Review

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Posted Date: 26 November 2025

doi: 10.20944/preprints202511.2022.v1

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 doi:10.20944/preprints202511.2022.v1

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Clinical and Psychosocial Impact of Limited Mobility During the Interstage Period of Two-Stage Revision Arthroplasty for Prosthetic Joint Infection: A State-of-the-Art Review

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Abstract

Background: Two-stage revision arthroplasty remains the gold-standard treatment in the USA for patients diagnosed with periprosthetic joint infection (PJI) of the hip and knee. However, during treatment, patients have an extended interstage period between prosthesis removal and reimplantation, which is frequently characterized by substantial reductions in mobility, prolonged rehabilitation, and a high incidence of medical and psychosocial complications. This review examines the physical, psychological, and social effects of immobility during the interstage period. **Methods:** A comprehensive literature review was conducted to identify studies addressing mobility limitations, functional assessment tools, and associated outcomes in patients undergoing two-stage revision arthroplasty for PJI. Studies were included if they reported on clinical complications and psychosocial outcomes affected by the prolonged interstage period and mobility limitations. **Results:** Patients undergoing two-stage revision often experience significant immobility lasting several months, which can be influenced by pain, soft-tissue compromise, and spacer type. Prolonged inactivity can contribute to muscle atrophy, joint stiffness, and impaired range of motion (ROM) and is often associated with an increased risk of venous thromboembolism, pressure injuries, and bleeding complications related to extended thromboprophylaxis use. Psychologically, patients frequently report heightened anxiety and depression during the interstage period, compounded by uncertainty regarding infection eradication. Socially, patients have restricted independence, are dependent on caregivers, and have occupational disruption that further diminishes their overall quality of life. Current studies demonstrate wide variability in how mobility is assessed, hindering cross-study comparison and limiting targeted rehabilitation strategies. **Conclusions:** The interstage period of two-stage revision arthroplasty is a critical, yet understudied phase marked by significant physical, psychological, and social challenges that are not fully captured by traditional orthopedic patient reported outcome measures (PROMs). Standardized measurement of mobility is needed to assess the impact of limited mobility during the interstage period. Also, novel treatment approaches that shorten or eliminate the interstage period have the potential to mitigate complications, enhance functional recovery, and improve overall quality of life for patients undergoing staged management of PJI.

Keywords: hip; knee; mobility; prosthetic joint infection; quality of life; revision arthroplasty

 doi:10.20944/preprints202511.2022.v1

1. Introduction

The In the United States, two-stage revision arthroplasty remains the gold-standard approach for managing prosthetic joint infection (PJI) of the hip and knee [1–3]. During the treatment period of a two-stage revision arthroplasty, a prolonged period of reduced mobility between stages (i.e., interstage) occurs [1–3]. The degree of interstage immobility varies and can range from partial dependence on assistive devices to near-complete loss of independent ambulation, particularly with the use of static or low-function spacers. These mobility restrictions have clinical and psychosocial implications for patients, affecting their physical activity levels, increasing the risk of medical complications, and reducing their overall quality of life (QoL) [2,4,5]. Also, the effects are often compounded by the prolonged antimicrobial therapy and the associated side effects, uncertainty of the treatment success, and the anticipation of the second stage reimplantation procedure.

The interstage period during a two-stage revision arthroplasty for PJI requires a period of limited mobility or non–weight-bearing to facilitate treatment and healing of the infection, and associated recovery following reimplantation. While early mobilization following total joint arthroplasty (TJA) is often associated with improved outcomes and reduced complications [6–11], the degree and duration of mobility limitations can vary depending on the anatomical site, type of injury or procedure, and is driven by patient-specific factors [12–14]. These patient factors associated with perioperative and postoperative limitations in mobility include advanced age, level of mobility preoperatively, physical conditioning, preoperative comorbidities, poor muscle strength, cognitive impairment or dementia, obesity and fear of falling [15–19]. Patients with limited preoperative mobility often face greater challenges in regaining independence and achieving optimal postoperative functional recovery following lower extremity orthopedic surgery [20–23]. In addition, suboptimal physical conditioning prior to the procedure is further associated with delayed rehabilitation and an elevated risk of postoperative complications [24]. These mobility limitations can result in the need for the routine use of assistive devices (e.g., cane, walker) to provide stability and promote restoration of gait or include the use of a wheelchair or prolonged bed rest in certain patient populations.

