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Staphylococcus aureus colonization and periprosthetic joint infection in patients undergoing elective total joint arthroplasty: a narrative review

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- Peri-prosthetic joint infections (PJIs) following total joint arthroplasty (TJA) are associated with higher treatment costs, longer hospital admissions and increased morbidity and mortality.
- Colonization with *Staphylococcus aureus* is an independent and modifiable risk factor for PJIs and carriers of *S. aureus* are ten times more likely than non-carriers for post-operative infections.
- Screening and targeted decolonization, vs universal decolonization without screening, remains a controversial topic.
- We recommend a tailored approach, based on local epidemiological patterns, resource availability and logistical capacity.
- Universal decolonization is associated with lower rates of SSI and may reduce treatment costs.

Keywords

- arthroplasty
- staphylococcus
- infection
- *Staphylococcus aureus*
- PJI
- colonization
- eradication

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Introduction

In 2020, over 1 million total joint arthroplasties (TJAs) were performed annually with the demand for arthroplasty projected to rise by 400% from the early 2000s to 2030 (1, 2). As the number of TJAs increases to accommodate an ageing population, so too does the incidence of complications.

Definitions

Surgical site infections (SSIs) are defined as infections occurring within 90 days of surgery involving the skin or subcutaneous tissue, in the region of the body where the surgery took place (3). Periprosthetic joint infection (PJI) refers to a spectrum of all infective conditions related to TJA, ranging from superficial SSIs to deep infections involving the implanted prostheses (4, 5). Many attempts have been made to produce diagnostic criteria for PJI since the initial definition by the Musculoskeletal Infection Society (MSIS) in 2011, but the overall consensus has been poor (4, 5, 6).

Incidence

It is estimated that 0.7–2.5% of primary total hip arthroplasty (THA) and 1–3% of primary total knee arthroplasty (TKA) are complicated by PJIs (7). Infection is cited as the indication for 14.7% of revision THAs and 25.2% of revision TKAs (8). The United Kingdom (UK) National Joint Registry (NJR) showed that revision procedures necessitated by PJI have risen from 140 in 2003 to over 1000 annually in 2019 despite targeted efforts to reduce infections (2). In addition, the Danish Joint Registry shows that the burden of PJI may be underreported by as much as 33% (2).

Impact of PJIs

PJIs are associated with longer hospital admissions, higher re-operation rates, prolonged use of analgesics and antibiotics and extended rehabilitation periods (8). PJIs increase the length of hospital stays by 7–10 days (9). Morbidity associated with PJI ranges from functional impairment and re-intervention to amputation (10). The 5-year survival rate of PJI is 87.3%, which is worse than prostate cancer (99%), melanoma (92%) and breast cancer (89%) (11). Two-stage hip revisions necessitated by infection are linked to 25.8% all-cause mortality at 2 years (8).

Financially, the global economic burden of THA revisions is estimated at over $1 billion annually (12).

The total economic impact of PJI was estimated at $1.62 billion in the USA in 2020 (10). The cost of revision procedures is reported to be as high as €80 000 per case; up to five times greater than the cost of primary TJA (8). A revision procedure for an infected THA in the UK costs a mean of £50 000 (2). A case of deep PJI costs between $60 000 and $110 000 to treat (13).

Causative organisms

Staphylococci, including coagulase-negative *Staph.* and *S. aureus*, are the most commonly isolated microbes in PJI and account for approximately 40% of the cases (14). These gram-positive bacteria are well-described commensals of the skin and upper airways becoming opportunistic pathogens when exposed to specific host factors, environmental influences and bacterial interactions (15, 16). Staphylococcus species have the ability to form a biofilm on foreign objects with their enclosure in this polymeric matrix and low growth rate resulting in relative protection from host immune defenses and antimicrobials (17).

S. aureus is broadly classified into methicillin-sensitive *S. aureus* (MSSA) and methicillin-resistant *S. aureus* (MRSA), based on its susceptibility to a penicillin-related antibiotic. Carriers of *S. aureus* are at a higher risk of developing SSIs compared to non-carriers (18).

Surgical interventions for PJIs

Surgical strategies to eradicate PJIs include debridement, antibiotic and implant retention (DAIR), one-stage revision and two-stage revision (9, 10). Salvage techniques include antibiotic suppression, amputation and arthrodesis limited to patients who are medically unfit for the aforementioned techniques (9).

