatment, ultimately leading to better patient outcomes.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Izakovicova, P., Borens, O., Trampuz, A. (2019). Periprosthetic joint infection: current concepts and outlook. EFORT open reviews, 4(7), 482-494.
2. Corvec, S., Portillo, M. E., Pasticci, B. M., Borens, O., Trampuz, A. (2012). Epidemiology and new developments in the diagnosis of prosthetic joint infection. The International journal of artificial organs, 35(10), 923-934.
3. Ong, K. L., Kurtz, S. M., Lau, E., Bozic, K. J., Berry, D. J., Parvizi, J. (2009). Prosthetic joint infection risk after total hip arthroplasty in the Medicare population. The Journal of arthroplasty, 24(6), 105-109.
4. Askar, M., Bloch, B., Bayston, R. (2018). Small-colony variant of Staphylococcus lugdunensis in prosthetic joint infection. Arthroplasty today, 4(3), 257-260.
5. Solarino, G., Abate, A., Vicenti, G., Spinarelli, A., Piazzolla, A., Moretti, B. (2016). Reducing periprosthetic joint infection: what really counts? Joints, 3(04), 208-214.
6. Slullitel, P. A., Oñativia, J. I., Buttaro, M. A., Sánchez, M. L., Comba, F., Zanotti, G., Piccaluga, F. (2018). State-of-the-art diagnosis and surgical treatment of acute peri-prosthetic joint infection following primary total hip arthroplasty. EFORT Open Reviews, 3(7), 434-441.
7. Wang, F. D., Wang, Y. P., Chen, C. F., Chen, H. P. (2018). The incidence rate, trend and microbiological aetiology of prosthetic joint infection after total knee arthroplasty: A 13 years' experience from a tertiary medical center in Taiwan. Journal of Microbiology, Immunology and Infection, 51(6), 717-722.
8. Rakow, A., Perka, C., Trampuz, A., Renz, N. (2019). Origin and characteristics of haematogenous periprosthetic joint infection. Clinical Microbiology and Infection, 25(7), 845-850.
9. Nickel, J. C., Ruseska, I., Wright, J. B., Costerton, J. W. (1985). Tobramycin resistance of Pseudomonas aeruginosa cells growing as a biofilm on urinary catheter material. Antimicrobial agents and chemotherapy, 27(4), 619-624.
10. Casanova, D., Olivier Hulard, Rémy Zalta, Jacques Bardot, Guy Magalon, D. (2001). Management of wounds of exposed or infected knee prostheses. Scandinavian journal of plastic and reconstructive surgery and hand surgery, 35(1), 71-77.
11. Adam, R. F., Watson, S. B., Jarratt, J. W., Noble, J., Watson, J. S. (1994). Outcome after flap cover for exposed total knee arthroplasties. A report of 25 cases. The Journal of Bone & Joint Surgery British Volume, 76(5), 750-753.
12. Gault, D. T., Quaba, A. (1986). Is flap vover of exposed metalwork worthwhile? a review of 28 cases. British journal of plastic surgery, 39(4), 505-509.
13. Greenberg, B., LaRossa, D., Lotke, P. A., Murphy, J. B., Noone, R. B. (1989). Salvage of jeopardized total-knee prosthesis: the role of the gastrocnemius muscle flap. Plastic and reconstructive surgery, 83(1), 85-89.
14. Gehrke, T., Alijanipour, P., Parvizi, J. A. V. A. D. (2015). The management of an infected total knee arthroplasty. The bone & joint journal, 97(10_Supple_A), 20-29.
15. Parvizi, J., Zmistowski, B., Berbari, E. F., Bauer, T. W., Springer, B. D., Della Valle, C. J., ... & Zalavras, C. G. (2011). New definition for periprosthetic joint infection: from the Workgroup of the Musculoskeletal Infection Society. Clinical Orthopaedics and Related Research, 469, 2992-2994.
16. Parvizi, J., Gehrke, T., Chen, A. F. (2013). Proceedings of the international consensus on periprosthetic joint infection. The bone & joint journal, 95(11), 1450-1452.
17. Parvizi, J., Tan, T. L., Goswami, K., Higuera, C., Della Valle, C., Chen, A. F., Shohat, N. (2018). The 2018 definition of periprosthetic hip and knee infection: an evidence-based and validated criterion. The Journal of arthroplasty, 33(5), 1309-1314.
