MENTORS IN ORTHOPEDICS

DEBRIDEMENT, ANTIBIOTICS, AND IMPLANT RETENTION (DAIR) IN PERIPROSTHETIC JOINT INFECTION (PJI)

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SUMMARY

Background: Periprosthetic joint infection (PJI) remains a significant complication following total joint arthroplasty. Debridement, antibiotics, and implant retention (DAIR) is a primary treatment strategy for acute PJI, offering lower morbidity and reduced costs compared to staged revision. However, success rates vary widely, and failure complicates subsequent infection eradication.

Objective: This review evaluates the indications, prognostic factors, and surgical techniques associated with DAIR success and failure in hip and knee arthroplasty.

Key Points: Optimal candidates for DAIR present with acute symptoms (<4-6 weeks), well-fixed prostheses, and adequate soft tissue. Factors associated with treatment failure include age over 80 years, rheumatoid arthritis, elevated inflammatory markers (CRP >65 mg/dL; ESR >107.5 mm/hr), and systemic sepsis. Microbiological challenges, particularly Methicillin-resistant Staphylococcus aureus (MRSA) and polymicrobial infections, significantly reduce success rates. Essential surgical components include radical debridement, obtaining five culture samples, and mandatory exchange of modular components to address the biofilm. In hip DAIR, the risk of dislocation (14-26.6%) can be mitigated by increasing femoral head size or offset. While repeated DAIR remains controversial, some protocols report success with a "double DAIR" approach. Emerging machine learning algorithms utilizing variables such as immune status and bacterial profile demonstrate potential in predicting clinical outcomes.

Conclusion: DAIR success is contingent upon rigorous patient selection and standardized surgical execution. Integrating advanced predictive tools and machine learning may facilitate personalized treatment algorithms to improve outcomes in PJI management.

KEYWORDS

Prosthesis-Related Infections; Debridement; Arthroplasty, Replacement, Knee; Arthroplasty, Replacement, Hip; Reoperation

INTRODUCTION

Periprosthetic joint infections (PJI) after joint arthroplasty continues to be the most devastating complication, posing significant challenges for patients, surgeons, and healthcare system. The various treatment options for PJI are subject to ongoing debate. For acute PJI, one such option is debridement, antibiotics, and implant retention (DAIR).[12] The outcome of DAIR depends on both host factors and bacterial characteristics. Despite varied success rate, DAIR remains to be a viable option for acute PJI.

DAIR is frequently chosen due to its association with lower morbidity, reduced cost, less bone and tissue damage, shorter hospital length of stay, and less technical demand compared with one or 2-stage. It also offers better functional outcome with variable success rate, and often high success rate when the right patients are selected. However, a crucial consideration is that if DAIR fails, eradication of the infection becomes more difficult. Therefore, careful patient selection is paramount. This involves understanding the factors associated with DAIR success and failure. DAIR is indicated in PJI patient with well-fixed prostheses, adequate soft tissue support of the joint, and duration of infection which is less than 4 to 6 weeks.[4] The success rate of DAIR in patients with good indication was 11-100%. [5],[10],[23]

INDICATION

The success rate in DAIR largely hinges on appropriate patient selection. Several factors contribute to DAIR failure that needs to be carefully considered.

1. Patient factor:

a. Time of onset

Timing is critical for DAIR success. DAIR has a high failure rate if symptoms arise more that 1 year after primary total joint arthroplasty (TJA), with success rate as low as 37%.[32] Consequently, the ICM 2018 recommends DAIR for acute infections occurring within 1 month of primary arthroplasty or in cases of late hematogenous infection with symptoms less than 4 weeks.[1],[19] Early diagnose of PJI is crucial.[20]

b. Age

Woythuyzen-Bakker found that age > 80 years will likely result in DAIR failure although this finding has not consistently found in other studies.[30]

c. Gender

Some studies suggest that male sex increases the DAIR failure rate, but this observation lacks widespread support from other studies.[30]

d. Rheumatoid arthritis

Rheumatoid arthritis has been identified as a contributing factor to DAIR failure.[21]

e. Comorbidities

McPherson et al developed a staging system for PJI based on infection type, systemic host grade, and local extremity grade.[15] McPherson host grade A patients exhibited a lower DAIR failure rate compared to those in grade B and C.[3] However, conflicting findings were reported by Toh et al who found no correlation between the Charleston Comorbidity Index (CCI) and American Society of Anesthesiologists (ASA) score with DAIR failure rates.[26]

