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Research Article

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Comparative Outcomes of Minimally Invasive vs. Traditional Arthroplasty in Immunosuppressed Patients: A Literature Review

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Abstract

Minimally invasive arthroplasty (MIA) is an increasing surgical approach utilized due to its benefits of reduced soft tissue trauma, shorter hospital stays, and faster postoperative recovery. However, its safety and long-term effectiveness in immunosuppressed patients remain uncertain when compared to traditional total joint arthroplasty (TJA). Individuals, who are immunosuppressed due to chronic corticosteroid use, post-organ transplantation, or conditions like autoimmune diseases, tend to have higher risk of postoperative complications, such as surgical site infections, impaired wound healing, and implant failure. This narrative review compared outcomes of MIA versus traditional TJA in immunosuppressed populations across studies from 2008-2025. Findings suggest MIA may be associated with lower surgical site infection rates, faster rehabilitation, and reduced postoperative pain, but higher early prosthetic failure rates in some techniques (e.g. tourniquet-free TKA). Conversely, TJA is associated with greater prosthetic longevity and implant durability. Definitive conclusions are limited due to significant heterogeneity in immunosuppressive etiology and surgical techniques combined with a lack of randomized controlled trials. Nonetheless, MIA may offer selective advantages in short-term recovery for immunosuppressed patients. Further prospective studies are warranted to inform clinical decisions.

Keywords: minimally invasive arthroplasty, total joint arthroplasty, total hip arthroplasty, total knee arthroplasty, immunosuppression, surgical outcomes, infection, implant survival

Introduction

Total joint arthroplasty (TJA) is an established surgical intervention to improve mobility, alleviate chronic joint pain, and enhance overall quality of life in patients experiencing degenerative joint disease or from a traumatic injury. Patients who are immunosuppressed, whether due to long-term corticosteroid use, post-organ transplantation, autoimmune disease, or Human Immunodeficiency Virus (HIV), are a specific population with challenges in orthopedic care due to their increased risk of postoperative complications. These complications include wound healing difficulties, increased incidence of surgical site infections, such as periprosthetic joint infections (PJIs), and issues related to prosthetic implants [1]. Minimally invasive arthroplasty (MIA), an alternative to traditional TJA, has the potential to inflict less tissue damage, decrease postoperative pain, decrease risk of infections, and increase recovery time. Existing literature supports that MIA in the general population can lead to faster return to ambulation, reduced postoperative pain, and decreased length of stay when compared to traditional approaches [2]. These advantages may be particularly valuable for immunosuppressed patients who are at higher risk for postoperative complications. However, despite advantages in undergoing MIA, there is limited literature that directly compares outcomes between MIA and TJA in immunosuppressed patients. Current studies often focus on arthroplasty outcomes broadly without distinguishing surgical approaches. For example, Patel et al. did not clarify whether patients in their study underwent traditional or minimally invasive procedures when evaluating outcomes in solid organ transplant patients undergoing shoulder arthroplasty [3]. Similarly, Hatta et al. identified an elevated risk of periprosthetic fractures among immunosuppressed patients post-transplantation, but did not differentiate between surgical approaches when reporting outcomes [4]. This lack of direct comparison creates uncertainty about which approach provides the best outcomes in terms of infection prevention, functional recovery, and long-term prosthetic survival in immunosuppressed patients.

While some literature suggests that TJA has demonstrated durable outcomes in this population, including implant survivorship and patient-reported improvement in quality of life, the specific role of MIA remains underexplored. In a 2024 systematic review, data between HIV-positive and HIV-negative patients had similar postoperative outcomes, such as patient-reported outcome measures (PROMs) [5]. However, data on long-term outcomes in patients with immunosuppression undergoing a MIA, has yet to be clearly established in the literature. This narrative review aims to compare outcomes of MIA and traditional TJA in immunosuppressed patients, focusing on infection rates, postoperative rehabilitation, implant survival, and functional outcomes.

While TJA is commonly performed on joints such as the hip, knee, elbow, and shoulder, the surgical indications and approaches differ by regions of the body. Curtis et al. reported no significant differences in operative time for immunosuppressed patients undergoing TJA, but identified higher rates of urinary tract infections, systemic sepsis, and surgical site infections when compared to immunocompetent patients [6]. In contrast, other studies showed that HIV-positive patients undergoing arthroplasty with appropriate perioperative management, including antivirals and antibacterials, did not experience increased infection rates [7]. These studies highlight the variability in outcomes and the need for greater clarity regarding surgical approach options in this patient population. By examining the current evidence comparing MIA to TJA in immunosuppressed patients, this review seeks to identify key factors influencing outcomes, highlight areas where further research is needed, and ultimately guide clinical decision making to improve surgical care in this high-risk group.