2. Materials and Methods

This narrative review collates results from a literature review conducted to identify studies addressing mobility limitations, functional assessment tools, and associated outcomes relevant to patients undergoing two-stage revision arthroplasty for PJI. Publications were identified via a systematic search using PubMed and EMBASE databases. The search strategy used a combination of terms, including “mobility”, “ortho*, “prosthetic joint infection”. The results of the search were then screened for relevance based on titles and content of abstracts. A full text review of publications determined to be possibly relevant was then conducted to identify content for possible inclusion in this state-of-the-art review. Additional publications were subsequently assessed for possible inclusion in the review based on primary clinical research referenced in publications identified in the initial literature search.

3. Results

3.1. Assessment of Mobility

No standardized definition for determining perioperative or postoperative mobility levels following various lower extremity injuries or orthopedic surgical procedures was identified in the literature. Significant inconsistencies and variability exist in how mobility is documented. This can include non-standardized categorization of mobility (Table 1), simple functional tests (e.g., timed up and go, sit to stand, timed walk test, number of steps and gait speed test), standardized assessment tools (e.g., Functional Independence Measure, Barthel Index), and patient-reported outcome measures (PROMs) [25–33]. In addition, other assessments used include whether the patient is

 doi:10.20944/preprints202511.2022.v1

housebound, has limited versus normal community ambulatory, and the level of independence related to self-hygiene and activities of daily living (ADLs) [34].

Table 1. Example of simplified categorization of post-operative mobility[25].

↓decreased	
Level of mobility	Bedbound
	Stand with walker
	Walk with walker assisted
	Walk with walker unassisted
	Walk with cane
	Walk unassisted
↑increased	

3.1.1. Categorization of Mobility

Various categories of mobility and how these are classified using several validated assessment instruments were identified in the literature (Table 2). Heterogeneity in the categorization of mobility can create challenges when comparing the impact of mobility status on outcomes between studies due to a lack of universal definitions and limitations of existing assessment tools remain. These inconsistencies can limit the ability to assess the relationship of the differing types of mobility on clinical outcomes, including complications and psychosocial issues, which can arise during interstage and post-reimplantation following a two-stage revision arthroplasty.

Table 2. Categories of mobility and standardized mobility classification scales.

Mobility Category	Definition / Description	Examples of Assessment Tools[30-35]
Independent Mobility	Complete independence ambulation without assistive devices.	FIM: 7 – Complete Independence Barthel Index: 100 out of 100 ICF: d450 "Walking" – No limitation (0%)
Limited Mobility	Mild-to-moderate restrictions in movement or endurance. Occasional or common use of an ambulatory assistive device like a walker or cane.	FIM: 6 – Modified Independence Barthel Index: 60 to 90 ICF: d450 – Mild/moderate limitation (5% to 95%)
Immobility / Severe Impairment	Unable to ambulate or transfer independently; bed or chair bound.	FIM: 1 to 3 – Total/Maximal Assistance Barthel Index: <30 ICF: d450 – Complete limitation (96% to 100%) Braden Scale (Mobility Subscale): 1 to 2 = Very limited / Completely immobile
Functional Mobility (Occupational Therapy)	Ability to move safely within an environment to perform ADLs (bed mobility, transfers, ambulation).	FIM: Movement components rated individually (e.g., transfers, locomotion)
Household Ambulatory	Independent mobility is limited to indoors or their home environment.	FIM: 5 to 6
Community Ambulatory	Independent ambulation in home and community settings.	FIM: 6 to 7
Bed Mobility Only	Can reposition self in bed, cannot sit or transfer without help.	FIM: 1 to 2 (Bed/Chair/Wheelchair Transfer) Braden Mobility Subscale: 1 to 2

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ADLs, Activities of Daily Living; FIM, Functional Independence Measure; ICF, International Classification of Functioning, Disability and Health

3.2. Standardized Assessment Tools

3.2.1. Functional Independence Measure

The Functional Independence Measure (FIM) is an 18-item, seven-level ordinal scale assessing two domains (i.e., motor and cognition) and is used to assess patients' functional independence and level of disability (Supplementary Figure S1) [31,32]. This includes assessments for locomotion, transfers, and self-care. Total score ranges from 18 to 126 with a lower score on the FIM associated with an increased level of disability.