f. Immune status

Similar to other surgical procedure, a patient's innate immunity plays a vital role in controlling infection after TJA. No immunocompromised patients tend to respond effectively to DAIR.[17]

g. Blood examination

Elevated Erythrocyte Sedimentation Rate (ESR) and C-reactive protein (CRP) level [26],[28],[31] have been shown to affect DAIR success rate. A CRP> 65mg/dL has been associated with an increased DAIR failure rate.[32] Toh et al. found that an ESR elevation >107.5 mm/hr was associated with treatment failure in DAIR.[26] However, Surgeons must also consider other conditions that can cause elevated CRP or ESR, such as aging, anemia, obesity, renal impairment, and other cases not related to infection.

h. General condition

Poor general condition [31] lower the success rate of DAIR, especially in sepsis patient with PJI. Sepsis patient with PJI had lower rate of no recurrent PJI compare with PJI without sepsis. Ludwick et al design a monogram for the sepsis score in PJI patient that can be used to identify which PJI patient had factors associated with sepsis. This scoring system will count the probability of patient developing sepsis.[13]

Tornero et al used the KLIC-score in predicting the failure of DAIR in early acute PJI (post-surgical PJI). Tornero used classical DAIR and used the needed for second DAIR as one of failure criteria. They found that having KLIC score lower than 2 has 100% failure rate.[27] Interestingly, the KLIC-score only work in patients with a very low and very high score, and not on average score patients.

Wouthuyzen-Bakker et al used CRIME80-score for late acute (hematogenous) PJI. The CRIME80-score did not use the second DAIR as a failure criteria. However, its predictive strength is lower than KLIC-score. Therefore, the CRIME80-score is not frequently used as a predictor for DAIR.[30]

2. Bacterial factor:

a. Positive blood culture

Several studies reported that around 44.9-53.1% PJI patients has positive blood culture. This positive blood culture decreases success rate of treatment.[9],[11]

b. Methicillin-resistant Staphylococcus aureus and polymicrobial infections

Several studies reported that the incidence of Methicillin-resistant Staphylococcus aureus is increasing overtime (13.6-19%) with decreasing the coagulase-negative staphylococci PJI (from 40.9% 22.0%) showing global trend of antibiotic resistance. This bacteria lower the success rate of DAIR.[31] Interestingly, not only MRSA and polymicrobial, but gram-negative bacteria, such as Staphylococcus aureus, and MSSA (methicillin-susceptible Staphylococcus aureus) also increase DAIR failure rate.[26]

DAIR can give better results with the right antibiotic selection based on culture results. On the other hand, 32.5% cases present as culture-negative PJI, making it difficult to treat due to inability to choose the specific antibiotic. This often mandates the use of broad spectrum antibiotic with high risk toxicity and contributes to antibiotic resistance. Two-stage exchange remained an effective treatment for culture-negative PJI. In contrast, Tirumala et al found that the success rate of DAIR in culture-negative PJI is similar with acute culture-positive PJI. Therefore, culture-negative PJI is not a contraindication for DAIR.[25]

3. Surgical factor:

a. Number of debridement

Contradiction studies were found regarding multiple DAIR. Even though repeated DAIR was an independent factor associated with DAIR failure[26], repeated DAIR is not recommended other than in early infection.[16]

b. Repeated joint surgery

The success rate of DAIR varied and failure after DAIR can be seen as persistent PJI or recurrent PJI. The number of prior surgical procedure on the joint increase the possibility of persistent or recurrent PJI.[13] Interestingly, Salmons et al reported DAIR success rate of up to 80% in PJI patient following aseptic revision TJA with suppression antibiotic therapy.[18]

c. Type of implant

Liner exchange or modular exchange is important in DAIR as it is correlated with treatment failure.[32] Therefore, modular exchange should be included as a part of the procedure in DAIR.

d. Sinus tract and soft tissue condition

The presence of sinus tract is not an absolute contraindication of DAIR[31] but success rate of DAIR is higher when the bone and soft tissue is in good condition[33]. The presence of sinus tract was believed to increase failure rate of DAIR.[14] Additionaly, intraoperative finding of purulent also increase failure rate.[32]