Two-stage revision, the gold standard, involves removal of all prosthetic components, cement and compromised soft tissues and the insertion of a temporary mobile or static antibiotic-impregnated spacer (14). Success rates range between 80 and 95% (9, 14).

One-stage revision requires the infective pathogen to be known, a suitable soft tissue envelope, thorough intra-operative debridement of all infected/necrotic tissue and local and systemic antibiotic delivery (11). Infection-free success for single-stage revisions in appropriate cases should be between 77 and 100% (11).

DAIR is used in early post-operative infection (<4 weeks since surgery or <4 weeks since symptoms in haematogenous infection) and may or may not include removal of modular parts (9). Success with DAIR was reported between 14 and 100% (9, 12).

Use of anti-microbials

In monomicrobial PJIs secondary to MSSA or Streptococcus, cloxacillin or cefazolin is typically used as first-line antibiotics with piperacillin-tazobactam and vancomycin recommended in polymicrobial infections (19).

Rifampicin, a broad-spectrum antimicrobial agent, penetrates the biofilm and is able to kill sessile bacteria by reaching high intracellular levels (17, 20). Its use as monotherapy is contraindicated due to the rapid development of resistance and its use is associated with significant side effects and potential drug–drug interactions (17, 20, 21).

Scheper *et al.* (2021) in a systematic review and meta-analysis showed that the addition of rifampicin was associated with a 10% increase in the success rate of PJI eradication. In a retrospective cohort study, Suzuki *et al.* (2022) demonstrated adjunctive rifampin was associated with a significantly lower recurrence for *S. aureus* PJI compared with no rifampicin and recommended adjunctive rifampin for 6 months in patients with *S. aureus* PJI treated with DAIR (22).

The Infectious Diseases Society of America (IDSA) treatment guidelines recommended rifampicin as an adjunctive antibiotic for staphylococcal PJI, especially in patients undergoing a DAIR procedure (22).

Risk factors for PJI

Despite established perioperative infection control measures, patient-related predisposing factors continue to significantly influence the rates of PJI. Modifiable risk factors include obesity, smoking, alcohol abuse, malnutrition and *S. aureus* colonization (10, 18, 23). Diabetes, renal insufficiency, inflammatory arthritis and immunosuppression are non-modifiable risk factors known to increase the risk of PJI (18, 24). Institutional strategies for preventing infection after TJA should therefore begin with the identification, investigation and optimization of predisposing comorbid conditions and modifiable risk factors.

Despite much energy and money being spent on different surgical techniques, implant coatings and antibiotic prophylaxis, the rate of PJI has remained constant and therefore extensive research into adjusting and addressing risk factors has been done.

Prevention of PJI is a crucial strategy in reducing the burden of revision TJA and decreasing morbidity and mortality rates and costs (9, 13). Optimization of patients and their risk factors pre-operatively remains a fundamental strategy to mitigate the impact of PJI (9).

Screening and decolonization of *S. aureus* prior to TJA is a controversial topic with widespread differences.

This article describes the association between *S. aureus* and SSIs and PJIs and reviews the current literature on eradication.

Infections and *S. aureus* colonization

It is estimated that SSIs complicate approximately 1.9% of the 80 million procedures performed annually in the USA (11). Incidence of SSIs differ according to the type of procedure with rates of 10.8% in cardiac surgery, 7% for vascular procedures, 4.8% for breast surgery and 2.4% for orthopaedic procedures reported. SSIs are more frequent in low-income (5.6%) vs high-income settings (1.6–2.6%).

S. aureus is the most commonly isolated pathogen in SSI and is capable of causing a broad spectrum of infections with a mortality rate approaching 40% (25, 26). Colonization by *S. aureus* is a modifiable risk factor for SSI and carriers of *S. aureus* have a 9–10 times greater risk of developing SSI than non-carriers (27, 28). MRSA colonization leads to four times greater risk of PJI (29).

The incidence of SSIs in orthopaedic surgery is reported as 2.55–2.7% and at 1.6%, *S. aureus* is the most frequently implicated organism (30, 31).

An endogenous origin of *S. aureus* was demonstrated in more than 80% of cases of SSI (32). Skramm *et al.* used molecular typing demonstrating that *S. aureus* subspecies cultured on pre-operative nasal swabs were the same as the infective organism in 85.71% cases of SSI in THA, TKA and spine surgery patients (33).