3.2.2. Barthel Index

The Barthel Index is a standardized instrument used to measure patients' individual level of functional independence and mobility associated with ADLs [33]. This instrument assesses the patient's ability to perform ten basic ADLs and was developed to track progress and assess the need for assistance in patients with either neuromuscular or various musculoskeletal disorders. The Barthel Index has a total score ranging from 0 to 100, where a higher score indicates greater independence. Scores from 0 to 20 are considered total dependence, 21 to 60 equates to severe dependence, 61 to 90 is associated with moderate dependence, 91 to 99 is slight dependence, and a score of 100 is complete independence.

3.2.3. The International Classification of Functioning, Disability d450

The International Classification of Functioning, Disability (ICF) d450 assesses the ability to move on a surface on foot, step by step, including walking forward, backward, or sideways [35]. The total score rates the degree of limitation on a 5-point scale ranging from 0 (no problem) to 4 (complete problem) and can include sub-qualifiers for specific aspects of walking like distance or terrain. The ICF does not explicitly use the term "Likert scale," but its standard qualifier system uses a points-based ordinal scale that is comparable in function.

3.2.4. Braden Scale

The Braden Scale is an instrument that assesses a patient's risk of developing a pressure ulcer based on six subscales: sensory perception, moisture, activity, mobility, nutrition, and friction/shear [36,37]. Each of the subscales are summed together to create a cumulative total score, ranging from 6 to 23. A lower total score indicates a higher risk of developing a pressure ulcer.

3.2.5. The International Classification of Functioning, Disability d450

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3.2.6. Assessment of Mobility using Standardized Assessment Tools Specific to Patients with Periprosthetic Joint Infection

Few studies referencing the above instruments were identified to assess mobility in patients undergoing two-stage revision arthroplasty for PJI. Walter et al. assessed mobility in geriatric patients diagnosed with PJIs using the Barthel index. They found that 26.7% of patients scored between 0 and 15, indicating total dependence which required assistance for nearly all basic ADLs including

 doi:10.20944/preprints202511.2022.v1

feeding, bathing, dressing, toileting, mobility, and transfers [38]. In the same study, these authors also identified that 53.4% of patients scored between 15 and 60, indicating severe to moderate dependence with partial independence but with significant help still needed to perform some ADLs.

Only one study was identified which reported the use of FIM to assess mobility in patients undergoing two-stage revision arthroplasty procedures. Zajonz et al. assessed the FIM when comparing intramedullary arthrodesis (i.e., nail plus a tibiofemoral plate) versus extramedullary plate arthrodesis for patients with persistent knee joint infections following two-stage revision arthroplasty [39]. Upon discharge, patients in the intramedullary nail group had a higher FIM (i.e., 66 points) when compared to patients in the extramedullary group (i.e., 22 points) with both scores associated with considerable impairment to perform mobility tasks (e.g., bed/chair/toilet transfers) and ambulation aid and/or wheelchair use.

While no published studies were identified specifically reporting the use of the Braden Scale to assess patients undergoing two-stage revision arthroplasty for PJIs, the Braden Scale is commonly used in clinical settings to identify patients at risk of pressure injuries, including those undergoing extended hospitalizations or complex surgeries such as a two-stage exchange arthroplasty. The lack of studies utilizing validated standardized instruments to measure mobility prevents the ability to assess the clear negative consequences associated with reduced mobility during the interstage period. This also makes it difficult to assess the association limited mobility has on the development of clinical complications and psychosocial issues prior to reimplantation, especially in patients who have pre-existing factors that impact mobility prior to the diagnosis of PJI.

3.3. Patient-Reported Outcome Measures (PROMs)

3.3.1. Hip disability and Knee Injury Osteoarthritis Outcome Score

The Hip disability and Osteoarthritis Outcome Score (HOOS) and the Knee injury and Osteoarthritis Outcome Score (KOOS) are disease-specific and joint-specific instruments designed to measure physical function through five constructs, including pain, other symptoms, function in daily living, sport and recreation, and QoL in patients undergoing TJA diagnosed with osteoarthritis [27,28]. Items of the HOOS and KOOS are individually scored using a 5-point Likert scale, ranging from 0 (no problems) to 4 (extreme problems); a total score is then calculated for each construct and transformed to a scale ranging from 0 (extreme joint problems) to 100 (no joint problems).