Methods

This study is a narrative review conducted using databases like PubMed, Scopus, and Embase to identify relevant studies published between 2008 and 2025. Keywords used in the literature searches were “minimally invasive arthroplasty,” “total joint arthroplasty,” “total hip arthroplasty,” “total knee arthroplasty,” “immunosuppression,” “surgical outcomes,” “infection,” and “implant survival” using Boolean operators AND and OR. Only English-language, peer-reviewed publications were included. Eligible studies consisted of randomized controlled trials, cohort studies, systematic reviews, and meta-analyses that evaluated outcomes of arthroplasty in immunosuppressed patients, specifically comparing minimally invasive arthroplasty (MIA) to traditional total joint arthroplasty (TJA). Immunosuppression was defined broadly and included patients with Human Immunodeficiency Virus (HIV), those receiving immunosuppressive therapy following organ transplantation, autoimmune disease, or long-term corticosteroid use. Included procedures involved arthroplasty of the hip, knee, shoulder, or elbow. Studies were excluded if they were non-peer-reviewed, case reports, had small sample sizes of less than 100 patients, unpublished studies, or did not specify the surgical approach used. Outcomes of interest included surgical site infections, periprosthetic joint infections (PJIs), wound healing, implant survival, revision rates, postoperative rehabilitation, functional outcomes, and pain management strategies.

Clinical Implications and Outcomes

Infection Considerations

One of the most common complications of any surgical procedure is infection. While there have been a multitude of medical advances to decrease the rates of infections, immunosuppressed patients are still predisposed to an increased rate of infection. Various studies support that immunosuppressed patients who undergo any surgical procedure have an increased risk of infection due to their weakened immune system [8]. One study examined national trends among post-transplant patients receiving a total joint arthroplasty [9]. They observed an increased risk of surgical site, wound, and systemic infections with increased rates of wound complications for these immunosuppressed patients [9]. Another study observed similar trends in patients with inflammatory rheumatic disease where they also experienced significantly increased postoperative infections. The rates of infections were further increased in patients taking multiple disease-modifying antirheumatic drugs or TNF-α inhibitors [10]. Therefore, it is essential for orthopedic surgeons to understand the increased risk of surgical site infections for immunocompromised patients, especially for periprosthetic joint infections (PJIs) in the setting of arthroplasty.

Regarding infection rates between patients undergoing minimally invasive arthroplasty (MIA) versus conventional arthroplasty, literature demonstrates significantly reduced odds of surgical site infections in patients who receive a minimally invasive approach [11]. One review article found 21 studies that affirm that minimally invasive surgeries significantly decreased surgical site infections compared to open procedures [12]. However, there are limitations in these generalizations, especially in orthopedic surgery, since there are a variety of indications for different arthroplasty surgeries. There are also surgeon-specific considerations, such as familiarity with different approaches, which could lead to increased operative time performing a minimally invasive approach that is less familiar to the surgeon.

Along with consideration of surgical approach, medical advances that have decreased infection rates are prophylactic antibiotics and other immunomodulatory measures, such as a povidone-iodide wash of the incision site. These same advances are shown to be helpful for immunosuppressed patients as well. One study noted that prophylactic antibiotics before orthopedic surgeries, particularly cefazolin, significantly decreased infection rates [13]. Further studies corroborated these findings for arthroplasty procedures [14]. Referring specifically to immunosuppressed patients, however, it is recommended to avoid glucocorticoid use, especially dosages above 10 mg/d, before surgery, as they can lead to increased risk of infections [15]. There are a variety of different immunosuppressive medications that patients may take, which should be considered in the preoperative medical clearance for elective orthopedic surgeries.