S. aureus is the most likely bacteria to evolve multi-drug resistance in hospitals globally, escalating morbidity and mortality rates and treatment costs (15). When the infective pathogen is MRSA rather than MSSA, the costs are almost doubled, the mortality rate is doubled and the duration of inpatient care is much greater (34, 35, 36). Poorer outcomes were seen in PJI as a result of MRSA, *Pseudomonas* spp. and *Proteus* spp, compared to MSSA (37).

Prevalence of *S. aureus* colonization

The prevalence of MSSA colonization in the general population is reported to be between 15.0 and 36.9% with MRSA nasal carriage prevalence ranging from 0.6 to 7% (13, 38, 39). Despite the low prevalence of nasal carriage, MRSA is implicated in 25.5% of community-acquired *S. aureus* infections and more than two-thirds of hospital-associated (HA) infections (13, 34, 40, 41).

In 7019 patients awaiting elective TJA or spine surgery, Kim *et al.* calculated the prevalence of MSSA and MRSA colonization to be 22.6 and 4.4%, respectively (42). A retrospective analysis of 912 patients who underwent elective TJA demonstrated a prevalence of *S. aureus* colonization of 22.6% (43). Ramos *et al.*, in a retrospective review of 13 828 patients awaiting TJA and spinal fusions, reported that 18.21% of patients were colonized by *S. aureus* (44). Pietrzak *et al.* in 2016 found that 31.9% of patients undergoing TJA at a South African academic hospital were colonized by *S. aureus* (45).

How *S. aureus* colonization occurs

Anterior nares are commonly colonized by *Corynebacterium* spp., *Propionibacterium* spp. and *Staphylococcus* spp. (16, 35, 46, 47, 48). *S. aureus* expresses adhesion protein molecules that interact with the carbohydrate in the stratified squamous epithelium of the nose to mediate successful colonization (25). Cell *Wall Teichoic Acid* (WTA), a staphylococcal adhesin, is considered critical for adherence to nasal cells (36).

Colonization of the anterior nares by *Staphylococcus* spp. may be restricted by the presence of other bacterial species (16). *Streptococcus pneumoniae* and *Staphylococcus lugdunensis* inhibit *S. aureus* colonization by the secretion of bactericidal substances (16, 49, 50). *Staphylococcus epidermidis* produces an enzyme that disrupts the adherence of *S. aureus* to the nasal mucosa (16, 51). *Corynebacterium* spp. and *S. aureus* compete for binding sites in the anterior nares (16, 52). In addition to inter-species competition for colonization, intra-species competition has been demonstrated showing colonization with MSSA impedes the co-existence of MRSA (16, 42).

Risk factors for *S. aureus* colonization

Risk factors for *S. aureus* colonization include age, gender, obesity, diabetes mellitus, immunosuppression, ethnicity, recent hospitalization and antibiotic treatment misuse (53, 54).

Bitterman *et al.* reported that age was the most consistent predictor of both MRSA nasal carriage and involvement of multiple anatomical sites (55). In a review of 924 healthy participants, *S. aureus* colonization rates were 50% in the age range of 5–10 years, compared to 30% in all other age ranges (56).

General practitioner records from 9 European countries suggested that males are 1.38 times more likely to be carriers of *S. aureus* (57). Similarly, Kent *et al.*, in a review of pre-operative screening results of 115 elective orthopaedic patients, reported that males were twice as likely to be *S. aureus* carriers than females (58). This may be attributed to males having more apocrine sweat glands in the nasal mucosa and poorer hand hygiene (26).

Malcolm *et al.* studied the records of 5678 patients undergoing elective TJA (29). The risk of MSSA

colonization was higher in patients of male gender and lower average age (29). MRSA colonization was notably more likely in patients with congestive cardiac failure and hospital admission within the previous 6 months (29).

The incidence of *S. aureus* colonization is reported to be higher in obese patients (59, 60). Olsen *et al.* found that increased waist circumference was associated with a greater likelihood of *S. aureus* colonization (59). This may be attributed to abnormal glucose metabolism and immune responses (59, 61).

Walsh *et al.* studied 716 patients undergoing elective TJA. Patients with diabetes, immunosuppression and renal failure were more likely to be colonized by *S. aureus* (62). Kent *et al.* reported that diabetics had 3.8 times greater risk of colonization than non-diabetics (58).

Ayepola *et al.* demonstrated that hospitalization in the previous 12 months, male gender, *S. aureus* skin infections and participation in sports were significant risk factors for colonization in Nigerian university students (63).