3.3.2. Oxford Hip and Knee Score

The Oxford Hip Score (OHS) and Oxford Knee Score (OKS) were designed to assess joint-specific pain and function after primary TJA [29]. Both instruments include a total of 12 individual items scored on a 5-point Likert scale, ranging from 0 (severe limitation) to 4 (maximum function); the individual items are then summed and scored, ranging from 0 (most severe symptoms) to 48 (least symptoms). These PROMs were primarily developed for use following TJA procedures. While the use of the OHS and OKS in patients with PJIs has been reported, scores vary considerably based on PJI type (i.e., early, late-acute, and chronic) [29].

3.3.3. University of California Los Angeles Activity Score

The University of California Los Angeles (UCLA) activity score is a validated instrument that assesses both patient and activity function following a total joint replacement [40,41]. The UCLA is a 10-level, single-item question assessing patients' overall levels of activity and is scored on a scale ranging from 1 (low levels of activity) to 10 (high levels of activity). Though prior studies have used this instrument for the assessment of function in patients diagnosed with PJI, it is often paired with other joint-specific questionnaires assessing pain and function.

 doi:10.20944/preprints202511.2022.v1

3.3.4. Assessment of Mobility using Patient-Reported Outcome Measures Specific to Patients with Periprosthetic Joint Infection

The impact of limited mobility during the interstage period has minimally captured using PROMs. While the HOOS and KOOS are thought to assess mobility though the assessment of pain, ADLs and QoL in patients undergoing TJA [27,28], no studies assessing the psychometric properties (e.g., scale validity, criterion validity) were identified in the literature specifically for patients diagnosed with PJI undergoing a two-stage revision arthroplasty. Similarly, no studies were identified to assess the psychometric properties of the OHS, OKS. Lastly, while the UCLA activity score demonstrates good reliability within the TJA population [42], psychometric properties have yet to be established in patients diagnosed with PJI undergoing a two-stage revision arthroplasty.

3.4. Impact of Two-Stage Revision Arthroplasty for Periprosthetic Joint Infection on Mobility

Two-stage revision arthroplasty is currently the gold standard surgical treatment for patients diagnosed with PJI associated with hip and knee implants [43]. This approach involves two separate surgeries with an interstage period focused on the eradication of the infection [44]. The first stage includes the removal of all implant components, debridement of any infected and necrotic tissue to reduce microbial load, and placement of an antibiotic loaded polymethyl methacrylate (PMMA) cement spacer. The level of mobility and weight-bearing activities during the interstage period is influenced by the spacer type utilized (i.e., weightbearing or non-weightbearing construct, articulating or static) and the joint involved. Following the interstage period, assuming infection has been eradicated, a second stage procedure is performed (i.e., reimplantation) to implant the new prosthesis following spacer removal and a repeat debridement [44].

Rehabilitation after reimplantation is often more complex after two-stage revision arthroplasty when compared to primary TJA procedures, due to the amount of soft tissue damage, especially muscular and tendinous tissues, from the multiple surgeries and the prolonged period of limited mobility during the interstage period. The interstage period may often exceed four months [2] during which limitations in joint function can increase the risk of complications and negatively impact patients' QoL [2,4,45–47]. The reported median hospital length of stay following the initial stage of a two-stage revision arthroplasty is six days for procedures specific to the hip joint and five days for procedures specific to the knee joint. However, longer interstage durations have been associated with higher rates of additional procedures and additional hospitalizations [48]. Additional procedures during the interstage period are often required due to spacer-related complications (e.g., fracture, dislocation, exchange). In addition to adding a median of five additional days of hospitalization [49], these complications further prolong the interstage period [2]. A longer interstage period may be associated with a greater risk of reinfection, higher costs, and worse functional and clinical outcomes [50]. Limited mobility during this time can ultimately lead to muscle loss, reduced ROM, medical complications, and a decrease in patient-reported QoL.