Recovery Considerations

Minimally invasive arthroplasty (MIA) has been shown to reduce the recovery time following surgery compared to total joint arthroplasty (TJA). This is largely attributed to utilizing an intermuscular and internervous dissection techniques through muscle-sparing interventions, which can result in less soft tissue disruption. This has the potential to allow patients receiving MIA to ambulate and return to their daily activities at a faster rate in comparison to patients undergoing TJA with a traditional approach. In a 2014 study, outcomes between 22 patients who underwent a staged bilateral total hip arthroplasty (THA) conventionally, followed by a two-incision minimally invasive (MIS-2) THA were compared [16]. Results showed that with a mean time of 73.8 months between both procedures, the MIS-2 THA resulted in a shorter average hospital admission duration of 10 days (range 6-27 days) compared to the conventional THA, which was 13 days (range, 10-34 days), resulting in a faster return to daily activities [16]. The MIS-2 THA also resulted in significantly earlier partial-weight-bearing ambulation [16]. MIS-2 THA patients used weight-bearing crutch walking on the 3rd postoperative day (range, 1-6 days), whereas conventional THA patients had this on postoperative day 6 (range, 2-8 days) [16]. It is important to recognize that there are different approaches for different TJA depending on the region involved and indications for surgery. Tumin et al. focused on THA, where there are many approaches for THA, such as direct anterior and posterolateral [16]. Surgeon comfortability in a traditional approach could lead to less operative time with decreased risk of infection compared to a surgeon doing an unfamiliar MIA technique. Therefore, there are limitations in generalizing MIA showing superiority to traditional TJA approaches.

Pain Control Considerations

Pain control is another crucial component of postoperative recovery in patients receiving TJA. The methods differ between MIA and TJA patients with MIA patients often having less postoperative pain due to the smaller amount of tissue damage and intraoperative hemorrhage. However, it is important to consider that many traditional arthroplasty surgical approaches have intermuscular and internervous planes, which can result in minimal soft tissue disruption despite a larger incision. In the study by Tumin et al., 11 patients preferred the MIS-2 THA hip and cited faster rehabilitation (three patients), less pain (three patients), and less discomfort (five patients) as reasons [16]. Four patients preferred the conventionally treated hip and citing squeaking (one patient), clicking (one patient), and mild discomfort following exertion (two patients) in the MIS-2 THA hip as reasons [16]. Seven patients expressed no preference for one hip over the other [16]. In immunosuppressed patients, pain management is a larger factor and should be discussed during preoperative planning and implemented strategically during postoperative recovery. While MIA compared to TJA often produces less postoperative pain, immunosuppressed patients may require more tailored pain management regimens. These patients are often on chronic corticosteroid therapy, post-organ transplant, or managing autoimmune diseases that can impact the wound healing process, and increase risk of infection, such as PJIs.

The administration of certain opioid analgesics in immunocompromised patients must be carefully considered due to the resulting potential interactions. Cavanaugh et al. examined the National Inpatient Sample (NIS) data for 1993-2011 and identified transplant patients undergoing joint arthroplasty procedures to have a higher rate of complications, particularly acute renal failure, and wound infections [17]. Higher complications can result in decreased pain control and poor patient-reported outcomes. This finding emphasizes the significance of personalized pain management, especially in immunosuppressed patients, who may have increased risks of dependence with opioid analgesics and other pain medications, due to poor pain control. As the number of solid organ transplants continues to increase, orthopedic procedures for transplant recipients are more frequent, often as a consequence of avascular necrosis of the femoral head, a condition potentiated by immunosuppressive therapy [18]. Despite the higher risks, transplant patients generally report significant pain relief and improvements in quality of life postoperatively from TJA, underlining the importance of effective pain management strategies.

A multidisciplinary approach could stress utilization of nonopioid analgesics, nerve blocks, and multimodal pain management to improve, and more safely manage, postoperative pain in this population, decrease complications, and promote postoperative recovery. Literature suggests that use of nonopioid analgesia, such as nonsteroidal anti-inflammatories (NSAIDs) and gabapentinoids (pregabalin & parecoxib), can reduce postoperative opioid consumption, and improve pain control in arthroplasty patients in the early postoperative course [19]. Although the pain reduction is not necessarily clinically relevant, these medications diminish side effects, such as constipation and risk of dependence. The risks of opioid use are particularly significant in immunosuppressed patients with possible interactions from their immunosuppressive therapy.