Notably, Boadas-Girones et al evaluate DAIR combined with flap coverage for acute soft tissue defect compared with flap coverage in primary TKA and found no significant difference. This can be used in treating DAIR with persistent drainage, wound dehiscence, or necrosis.[2]

CONSIDERATION IN DAIR DISLOCATION

One possibility of non-infection outcome of hip DAIR is hip dislocation. Previous study mentioned that the incidence of hip dislocation after hip DAIR is up to 14%-26.6% due to soft tissue changes either due to infection or the procedure itself.[6],[8] Changing the offset during hip DAIR can reduced the possibility of dislocation in patients by 11-fold post.[8] Several things can be done during component exchange to increase stability after hip DAIR including the use of femoral head size ≥32 mm with face changing or lipped liners, or increase offset or femoral neck length, whether with femoral or acetabular component,[8],[22] Patients who had multiple hip dislocation after hip DAIR had higher rate of failure in DAIR and switch to re-revision THA.[8]

Success rate of 2-stage revision after DAIR

Patient who failed DAIR, will continue to 2-stage revision surgery. Some surgeons considered the success rate of 2-stage revision in patient with failed DAIR. Interestingly, the success rate of 2-stage revision after failed DAIR is comparable with patients who underwent a 2-stage revision without prior DAIR.[7]

Multiple DAIR

Some surgeons are now talking about multiple DAIR. The reason behind it is because of the variety of success rate of DAIR. In the setting of 2-DAIR, the surgeons do the first DAIR by taking the culture, removing the modular implant, performing debridement, and soaking the modular implant in an antiseptic solution for 15 minutes and temporarily reinserting the original modular parts. The surgeons then put the high-dose antibiotic cement beads into the joint. The second DAIR will be perform on the next 5-6 days by removing the beads, repeating the debridement, and exchanging for new modular component. The success rate for infected primary and revision was 86.1% and 71.4% respectively with 2-DAIR.[24]

Another study also described the 2-DAIR. They did the 2-DAIR only if the first DAIR fail. They did not use high-dose antibiotic cement beads. They performed a classical DAIR and re-evaluated whether a second DAIR was necessary. If the patient showed classical sign of failure or the first DAIR such as persistent or recurrent wound leakage with redness, fever or persistent elevated inflammatory markers without any possibility but infection, then a 2-DAIR was considered. The success rate of second DAIR is 74.3%. However, this was probably due to the microbiology result on the second DAIR is negative culture in 60% cases.[29] Therefore, a second DAIR might be considered in certain patients where the implant is well-fixed, good soft tissue, with first DAIR failure is not due to microbiological failure.

KEY OF SUCCESS RATE

The key of DAIR is choosing the right patient and patient optimalization. One study showed that failure of DAIR was associated with earlier time to mortality. This highlights the importance of proper patient selection for DAIR to maximize success and optimize quality of life for TKA PJI patients.[26] Several patient's criteria will be suitable for DAIR is stable implant with good skin and soft tissue, and short onset. The second is finding the right antibiotics. It is crucial to identify the microorganism prior to surgery through aspiration. Before taking the sample, antibiotics should be withheld. The other important factor is how to do DAIR. The DAIR is not only washout, but radical debridement (figure 1), remove the unhealthy soft tissue and scar and take 5 samples culture (figure 2), replace the modular implant (figure 3), and soak it in an antiseptic solution, either with chlorhexidine or povidone-iodine 0.35% for 15 minutes (figure 4). In case of PJI after UKA, use plain saline only. Failure to do so will result in lower success rate.