3.4.1. Impact of Spacers on Mobility

Following removal of the infected implants, spacers are temporarily used to maintain joint space and alignment during the interstage period. These spacers can deliver local antibiotics via the use of antibiotic loaded PMMA cement [5,41,51]. The two primary types of spacers used during two-stage revision arthroplasty procedures are static and dynamic (i.e., articulating).

Static spacers are typically made of PMMA bone cement mixed with vancomycin, and either gentamicin or tobramycin, which achieve broad coverage, and a predictable local release of profile for the antibiotics during two-stage revision arthroplasty [5,52] The cement is molded into a shape that fits into the joint cavity created following implant and enables the ability to personalize the spacer to the patient's anatomy [5]. The use of static spacers can significantly impact patient mobility during the interstage period; patients often report severe mobility limitations that impact all aspects of ADLs [1]. In addition to causing immobility at the joint, cemented spacers have a high risk for

 doi:10.20944/preprints202511.2022.v1

fracture which may lead to additional revision surgeries, ultimately decreasing patients' mobility [5,53–55]. The use of static spacers can lead to instability, additional bone loss, and soft-tissue injury that further reduce mobility and may result in the need for additional surgeries. The reimplantation procedure is also longer with static spacers due to increased stiffness of the knee and difficulty with exposure. The risk of these complications and further mobility limitations are increased when the interstage period is prolonged. Lunz et al. reported that the mechanical strength of antibiotic-loaded PMMA bone cement decreases substantially over six weeks, resulting in an increased risk of periprostatic fracture with prolonged interstage periods [52].

Since the use of static spacers may be associated with joint stiffness, muscle atrophy, and challenging reimplantation due to lack of mobility and soft tissue tension, their use is reserved for patients undergoing two-stage revision arthroplasty who have severe infections, ligament compromise, damage to joint extensor mechanisms, soft tissue disruption over the joint or severe bone loss [56]. However, benefits associated with the use of static spacers exist. These benefits include the ability to improve the recovery of severely irritated and swollen tissues surrounding the infected joint and are a more economical option to articulating spacers [51,57].

Articulating spacers provide better joint motion and enable a higher level of function and independence during the interstage period [5,51]. Several types of articulating spacers exist including handmade cement spacers, which combine antibiotic loaded PMMA cement with exoskeletons constructed of screws, rods and wire to increase the strength of the cement spacer, molded or preformed spacers, real implant articulating spacers [5,52,57]. While articulating spacers increase mobility when compared to static spacers, they can be more costly; some options require increased time to construct during the procedure, pre-made spacers are limited in the selection of sizes commercially available, and there is a possibility of a lower amount of antibiotic being released compared to other spacers [5]. This potentially impacts mobility by extending the time required to resolve the infection and the interstage period.

Patients with articulating spacers are generally more mobile and report less pain than those with static spacers, though limitations still exist. While articulating spacers permit weightbearing and better mobility, they are not indicated for use when there is significant bone loss which inhibits adequate fixation and stability [5]. Articulating spacers are associated with fractures of the spacer themselves, periprosthetic fracture, and dislocation, which result in further surgical procedures during the interstage period and resultant post-procedure limitations to mobility [59]. Similar to static spacers, the risk of these complications increases with the duration of the interstage period [52].

3.4.2. Girdlestone Procedure

A Girdlestone procedure, also known as a resection arthroplasty, is an operation where the femoral head and neck are removed in patients being treated for PJI specific to the hip joint [60]. During this procedure, no spacers are used during the interstage period. Also, this procedure is sometimes used as an initial step of a two-stage revision arthroplasty in patients with severe infections who have poor bone quality, bone loss, or soft tissue damage which make spacer use unfeasible [61]. A recent systematic literature review by Piuzzi et al. demonstrated a Girdlestone rate of 4.5% in patients undergoing two-stage revision hip arthroplasty [2]. However, reimplantation after a Girdlestone procedure is extremely challenging; this procedure produces limb length discrepancies, is associated with abductor muscle dysfunction, and altered anatomy increasing the need for custom or modular implants [60]. Additionally, Sigmund et al. reported that a prosthesis-free period of >10 weeks is associated with a greater incidence of thromboembolic events [60].