Soft Tissue Healing Considerations

While most patients experience improvements in pain, mobility, and quality of life following arthroplasty procedures, most immunosuppressed patients typically experience problems of muscle recovery and joint function from deranged healing responses. These patients can develop reduced rates of muscular recovery, atrophy, pain, and loss of mobility. A 2018 study investigated the use of placenta-derived mesenchymal-like adherent cells (PLX-PAD) in enhancing muscle regeneration following hip arthroplasty [20]. Researchers found that low-dose PLX-PAD treatment significantly increased gluteus medius muscle strength and mass compared with placebo, with improvement observed as soon as six weeks following surgery and sustained through week 26 [20]. Importantly, these functional improvements were accompanied by a blunted postoperative immune stress response, suggesting that immune regulation may represent a major mechanism by which musculoskeletal repair is promoted [20]. These findings are particularly relevant in immunosuppressed patients, as they provide a therapeutic intervention for reversing failed muscle regeneration and joint function following TJA.

Prosthetic Component Considerations

Aseptic loosening, osteolysis, and periprosthetic fractures are severe arthroplasty complications with multiple risk factors. Aseptic loosening accounts for approximately 35.1% of revisions in total hip arthroplasty (THA) [21]. In total knee arthroplasty (TKA), aseptic loosening accounts for approximately 18.3% [21]. Osteolysis, another critical issue, is usually related to poor osseous quality, trauma, or debris that may break down from the implant [22]. In a systematic review of post-THA patients, the rate of osteolysis was reduced significantly with highly cross-linked polyethylene (HXLPE) liners compared to conventional polyethylene (CPE), and rates were reduced from 25.4% to 4.05% in young patients and from 29.7% to 6.6% in older patients [22]. The most frequent cause of late revision in TKA was osteolysis, and a higher rate has been seen with cementless compared to cemented implants [23]. Periprosthetic fractures account for 11.4% of THA revisions and are less commonly described in TKA [23]. Periprosthetic fractures seem to be a less common, but notable cause of revision procedures, compared to other complications like osteolysis and infections. The risk factors for these different complications of MIA and TJA are compounded when considering an immunocompromised patient, so further investigation is needed.

Comparing MIA and TJA, the rates of prosthetic wear and loosening vary by joint and surgical approach. For the hip, research has shown that MIA procedures, like direct anterior and anterolateral approaches, have minimal risk of prosthetic loosening when compared to conventional posterior or direct lateral approaches [24]. However, some reports suggest minimally invasive techniques may be linked to early failures, higher rates of periprosthetic fractures of the femur, and higher revision rates in select cases [24]. Tourniquet-free MIA-TKA was found to be associated with increased rates of aseptic loosening [25]. This could be due to inability to maintain a dry surface for cement to harden with lack of tourniquet, but the etiology is not clear. In addition, cementless techniques in TKA have been seen to have higher loosening risk compared to cemented techniques, with cemented techniques currently the gold standard for TKA [26]. These findings demonstrate that while MIA can provide comparable prosthetic integrity in hip arthroplasty, certain minimally invasive techniques in knee arthroplasty can compromise early implant stability. Generalizing these results to immunocompromised patients is limited due to limited studies focusing on clinical and patient-reported outcomes of TJA on immunocompromised patients.

Immunosuppression Sequela

Immunosuppressed patients, such as recipients of solid organ transplant (SOT), often have higher risks and challenges following joint arthroplasty. In a study by Ledford et al., these patient populations have reduced prosthesis survival and higher revision rates postsurgical [27]. Immunosuppressed patient populations, such as recipients of solid organ transplant (SOT), have reduced prosthesis survival, and higher revision rates following joint arthroplasty. Chronic immunosuppressive therapy in these patients is associated with a higher rate of aseptic loosening and periprosthetic joint infections (PJIs), the most frequent causes of failure of total hip (33% and 23%) and knee arthroplasties (PJIs being 56%) [27]. Re-revision rates are similarly high, with up to 22% of total knee arthroplasties requiring additional surgery for infection [27]. Long-term prosthesis survival is also decreased, with only 60% of revision THA and 21% of revision TKA surviving more than 10 years in this population [27]. These findings increase the importance of preoperative planning, perioperative infection prevention, and postoperative monitoring to reduce the likelihood of revision in arthroplasty patients who are immunocompromised.