18. Gómez-Barrena, E., Warren, T., Walker, I., Jain, N., Kort, N., Loubignac, F., ... & De la Torre, B. J. (2022). Prevention of periprosthetic joint infection in total hip and knee replacement: one European consensus. Journal of Clinical Medicine, 11(2), 381.
19. Berbari, E., Mabry, T., Tsaras, G., Spangehl, M., Erwin, P. J., Murad, M. H., ... & Osmon, D. (2010). Inflammatory blood laboratory levels as markers of prosthetic joint infection: a systematic review and meta-analysis. JBJS, 92(11), 2102-2109.
20. Shahi, A., Parvizi, J. (2015). Prevention of periprosthetic joint infection. Archives of bone and joint surgery, 3(2), 72-81.
21. Stone, W. Z., Gray, C. F., Parvataneni, H. K., Al-Rashid, M., Vlasak, R. G., Horodyski, M., Prieto, H. A. (2018). Clinical evaluation of synovial alpha defensin and synovial C-reactive protein in the diagnosis of periprosthetic joint infection. JBJS, 100(14), 1184-1190.
22. Wang, C., Li, R., Wang, Q., Wang, C. (2018). Synovial fluid leukocyte esterase in the diagnosis of peri-prosthetic joint infection: a systematic review and meta-analysis. Surgical Infections, 19(3), 245-253.
23. Zahar, A., Lausmann, C., Cavalheiro, C., Dhamangaonkar, A. C., Bonanzinga, T., Gehrke, T., Citak, M. (2018). How reliable is the cell count analysis in the diagnosis of prosthetic joint infection? The Journal of arthroplasty, 33(10), 3257-3262.
24. Tarabichi, M., Shohat, N., Goswami, K., Parvizi, J. A. V. A. D. (2018). Can next generation sequencing play a role in detecting pathogens in synovial fluid? The bone & joint journal, 100(2), 127-133.
25. Zhao, Y., Chen, B., Li, S., Yang, L., Zhu, D., Wang, Y., ... & Zhang, L. (2018). Detection and characterization of bacterial nucleic acids in culture-negative synovial tissue and fluid samples from rheumatoid arthritis or osteoarthritis patients. Scientific reports, 8(1), 14305.
26. Kamal, A. F., Rubiansyah, P. (2019). Clinical outcome of various limb salvage surgeries in osteosarcoma around knee: Megaprosthesis, extracorporeal irradiation and resection arthrodesis. Annals of Medicine and Surgery, 42, 14-18. doi: 10.1016/j.amsu.2019.04.005. PMID: 31080592; PMCID: PMC6505041
27. Shih, H. N., Shih, L. Y. (2005). Resection arthrodesis of the knee for osteosarcoma: an alternative when mobile joint reconstruction is not feasible. Chang Gung medical journal, 28(6), 411-420.

28. Soudry, M., Greental, A., Nierenberg, G., Falah, M., Rosenberg, N. (2013). Periprosthetic infection following total knee arthroplasty. IntechOpen.
29. Petretta, R., Phillips, J., Toms, A. (2017). Management of acute periprosthetic joint infection of the knee–Algorithms for the on-call surgeon. The Surgeon, 15(2), 83-92.
30. Zahar, A., Sarungi, M. (2021). Diagnosis and management of the infected total knee replacement: a practical surgical guide. Journal of Experimental Orthopaedics, 8, 1-8.
31. Pellegrini, A., Suardi, V., Legnani, C. (2020). Classification and management options for prosthetic joint infection. Annals of Joint, 7, 3.
32. Falahee, M. H., Matthews, L. S., Kaufer, H. (1987). Resection arthroplasty as a salvage procedure for a knee with infection after a total arthroplasty. JBJS, 69(7), 1013-1021. PMID: 3654692.
33. Habermann, E. T. (1991). The infected total knee arthroplasty. In Total knee replacement. London: Springer London, 241-252.
34. Knutson, K., Hovelius, L., Lindstrand, A., & Lidgren, L. (1985). Arthrodesis after failed knee arthroplasty: a nationwide multicenter investigation of 91 cases. Clinical Orthopaedics and Related Research, 191, 202-212.32
35. Franceschini, M., Pedretti, L., Cerbone, V., Sandiford, N. (2020). Two stage revision: indications, techniques and results. Annals of Joint, 7, 4.

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