question. Success of treatment with a two-stage arthroplasty varies between <70 to 100%, with no direct correlation to the spacer time interval [1,2,6,7,9,11].

Several studies have reported on time to reimplantation and its influence on success or failure. Haddad et al. reported no increase inreinfection rates by reducing the interval to three weeks [5]. Sabry et al. found that an increased duration between resection and reimplantation was associated with higher rates of infection recurrence in a cohort of 314 infected total knee arthroplasties (TKAs) treated with two-stage exchange [7]. Their median interval between stages was 103 days (range, 2 to 470 days). A study by Kubista et al. [8] also found that a longer time period between spacer insertion and reimplantation was associated with increased PJI recurrence. In contrast, Babis et al. obtained a 100% success rate when using a long interval—mean 9 months (range, 8 to 12 months)—in a group of patients with a high percentage of multiresistant bacteria [9].

One common belief is that a delayed second-stage or reimplantation will result in a higher rate of treatment success. However, this is not based on strong evidence and may lead to an unnecessarily long inter-stage interval with its associated morbidity. Aali-Rezaie et al. [10], in a recent, large retrospective cohort study evaluating patients with two-stage exchange arthroplasty, did not detect a clear association between time to reimplantation and treatment failure. Furthermore, they found that delaying the time to reimplantation did not significantly improve treatment success of two-stage exchange arthroplasty. In addition, Vielgut et al. found, in a study of 76 hip infections, that patients who had their reimplantation between 4 and 11 weeks had a significantly higher success rate when compared to less than 4 and greater than 11 weeks [6].

When deciding on the optimal timing for reimplantation, most surgeons prefer to rely on a combination of clinical evaluations, such as a completely healed wound, no pain and serologic tests trending downwards after a period of antibiotic therapy [11]. Various studies recommend a complete workup with normalized laboratory and clinical variables to assure infection control prior to reimplantation.

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QUESTION 2: Is it safe to retain a stable cement mantle for later use in patients undergoing resection arthroplasty for periprosthetic joint infections (PJIs)?

RECOMMENDATION: Meticulous debridement and removal of all foreign material, including cement, should be part of resection arthroplasty in the management of PJIs. Limited data suggests that under strict conditions and following a meticulous surgical technique, a stable cement mantle in the femur may be left in place for later use in order to minimize damage to the femoral bone stock.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 63%, Disagree: 29%, Abstain: 8% (Super Majority, Weak Consensus)

RATIONALE

Historically, resection arthroplasty for PJIs involved removal of all the foreign material including cement, as these materials can act as a nidus for biofilm and persistence of infection [1–5]. However, removal of the cement mantle increases operative time and causes increased morbidity through bone loss and fractures. The in-cement revision technique is a useful, well-described technique utilized in aseptic conditions to avoid the tedious task of cement removal and therefore avoid complications associated with cement extraction [6–10]. Retention of an intact cement mantle in cases of resection arthroplasty for PJI would be preferable to avoid the morbidity associated with its removal and would make subsequent reimplantation technically easier.

The concern for retaining cement in the setting of PJI has been supported by in vitrostudies. Kendall et al. examined microbial growth of staphylococcal species on the surface of antibiotic-loaded cement discs incubated in broth. While the broth itself was sterilized by the discs after 96 hours, growth was consistently seen on the surface of the cement discs themselves. The cement, therefore, seemed to be a habitable surface for continued growth of bacteria, despite elution of antibiotics [11]. Mariconda et al. demonstrated that fluid around antibiotic-loaded cement that is sonicated can yield positive cultures, even if aspiration fluid was culture-negative, indicating that biofilms can persist on antibiotic-loaded cement [12]. Tunney et al. and Minelli et al. showed that biofilm could form even

on antibiotic-loaded cement, depending on the inoculum and the type and dosing of the antibiotic agent [13,14]. Although Griffinet al. could not demonstrate biofilm formation in explanted spacers, Ma et al. demonstrated that 30.7% of spacers had bacterial contamination at the time of the second stage [15,16]. This laboratory data should give some cause for concern for the retention of cement in the setting of infection, even if loaded with antibiotics.

The clinical data on this topic is extremely limited. There are two case series that examine this specific issue, both involving a stable cement mantle in revision total hip arthroplasty for infection. Morley et al. reviewed 15 total hips with two-stage revisions for PJIs while retaining the original cement mantle and reported infection-free outcomes in 14 of 15 patients [17]. The authors used a very strict selection criteria for the patient cohort. These selection criteria, which included a stable cement mantle, prior use of antibiotic-loaded cement and meticulous burring of the cement mantle in order to remove biofilm and liberate antibiotics were vital to the success of this technique.In a similar study, however, Leijtens et al. reported success in only 2 out of 10 patients undergoing two-stage revision total hip arthroplasty for infection at an average of 26 months [18]. It should be noted that this study did not mention whether the existing cement mantle contained antibiotics or not.

There is only one Level IV study showing good results with a retained stable cement mantle for later use in resection arthroplasty in the treatment of PJIs. While this technique presents theoretical advantages, there is a lack of robust evidence in the literature to support its routine use. Direction for further research might include the use of chemical debridement agents, such as dilute povidone-iodine, chlorhexidine irrigation and/or acetic acid preparations, which some evidence suggests might help eradicating microbes and biofilms in some settings [19]. The role of chemical debridement agents in eliminating sessile bacteria and biofilm on the surface of retained cement has yet to be explored. With further research, the answer to this question might become known.

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QUESTION 3: Should surgeons make an effort to remove cement that has extruded into the pelvis or at difficult anatomical positions in patients with periprosthetic joint infections (PJIs)?

RECOMMENDATION: The orthopaedic surgeon should carefully consider whether the potential benefits of cement extraction from the pelvis or difficult anatomical positions outweigh the potential risks of persistence of infection.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 85%, Disagree: 9%, Abstain: 6% (Super Majority, Strong Consensus)

RATIONALE

Extrusion of cement during primary arthroplasty is reported to occur in 25% of patients [1]. Bacteria can form biofilm on foreign bodies in patients with PJIs [2]. Therefore, in patients with PJIs who are undergoing resection arthroplasty, it is recommended that the prosthesis and all foreign material including bone cement be removed and thorough debridement performed. Whether or not