3.5. Physical Effects of Limited Mobility During the Interstage Period

The interstage period of a two-stage revision arthroplasty for treatment of PJI is frequently associated with limited mobility and a reduction in weight-bearing activities. Limitations to mobility can be influenced by factors such as pain, soft-tissue condition, and the type of spacer implanted, and can result in negative physiologic effects, including an increased risk of venous thromboembolism

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(VTE), pressure-related injuries and muscle wasting. These complications can have a detrimental effect on functional recovery and negatively impact outcomes after reimplantation.

3.5.1. Venous Thromboembolism

Patients undergoing major orthopedic surgery procedures of lower extremity are at high risk of developing thromboemboli due to the extended period of postoperative venous stasis [65]. In patients undergoing an orthopedic procedure, DVT and pulmonary embolism (PE) are among the leading causes of perioperative morbidity and mortality [66,67], and DVT-related PEs are the third most common cause of death [68]. The Caprini Risk Score has been validated to assess a patient's risk level (i.e., low or high risk) of VTE following primary and revision TJA and provides recommendations for thromboprophylaxis [69]. The Caprini score incorporates factors related to impaired lower-extremity mobility, including restrictions imposed by medical devices, bed rest, or limited ambulation, as well as the presence of venous catheters used for medication delivery. Each of these can contribute to increasing the risk of VTEs during the interstage period in patients undergoing two-stage revision arthroplasty.

According to the American Society of Hematology (ASH) guidelines for management of VTEs, patients undergoing major orthopedic procedures, especially those with limited mobility, should receive pharmacologic prophylaxis unless contraindicated [70]. In addition, concurrent factors that further increase DVT risk include age (i.e., 60 years or older), history of cardiovascular disease, history or DVTs or PEs, and obesity [66]. Furthermore, the ASH guidelines emphasize that individualized risk assessment for both thrombosis and bleeding should be conducted preoperatively to guide the choice and duration of prophylaxis.

Many patients undergoing two stage revision arthroplasty for PJI have increased risk of thromboembolic disease. Thomas et al. recently reported that 6.1% of individuals undergoing two-stage revision arthroplasty in their patient series developed VTEs [46]. This increased risk results from the combination of the aforementioned factors and the extended time during the interstage period where patients may have limited mobility. Additionally, the development of complications which contribute to additional hospitalizations during the interstage period, such as fracture of the spacer periprosthetic dislocations and periprosthetic fractures, further increases the risk of DVTs as a result of having to undergo additional orthopedic surgeries that may extend limitations to mobility. As such, patients with predisposing factors which extend the risk of developing VTEs may require administration of thromboprophylaxis for a longer period of time.

The extended use of thromboprophylaxis during the interstage period may increase the risk of future bleeding events. Patients undergoing two-stage revision arthroplasty for PJI have an increased risk of bleeding because of the large amount of soft tissue damage resulting from the infection and the procedure and the potential need for repeated operations [71]. Bautista et al. reported that 38.4% of patients undergoing revision procedure to their hip for any cause had major bleeding events during hospitalization [71]. While the authors noted that these bleeding events could not be attributed to the use of thromboprophylaxis, extending the period of time patients receive anticoagulant therapy during the interstage period could be a contributing factor, especially in patients undergoing additional surgical procedures prior to reimplantation in patients with PJI.

3.5.2. Musculoskeletal Effects and Functional Loss

Muscle disuse atrophy is characterized by a reduction in skeletal muscle mass and strength and is primarily triggered by prolonged inactivity and lack of mechanical stimulus [72]. Muscle atrophy can occur due to injury or reliance on assistive devices that can accelerate this process, especially in clinical settings [72]. Patients often have limited mobility after lower extremity procedures due to post-procedure pain and soft tissue damage. While some patients use assistive devices to improve mobility, older, more frail patients may often remain immobile for longer periods of time during the interstage period [53]. Limited mobility and reduced muscle mass resulting from increased bed rest, and the use of assistive devices during the interstage period can lead to deconditioning and a

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reduction in ROM [3]. The severity of muscle atrophy is often exacerbated by additional factors, such as advancing age for whom lower extremity muscle mass is an important determinant of functional status [73].