Dave *et al.* aimed to establish whether screening of patients with specific risk factors would consistently identify MRSA carriage in 429 participants (64). Patients were classified as high risk if they had been admitted to a hospital in the previous year; transferred from another medical, residential care or nursing institution; had been in close contact with a known MRSA carrier or previously diagnosed with MRSA (64). The results showed that more than half the MRSA carriers would have been missed if selective screening using these parameters had been performed (64).

Testing for *S. aureus* colonization

There are three patterns of *S. aureus* colonization: 20% persistent carriers, 60% intermittent carriers and 20% non carriers (35, 53). The question of which anatomical site, or combination of sites, to sample to most reliably detect *S. aureus* colonization remains controversial with recommendations and sampling protocols varying internationally (53).

The primary reservoir of *S. aureus* colonization is the anterior nares (35, 46). *S. aureus* can also colonize other mucosal sites including the oropharynx, forehead, neck and rectum. *S. aureus* has a predilection for moist areas of the skin, such as the axillae, groin and the perineum (35, 40, 55, 65). The practice of sampling multiple anatomical sites increases the likelihood of detecting colonized patients (58, 65, 66).

Young *et al.* showed that testing the anterior nares most reliably detected *S. aureus* carriage, but by combining throat and nasal swabs, a 10% increased yield of *S. aureus* carriers was achieved (53).

In a study evaluating 403 patients, Coello *et al.* demonstrated that testing multiple sites, in addition to the anterior nares, increased the identification rates of patients colonized by MRSA (67). About 98% of MRSA carriers were identified by swabs of the throat, perineum and anterior nares, compared to 79% of MRSA carriers found by testing the anterior nares alone (67).

Matheson *et al.* found that nasal screening for MRSA was superior to sampling the throat, axilla or perineum (65). However, assessing multiple sites was recommended with only two-thirds of colonized patients identified by assessing the anterior nares alone (65).

Batra *et al.* demonstrated that sampling multiple sites for MRSA improved detection rates (68). Isolated sampling of wounds revealed only 4.7% of carriers (68).

The expense associated with sampling multiple anatomical sites for *S. aureus* places strain on healthcare budgets (35). It has therefore been suggested that testing only the anterior nares may be an adequate assessment for *S. aureus* colonization based on the observation that colonization of another site in the absence of nasal colonization is relatively uncommon (69).

Real-time PCR is a faster and more sensitive method than culture-based techniques (70). Tonotsuka *et al.* therefore recommend PCR for high-risk populations despite higher costs (71).

Eradication of *S. aureus* colonization

The most consistent and effective *S. aureus* eradication protocols include intranasal mupirocin ointment (72, 73). Mupirocin inhibits bacterial isoleucyl-tRNA synthetase and disrupts bacterial protein synthesis (35).

The WHO strongly advocates the use of mupirocin with or without chlorhexidine body wash for the pre-operative eradication of *S. aureus* from known nasal carriers (13). Chlorhexidine or triclosan body wash is utilized as a supplement to mupirocin ointment and has been shown to reduce the bacterial load on the skin, most impressively in extra-anatomical sites (74).

Moroski *et al.* looked at 289 patients undergoing primary or revision TJA; nasal colonization with MSSA and MRSA was 15.2% and 4.2%, respectively (72). Five days of mupirocin ointment yielded statistically significant eradication of both MSSA and MRSA colonization. Importantly, 5.2% of patients remained colonized following treatment (72).

The merit of mupirocin was further underscored by Perl *et al.* in a randomized control trial of 3864 patients undergoing surgical procedures, as intra-nasal mupirocin led to a significant reduction in SSI among *S. aureus* carriers (73).

However, treatment of *S. aureus* colonization is more likely to fail when there is involvement of multiple anatomical sites, longer hospital admissions and bacterial resistance to mupirocin (75). Ammerlaan *et al.*

reported that resistance to mupirocin developed in 1% of patients (74).

The true efficacy of mupirocin for the management of patients colonized by *S. aureus* has been called to question. In an academic hospital with endemic MRSA, Harbarth *et al.* performed a randomized control trial comparing mupirocin to a placebo for the eradication of multisite MRSA colonization (75). The cohort assigned to mupirocin ointment and the cohort assigned to the placebo both received chlorhexidine body washes (75). The eradication of MRSA colonization at multiple sites was not significantly greater with mupirocin than it was with the placebo. However, a higher rate of MRSA-related infections was observed in the cohort that did not receive mupirocin (75).