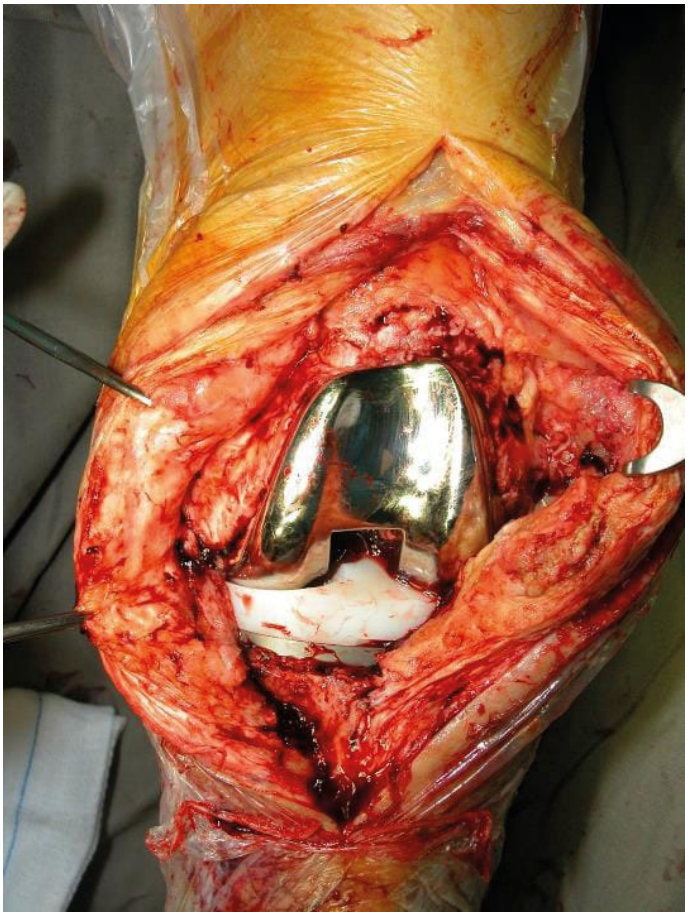

Figure 1. Radical debridement as one of the keys in surgical technique of DAIR

Figure 2. Take 5 samples of culture

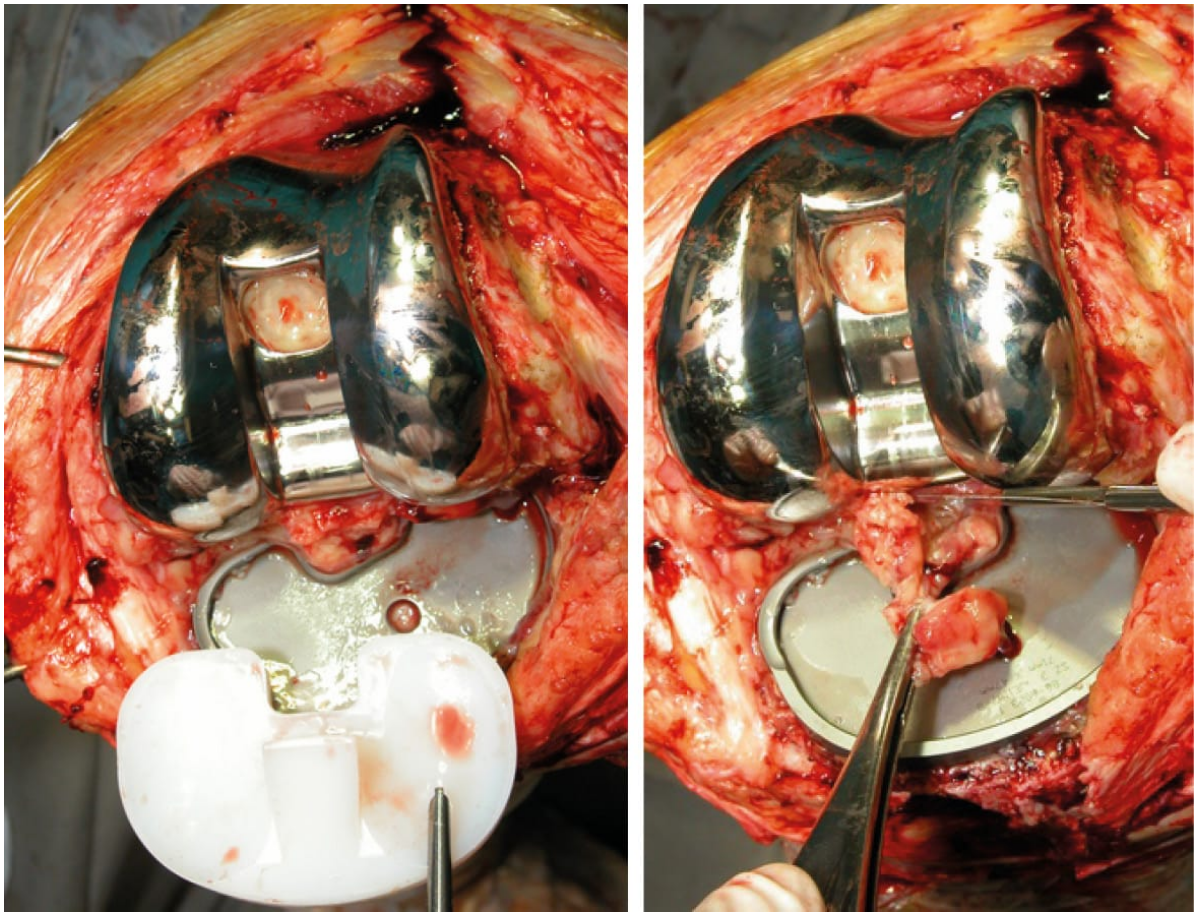

Figure 3. Exchange the modular component

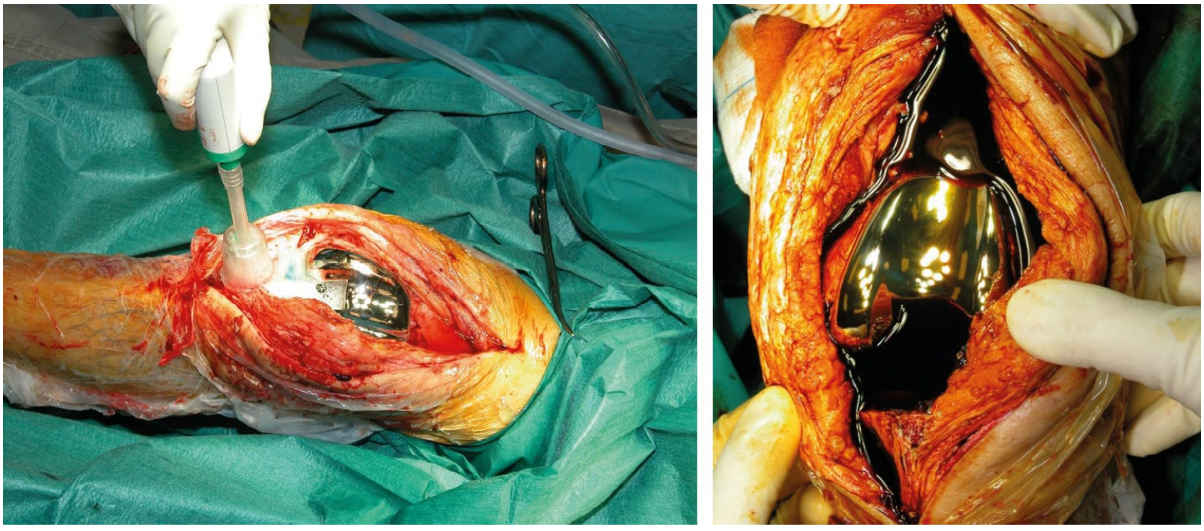

Figure 4. Wash and soak with antiseptic solution

It is evident that the success rate of PJI treatment has no substantial improvement over the last 17 years. Entering the new era, orthopaedic has significant transformation to artificial intelligence and machine learning. Those big data can be used for patient personalized treatment and to predict the surgical outcome. This machine learning apparently had been done for DAIR. Machine learning will help surgeons to choose and predict which patient that might be benefit from DAIR. Shohat et al had been trying to use machine learning in predicting the outcome of DAIR. They used the 10 most important variables that was associated with failure of DAIR, such as CRP, positive blood cultures, indication for arthroplasty, modular changing/not, immunosuppressive treatment, late acute PJI,

MRSA, polymicrobial infection, skin condition, and age. The algorithm demonstrates good capability, with an area under the curve (AUC) of 0.74 and high accuracy.[21] This study's scope is limited to classical DAIR. Hopefully, integrating big data and AI through machine learning can generate PJI algorithms crucial for personalized patient treatment

CONCLUSION

The varied success rate in DAIR necessitate that surgeon exercise wisdom in choosing the right patients and indications. As several factors contribute to the outcomes, there is a clear need for new scoring system, algorithms, or advanced tools to assist surgeon in deciding the best surgical option and tailoring personalized treatment for each PJI patient.

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