Kim et al. reported that ROM during the interstage period has shown to be a negative predictor of ROM following reimplantation [74]. Authors noted that while articulating cement spacers were used, they were unable to achieve knee joint stability and functional ROM simultaneously. In addition, they noted that post-procedure pain and soft tissue damage limited the patients' ROM for several months after the initial surgery due to the stiffness of the knee joint. As a result of these factors, patients with prolonged immobility during the interstage period may have greater functional loss following two stage revision arthroplasty and have a longer period of functional recovery. Lastly, Rajgopal et al. noted that a prolonged interstage period, when compounded by pain, muscle weakness, or poor soft-tissue condition, can lead to worse functional outcomes including reduced ROM [75].

3.6. Psychological effects and Quality of Life (QoL)

Beyond the physical burden of limited mobility and pain, the interstage period during a two-stage revision arthroplasty has substantial psychological challenges for patients. This interval of time, which can extend for months to even years, is associated with uncertainty regarding infection control, dependence on assistive devices, and restrictions in ADLs. In addition, possible prolonged hospitalizations, repeated procedures, and concern over treatment failure can exacerbate emotional distress and impair engagement during rehabilitation.

Studies have demonstrated that patients undergoing a two-stage revision arthroplasty for PJI experience elevated levels of anxiety and depression. Knebel et al. assessed anxiety and depression during the interstage period using a patient questionnaire that was completed preoperative, immediately postoperative stage one, one to three days prior to stage two, post-six weeks of antibiotic treatment, and three months postoperative stage two [76]. The highest anxiety and depression scores were reported during the interstage period after six weeks of antibiotic treatment. Patients indicated that they were most afraid of the risk of reinfection, the possibility of requiring an amputation, the side effects of antibiotic treatment, and being dependent on outside help [76].

In an additional study by Furdock et al., the authors reported on depression at four different timepoints for patients undergoing two-stage revision arthroplasty for PJI compared aseptic revision [77]. Patients undergoing the two-stage revision procedure had significantly worse depression scores at all time points, with the prevalence of moderate depression being the highest during the interstage period prior to reimplantation. Moreover, moderate to severe depression was reported for 34% of patients during the interstage period at this same timepoint. These authors also noted that no differences existed in depression scores between patients with static spacers compared to articulating antibiotic spacers at any of the time points.

Entezari et al. reported that 78% of patients experienced considerable mental health impacts during the period from diagnosis onset to successful treatment completion of PJI [4]. Prolongation of the interstage period as a result of spacer related complications, additional procedures, drug treatment and reinfections or treatment failures have a significant impact on patients' psychological symptoms. In turn, the authors noted that these factors exacerbate patient concerns and can cause heightened levels of anxiety and depression [4].

3.6.1. Social Effects

A prolonged interstage period associated with two-stage revision arthroplasty is also associated with significant social consequences. Patients, during this time, commonly experience restricted mobility, dependence on assistive devices, and limitations in performing ADLs, which can lead to social isolation and reduced familial and occupational participation. In addition, limited mobility during interstage may cause social disruptions leading to a patient's need for assistance. Patients may also increase their dependency on family members and/or others to assist with cooking and cleaning

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their home, aid in personal hygiene, assist with medication administration, and assist with providing transportation to medical appointments [76]. This can be particularly challenging for older patients who may have significantly more limited mobility during the interstage period [53]. Results of dependency can lead to negative feelings and increased levels of frustration for patients, families and caregivers, and may be even more frustrating for patients with greater amounts of limitations to their mobility for prolonged interstage periods.

Undergoing revision arthroplasty has a significant impact on employment status due to mobility limitations during the interstage period, as it often impacts the ability to return to work. Patients who are able to return to work will likely require gait aids (i.e., crutches, walker, cane) for some time following stage one surgery. The ability to drive to work or use public transportation, and move within the workplace, are necessary prerequisites for returning to work. Scott et al. assessed the return-to-work rate for patients under 65 undergoing revision total hip and knee arthroplasty [78]. Most patients underwent revisions due to either aseptic loosening, infection, or dislocation. Patients undergoing revision total hip arthroplasty had a return-to-work rate of 33% compared to only 7% for patients undergoing a revision total knee arthroplasty. Patient age significantly affected the ability to return-to-work; in patients undergoing a revision total hip arthroplasty, 79% of patients under 50 and 16% over 50 were able to return. Additionally, patients with jobs that were more sedentary and required less mobility were more likely to return-to-work than those with heavy or moderate manual labor jobs, which required higher function.