The efficacy of eradication therapy may be time-dependent. Decolonization was maintained for at least 10 days after intervention in a study by Tsang *et al.* (76). Agarwala *et al.* reported successful clearance over several weeks, but high recolonization rates 3 months after initial eradication (39). In a meta-analysis of *S. aureus* nasal carriers who were treated with mupirocin, 94% of patients were decolonized 1 week after treatment but only 65% remained decolonized at least 2 weeks after treatment (74). It is therefore recommended that eradication therapy begins 1 week prior to surgery (77).

In 2018, Tsang *et al.* demonstrated that MRSA decolonization protocols are safe and effective against MSSA colonization in the anterior nares and groin (76).

Screening and decolonization vs universal decolonization

An ongoing debate exists in the literature when looking at the merits of screening patients for *S. aureus* carriage and treating only those identified as colonized vs universal decolonization for all patients awaiting TJA. Recent PJI consensus guidelines acknowledge that *S. aureus* decolonization decreases the rate of SSI but provide no recommendation to screen or to universally decolonize patients (11).

Pre-operative *S. aureus* screening and decolonization of those identified as carriers or an *S. aureus* decolonization regimen given to all pre-operative patients (without assessing carrier status) are potentially cost-effective strategies for SSI prevention (78). However, decolonization approaches are largely undefined and techniques are highly variable. This is potentially due to limited randomized clinical trial data in outpatients (prior to elective surgery admission) and scepticism that patients will apply decolonization medications as reliably or effectively at home as would be done in a hospital setting (78).

Kline *et al.* analysed 427 pre-operative outpatients who were screened for *S. aureus* carrier status at four body sites (nares, throat, axillae and perianal area). Treatment of *S. aureus* carriers (121) was randomized to a standard of care (SOC) arm (two pre-operative antiseptic soap showers ($n=53$ participants)) or decolonization group who had 5 days of self-administered nasal mupirocin, chlorhexidine gluconate (CHG) bathing and CHG mouthwash ($n=57$ participants)) (78). When comparing the decolonization bundle (eradication in 41 of 57 patients, 71.9%) with the SOC protocol (eradication in 13 of 52 patients, 24.5%), there was a 47% improved eradication in the decolonization bundle (78). 'Test-and-treat' could miss certain carriers (false-negative result or newly acquired colonization between screening and surgery) (78).

A third arm in which all pre-operative patients would receive the decolonization bundle without screening was developed and a comparison was done looking at the cost and benefits of three SSI prevention strategies: the SOC, 'test and treat' and 'treat all' (78). A financial model was then used to show that the treat-all strategy prevented the most SSIs and resulted in the lowest healthcare-associated costs, followed by the test-and-treat strategy (78). Compared to the treat-all and test-and-treat strategies, the SOC was least favorable because it resulted in both the most SSIs and the highest healthcare-associated costs (78). Compared to the test-and-treat strategy, the treat-all strategy prevented 18 more SSIs per 10 000 patients undergoing surgery (78).

Average savings per patient were $217 for the treat-all strategy and $123 for the test-and-treat strategy and average savings per SSI prevented were $21 929 for the treat-all strategy and $15 166 for the test-and-treat strategy (78).

TJA and spine surgeries can specifically result in deep persistent SSIs leading to prolonged hospitalization and disability (Kline). Kline *et al.* showed that the savings per SSI prevented by the treat-all strategy increased by 40–167% for THA and TKA procedures compared to general surgery cases (78).

Although providing every patient with the 5-day decolonization bundle prior to surgery would reduce the number of *S. aureus* carriers, it exposes non-carriers to medication unnecessarily (78). Potential side effects (allergic reactions, irritated or dry skin) and possible selection for *S. aureus* resistance are the concerns (78). Furthermore, patients might be less motivated to apply the decolonization bundle medications compared to patients who test positive for *S. aureus* in the test-and-treat strategy (78).

Dancer *et al.* found that MSSA screening and decolonization reduces the rates of *S. aureus* SSI in

patients awaiting elective orthopaedic surgery and was associated with economic benefits (79).

Universal decolonization may be more cost-effective and easier to execute; however, it is associated with emerging antimicrobial resistance to mupirocin (7, 26). Mullen *et al.* proposed antiseptic body wash as an alternative to the universal use of antimicrobials to delay the emergence of mupirocin resistance (80).

