

Total Joint Arthroplasty Failure

Subjects: Orthopedics | Infectious Diseases

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Total joint arthroplasty is a common restorative surgery. Arthroplasty failure is a major complication of joint replacement surgery. It can be caused by periprosthetic joint infection (PJI) or non-infectious etiologies, and often requires surgical intervention and (in select scenarios) resection and reimplantation of implanted devices. Fast and accurate diagnosis of PJI and non-infectious arthroplasty failure (NIAF) is critical to direct medical and surgical treatment.

Keywords: PJI ; periprosthetic joint infection ; arthroplasty

1. Total Joint Arthroplasty Failure

Total joint arthroplasty is a common restorative surgery. In the United States (US), more than 1.5 million people undergo total hip arthroplasty (THA) or total knee arthroplasty (TKA) yearly and it is anticipated that numbers of arthroplasties will rise due to the aging population, high rates of obesity, and physical activity throughout the lifespan, including in later years. It has been predicted that THA and TKA procedures will grow by 137% and 601%, respectively, in the US between 2005 and 2030, resulting in more than 5 million primary THAs and TKAs and an estimated US\$1.85 billion in annual hospital-related costs by 2040 ^{[1][2][3][4][5]}. A study of over 1.5 million primary TKA or THA patients from the US National Inpatient Sample found the mean age of patients undergoing primary TKA to have decreased from 68 years in 2001 to 66 years in 2011, while the mean age of those undergoing primary THA decreased from 66 years in 2001 to 65 years in 2011. In total, 64% and 56% of those in the TKA and THA groups, respectively, were women ^[6].

There are several reasons patients undergo joint replacement surgery. Most commonly, the procedure is in response to symptomatic osteoarthritis, followed by inflammatory arthritides, such as rheumatoid arthritis, or joint damage due to injury, tumors, or osteoporosis; regardless of underlying disease, these conditions result in pain, loss of joint mobility, and/or an overall decrease in quality of life ^{[7][8][9][10]}. In most cases, joint replacement provides dramatic pain relief and restoration of joint function, although 1 to 3% of patients require revision surgery due to complications, such as periprosthetic joint infection (PJI) or non-infectious arthroplasty failure (NIAF) ^{[11][12][13][14][15]}. As primary arthroplasty procedures increase in numbers, so do revision surgeries. It is estimated that surgical revision procedures will grow from ~130,000 annually in 2014 to ~300,000 by 2030, with an increase from ~55,000 to ~85,000 for hip and ~72,000 to more than 200,000 for knee revisions. Not only are numbers of joint revisions increasing, but the rate of revisions in younger patients, particularly those between the ages of 55 and 64, is growing, with total increases of 9.1% and 8.6% for THA and TKA, respectively, from 2002 to 2014 ^[16]. A 2014 retrospective study of 120,538 patients with TKAs found that, one-year post surgery, those younger than 50 years old were more likely to develop arthroplasty failure than those 65 years or older. In that study, PJI developed in 1.4% of those under 50 years of age and 0.7% in those over 65 years of age, while NIAF developed in 3.5% and 0.8%, respectively ^[17]. Determining the underlying cause of arthroplasty failure, whether infectious or non-infectious, and in turn, choosing a suitable treatment approach is essential, albeit difficult in some cases ^[9].

2. Periprosthetic Joint Infection

PJI occurs in ~1 to 3% of patients undergoing primary total joint arthroplasty and makes up 20% to 50% of arthroplasty failures ^{[9][13][16][18][19][20][21]}. In 1995, the National Institutes of Health (NIH) Consensus Development Panel on Total Hip Replacement described PJI as a “devastating complication” that is “challenging” to diagnose ^[10]; antimicrobial agents plus surgery are needed to treat it. The type of surgical intervention is based on the infecting organism(s), timing and duration of infection, and clinical presentation. For acute PJI, joint irrigation, followed by debridement, long-term antimicrobials, and implant retention (DAIR), is typical, costing around US\$67,000 ^[22]. For non-acute cases, resection of components is characteristically necessary, either as one- or two-stage procedures. Two-stage exchange arthroplasties typically cost around US\$114,000, though costs vary ^{[9][23][24][25][26]}. In all, management of PJI costs hospitals ~5-fold more than uncomplicated hip arthroplasty, totaling approximately US\$2 billion per year, not including non-medical costs ^{[5][27][28]}. This

cost is in addition to the individual patient burden, often including devastating morbidity, expense, impairment of quality of life, and potential loss of implanted devices, or even limbs, in extreme circumstances [9][29]. There are several risk factors associated with PJI, including obesity, smoking, and immune-disrupting disorders and their treatments, such as diabetes mellitus and rheumatoid arthritis. Men have been observed to be more prone to infection than women, although the biological underpinning for this observation is unknown [30][31][32][33][34][35][36][37][38][39][40][41].

PJI is typically caused by the formation of bacterial biofilms on device surfaces and in the surrounding tissues; biofilm formation involves the production of extracellular polymeric substances and immune-modulating products that protect microorganisms from antimicrobial agents and the host immune response [42][43][44][45][46]. Staphylococci, primarily *Staphylococcus epidermidis* and *Staphylococcus aureus*, are the most common causes, followed by polymicrobial infections, streptococci, anaerobic bacteria, aerobic Gram-negative bacilli, and enterococci. In rare cases, other bacterial types, or even fungi, cause PJI [9][47][48][49][50][51][52]. Culture-negative infections make up 6 to 15% of PJI cases, although rates up to 42% have been reported. Culture-negative PJI is particularly challenging due to the difficulty in selecting a treatment regimen for an unknown causative organism (which may be “over” or “under” treated) or even in classifying the joint as infected in the first place [47][53][54][55].

3. Non-Infectious Arthroplasty Failure

NIAF includes causes of arthroplasty failure other than infection, accounts for ~50 to 80% of arthroplasty failures and can cost upwards of US\$40,000 per TKA revision and US\$15,000 per THA revision [16][56][57][58]. It is typically divided into aseptic loosening, periprosthetic fracture, instability, osteolysis/adverse tissue reaction, and other/miscellaneous subgroups, with classification dependent on clinician discretion in many cases. As with arthroplasty failure due to PJI, revision surgery is often used to treat NIAF (unlike PJI, without antimicrobial treatment) [9][11][12][14][15][59][60][61][62][63][64]. Studies conducted at the Mayo Clinic in 2017 and 2019 found that the distribution of causes of NIAF of TKAs included 36% aseptic loosening, 21% periprosthetic fracture, 21% instability, 19% osteolysis, and 2% arthrofibrosis, while the distribution of causes of THA revisions for NIAF included 37% periprosthetic fracture, 26% aseptic loosening, 19% adverse tissue reaction to the device, 13% instability, and 5% other, including implant failure/stem fracture, and iliopsoas tendinitis requiring repositioning [12][64].

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