Challenges and Limitations

This review's limitations include the variability within the defined patient population of immunosuppressed individuals, since many pathologies, including diabetes mellitus, can be broadly included as a disease causing the patient to be immunocompromised. A variety of conditions can cause immunosuppression including viral infections like Human Immunodeficiency Virus (HIV), or drug-induced immunosuppression in post-transplantation, or Rheumatoid Arthritis (RA) patients. This review does not differentiate between different types of immunosuppression etiologies, which is a limitation. This makes it challenging to compare outcomes of minimally invasive arthroplasty (MIA) to total joint arthroplasty (TJA). Not only can the pathophysiology of each immunosuppressive condition be different, but their distinct treatment courses can also cause significant variability in healing and infection risks as well. For example, one study found that patients with inflammatory rheumatic diseases, who take multiple disease-modifying antirheumatic drugs, have an increased risk of operation-related infection, especially when given at least one dose of a TNF-α inhibitor prior to their TJA [10]. Conversely, a different study indicated that there was no significant increase in TJA postoperative infections in HIV-positive patients when compared to HIV-negative patients [5]. Although these two conditions both result in immunosuppression, they pose different risks of infection, which presents a challenge in drawing conclusions about immunosuppressed patients in general.

Immunosuppressive conditions also require different medication regimens, which can complicate comparisons between patient outcomes. Various pharmaceutical agents, such as prophylactic antibiotics, biologics, and glucocorticoids, can have distinct effects on infection rates. George et al. suggest that while outcomes are similar across different biologics, a dosage of glucocorticoids greater than 10 mg/day can increase the risk of infection in immunosuppressed individuals after arthroplasty [15]. Furthermore, within immunosuppressive agents, there are variations in wound healing outcomes between drug classes due to different interactions with inflammatory mediators [28]. Thus, patient-specific factors regarding medication use and dosage make it challenging to interpret outcomes of MIA versus TJA in immunosuppressed individuals.

Another limitation in this review is that there is a lack of randomized controlled trials comparing MIA and TJA outcomes in immunosuppressed populations. Currently, available data stems from retrospective cohort studies, which are prone to selection bias and variation in measurement criteria. Among large-scale studies, Curtis et al. highlights the outcomes of TJA on immunosuppressed individuals [6]. However, it does not offer a comparative analysis.

Across the literature, studies also have different definitions of surgical techniques. Goosen at al. defines minimally invasive surgery for a hip arthroplasty as an incision of less than 10-12 cm or less muscle dissection compared to a classic approach [29]. Conversely, Saad et al. states that the same approach is defined by an incision specifically less than 10 cm, but can also be interpreted as a procedure with less osseous or soft tissue trauma [30]. The lack of standardized definitions presents a limitation in this study, since it complicates the comparison of outcomes for MIA across studies. These limitations must be considered when interpreting this study.

Future Directions

Proper surgical selection requires an appropriate personalized approach, including a patient's immune status and medical comorbidities. Surgical approaches and indications from surgery are variable and is often surgeon dependent. This review focused on immunocompromised patients rather than specific types of immunocompromised patients. Future work could provide insights into patients who are Human Immunodeficiency Virus (HIV)-positive, have an autoimmune disorder or have undergone organ transplantation. This study highlights the association of increased risk of infection with any type of invasive procedure for patient with immunodeficiency.

Focused research on rates of infections in MIA and TJA groups could better prepare providers to treat specific infections as they arise in patients with immunodeficiencies.

Conclusion

Immunocompetent and immunosuppressed patients equally benefit from improvements in ambulation, joint pain relief, and increased quality of life after arthroplasty procedures. However, immunocompromised patients are especially vulnerable to postoperative infections and systemic sepsis. When comparing total joint arthroplasty (TJA) and minimally invasive arthroplasty (MIA) for symptom relief and treatment success, both are similar in effectiveness. MIA has been associated with less soft tissue damage, decreased postoperative pain, shorter hospital durations, and decreased surgical site infections compared to non-MIA surgeries. For these reasons, immunocompromised patients may benefit from an MIA due to its decreased risk profile in select patients. There are many types of arthroplasty surgeries, different surgical approaches, and indications for surgery, so no clear conclusion can be made on if MIA is superior to TJA in immunocompromised patients. To help reduce the rate of infections in immunocompromised patients, literature supports utilizing, povidone-iodide intraoperatively.

For pain management, special attention should be used in selecting analgesics in concordance with immunosuppressive therapies, such as corticosteroids. Immunocompromised patients after arthroplasty are at increased risks for acute renal failure and wound infections. Multimodal analgesia should be utilized for pain management with careful consideration of medication interactions. Ultimately, both MIA and TJA treatments are effective in improving patient mobility and quality of life in immunocompromised patients. Future research directly comparing the effectiveness in infection reduction and prosthetic longevity of MIA versus TJA in immunocompromised populations would significantly aid the treatment selection for these patients.

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