A 2020 meta-analysis by Zhu *et al.* demonstrated that rates of SSI were dramatically reduced in patient groups that underwent pre-operative *S aureus* screening and decolonization, compared to the patient groups that were not decolonized (81). No difference was seen between the two groups in rates of SSI caused by non-staphylococcal bacterial species. (81).

Scholten *et al.* performed a retrospective review of 10 486 cases of TJA. Patients that underwent pre-operative nasal *S. aureus* screening and decolonization were compared with patients that did not undergo screening (82). Implementation of a pre-operative screening protocol resulted in a statistically significant decrease in the incidence of *S aureus*-induced early PJI but no difference in the overall rates of early PJI, most likely caused by non-staphylococcal bacteria (82).

Johns *et al.* investigated whether a pre-operative screening protocol aimed at modifiable risk factors would decrease the rate of complications following TJA (1). SSI rates were nearly five times lower, and the length of hospital stay, cost of care and hospital readmission rates were decreased if a pre-operative screening tool was used prior to TJA (1).

In 2021, Tonotsuka *et al.* compared the cost-benefit of using a risk-factor-targeted strategy for screening patients for *S. aureus* colonization, compared to universal pre-operative screening, for 1654 patients undergoing THA (71). Primarily on cost implications, a universal screening strategy was shown to be superior (71).

A cost-utility analysis commissioned by the National Institute of Health and Care Excellence in the UK in 2019 showed the superiority of universal decolonization, except in settings where rates of *S. aureus* SSI are low (83). Stirton *et al.* showed that for the 1 051 000 TJAs performed annually in the USA, universal decolonization saved $37.4 million vs a screening and decolonization programme (80, 84).

A 2021 meta-analysis by Ribau *et al.* endorsed universal decolonization as the preferable protocol, based on efficacy and fiscal considerations (18). Importantly, no carrier of *S. aureus* would be missed under this regimen (18).

Stambough *et al.* divided 4186 patients awaiting primary TJA into two cohorts – 1981 to the 'screen and treat' protocol and 2205 to the 'universal decolonization' programme (85). Universal decolonization was the superior strategy in reducing *S. aureus* colonization (85).

Screening and targeted decolonization may demonstrate responsible antimicrobial stewardship, identify patients at higher risk of complications and contribute to epidemiological data but it is resource intensive (14, 18, 80). Epidemiological and mathematical models suggest that protocols that forego screening may fail to control the spread of MRSA, due to a lack of targeted infection control interventions (26).

A 2021 systematic review by Lin *et al.* supported a screening and decolonization programme, citing the efficacy of eradication and financial benefits to the healthcare system (7). It was acknowledged that universal decolonization is a non-inferior alternative regimen for the pre-operative management of patients colonized by *S. aureus* (7).

A literature review by Saadatian-Elahi *et al.* focused on *S. aureus* SSIs in cardiac and orthopaedic surgeries and advocated for a screening and treatment protocol, expounding on the benefits of identifying patients at higher risk of complications and the creation of surveillance networks (14).

A *S. aureus* vaccine has been proposed as a means of reducing SSI among patients awaiting orthopaedic surgery (86, 87). Those undergoing primary THA are most likely to benefit from an *S. aureus* vaccine (86). Lee *et al.* concluded, by use of computer and mathematical modelling, that a vaccine effective against *S. aureus* would be an economically viable approach to pre-operative orthopaedic patients at high risk of SSIs (87).

Conclusions and recommendations

PJI remains a dreaded complication in patients undergoing TJA and is associated with increased morbidity, mortality and healthcare costs. Colonization by *S. aureus* is a modifiable risk factor for PJIs.

Globally, the prevalence of MSSA ranges from 15 to 36.9% and MRSA from 0.6 to 7%. It is recommended that known carriers of *S. aureus* awaiting TJA undergo eradication with mupirocin ointment, in combination with chlorhexidine baths, for 5–7 days prior to surgery.

There is an ongoing debate over the superiority of screening and targeted decolonization protocols, compared to universal decolonization without screening. The decision to adopt either strategy should be informed by institution-specific financial and logistical considerations. Ongoing studies into alternative protocols for screening and decolonization of *S. aureus* for patients awaiting TJA are encouraged. The development of a *S. aureus* vaccine is a promising new avenue of research for patients at high risk of developing SSI following TJA.

ICMJE conflict of interest statement
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