3.7. Future Surgical Considerations

While alternative surgical approaches for treatment of PJI exist, including irrigation and debridement with implant retention, one-stage and 1.5-stage revision, two-stage revision arthroplasty remains the gold standard in the USA and is associated with an overall lower long-term mortality [79]. The two-stage procedure is especially pertinent for patients with chronic or more-complex infections, compromised host immunity, or bone loss [3]. Improving options for mobility, reducing the duration of the interstage period, and reducing the need for reoperations in patients undergoing two-stage revision arthroplasty for treatment of PJI will aid in improving clinical and psychosocial outcomes within this patient population.

More recently, research has focused on advancing treatment methods to improve outcomes in patients with PJI. Rather than a two-stage revision arthroplasty, research has assessed the one-stage revision as a possible alternative for a select patient-population. Additionally, specific to a two-stage revision, a novel approach to treatment includes the use of intra-articular antibiotic irrigation as part of an abbreviated seven-day exchange protocol. This treatment protocol delivers high local concentrations of antibiotics directly to the infected joint space and surrounding tissues [3,80]. Treating the joint locally may allow for the ability of the infection to be eradicated within a shorter period of time, leading to an earlier reimplantation. Both of these procedures decrease the time of limited mobility allowing for a possible faster recovery and a reduction in the above-mentioned deleterious effects during a prolonged interstage period.

4. Discussion

Patients undergoing a two-stage revision arthroplasty for PJI of the hip or knee experience limited mobility during the interstage period. The associated physical limitations, psychological distress and social disruptions contribute to a delay in rehabilitation and diminished quality of life. Addressing both the medical and psychosocial aspects of limited mobility during the interstage period for patients undergoing two-stage revision arthroplasty is essential to improving recovery and maintaining patients' overall well-being. Standardized measurement of mobility to assess the impact of limited mobility during the interstage period is also warranted. Continued efforts are needed to improve mobility and reduce the duration of the interstage period to reduce the incidence of clinical complications, enhance functional recovery, and improve overall QoL for patients undergoing treatment of PJI.

 doi:10.20944/preprints202511.2022.v1

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

Author Contributions: Hari K. Parvataneni: Conceptualization, Writing – Original Draft, Review & Editing; Chancellor F. Gray: Writing – Original Draft, Review & Editing; Hernan A. Prieto: Writing – Original Draft, Review & Editing, Larry Yost: Conceptualization, Writing – Original Draft, Review & Editing, Project Administration; Emilie N. Miley: Conceptualization, Writing – Original Draft, Review & Editing, Supervision, Project Administration.

Funding: Funding for this project was provided by Osteal Therapeutics.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No datasets were generated or analyzed for the current paper.

Conflicts of Interest: Hari Parvataneni reports having stock options with Solenic Medical. Chancellor Gray reports having stock options from DeBogy Molecular, Hernan Prieto reports research support from ZimmerBiomet, Smith & Nephew and Osteal Therapeutics. Larry Yost reports being a paid consultant to Osteal Therapeutics and having an equity interest in the company. Emilie Miley reports having stock options with ZimmerBiomet and being a paid consultant to Osteal Therapeutics.

Abbreviations

The following abbreviations are used in this manuscript:

ADLs	Activities of daily living
ASH	American Society of Hematology
DVT	Deep vein thrombosis
FIM	Functional Independence Measure
HOOS	Hip disability and Osteoarthritis Outcome Score
ICF	International Classification of Functioning
KOOS	Knee injury and Osteoarthritis Outcome
OHS	Oxford Hip Score
OKS	Oxford Knee Score
PJI	Periprosthetic joint infection
PMMA	Polymethyl methacrylate
PE	Pulmonary embolism
PROMs	Patient Reported Outcome Measures
QoL	Quality of life
ROM	Range of motion
TJA	Total Joint Arthroplasty
UCLA	University of California Los Angeles
VTE	Venous thromboembolism

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