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QUESTION 3: Is the use of highly porous tantalum (Ta) associated with reduced risks of surgical site infections/periprosthetic joint infections (SSIs/PJIs) recurrences in revision total joint arthroplasties?

RECOMMENDATION: There is some evidence to suggest that the use of highly porous Ta is associated with reduced risks of SSIs/PJIs recurrences in patients undergoing revision total joint arthroplasties, particularly for treatment of PJIs.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 51%, Disagree: 36%, Abstain: 13% (Simple Majority, No Consensus)

RATIONALE

Cementless acetabular components are increasingly being used in complex revision total hip arthroplasty (THA) procedures. These implants have demonstrated favorable outcomes when compared to their cemented alternatives, with lower rates of aseptic loosening, osteolysis, fractures and infections [1]. The cementless options for revision THA procedures are components made primarily from either titanium (Ti) or Ta. Trabecular metal (TM) (Zimmer Biomet, Warsaw, Indiana, USA) constructs are increasingly utilized in difficult reconstructive procedures, especially when significant bone loss is encountered. TM is a porous composite, comprised of a carbon skeleton coated with Ta. Porous Ta coatings have a number of advantageous characteristics: increased volume of tissue ingrowth due to high porosity (75-85%); comparable elastic modulus to trabecular bone (2.5-3.9 MPa) to reduce stress shielding and favorable frictional attributes ($\mu = 0.88$) to reduce micromotion [2]. The benefits of porous metal augments are the direct ingrowth of host bone, impossibility of resorption, avoidance of disease transmission and easy availability. It has been reported in the literature that reconstruction with Ta implants can result in superior outcomes when compared to other cementless components. These results are hypothesized to be related to the superior osseointegration and have been reported both in animal and clinical practice studies [2–4].

Short- to medium-term results of porous Ta components are promising when compared to their cementless counterparts [4,5]. Flecher et al. reported global survivorship of 92.3% at 64 months with no aseptic loosening encountered [6]. Similar results have been reported by Clement et al., with implant survivorship of 92% at 5 years and no cases of radiological loosening [7]. Encouraging results have also been seen when the follow-up period is extended; Whitehouse et al. reported survivorship of 92% at 10 years for their series of patients managed with TM augments in combination with a TM acetabular component [8]. Promising results have also been reported with the use of TM cup-cage constructs, with 5- and 10-year survivorship figures of 93% and 85% respectively [9].

Wegrezyn et al. from the Mayo Clinic published their randomized control trial (RCT) comparing porous Ta ($n = 45$) with porous-coated Ti ($n = 41$) acetabular cups for primary THAs, with a minimum 10-year follow-up. Both groups had excellent overall survivorship, with 100% of patients in the TM group exhibiting osseointegration and no cup revisions for osteolysis, radiolucency or aseptic loosening. One patient (2%) in the Ti group was revised for aseptic loosening at 12 years. Radiographic analysis at final follow-up identified radiolucent lines in 4% of TM cups and 33% of Ti cups ($p < 0.0001$), raising concerns about the potential for future cup loosening and revision [10]. This concern echoed the results from the Rothman Institute, who found a significantly greater number of lucent zones in the Ti group when compared to the Ta group ($p = 0.02$), in patients reported to have major bone deficiency (Paprosky 2C, 3A and 3B) [11]. Similarly, Jafari et al. reported excellent survivorship with no differences between the two groups [11].

Klatte et al. performed a retrospective case-control study and found that the use of tantalum augmentation during one-stage exchange for infection had no effects on the incidences of reinfections or any other short-term complications. Average follow-up was only 3 years in both study groups, and the authors recommended further study to assess long term durability [12].

It has been reported that Ta, as a material, may have the ability to resist the development of infections better than Ti. A recently published retrospective case series involving 966 patients demonstrated lower rates of reinfections in cases revised for infection using Ta compared to Ti acetabular components [13]. The incidence of all-cause failures in the Ta group was lower than that for the Ti group (4.4% vs. 9.9%, $p < 0.001$). The results were more impressive in the cohort of hips revised for infection ($n = 144$). The failures due to reinfections were significantly lower in the Ta group compared to those in the Ti group (3.1% vs. 17.5%, $p = 0.006$). Three hypotheses were proposed to account for this observation:

I. Ta has a higher potential to stimulate osseointegration than Ti, and hence "dead space" is eliminated more rapidly; in addition, osteoblasts may adhere and integrate onto the surface more easily, thus depriving access to infecting organisms.

II. Due to the topographical three-dimensional structure of Ta, microbes may find it difficult to access and colonize compared to a flat surface, where a biofilm can easily be formed.

III. The chemistry or surface characteristics of Ta may be hostile to infecting organisms [13].

Adherence of bacteria to surgically used metallic implant materials is one of the most important virulence factors for local foreign body infections and a prerequisite for the development of biofilms on implants. An in vitro study from Germany tried to assess the differences between bacterial adherences to Ta vs. other commonly used orthopaedic metallic implant materials. Schildhauer et al. stated that pure Ta has a significantly lower *S. aureus* adhesion compared to Ti alloy ($p < 0.05$) [14].

An in vitro study from Sheffield et al. attempted to identify whether Ta exhibits any intrinsic antimicrobial or antibiofilm properties. Sections of both Ta and Ti were sterilized and then incubated with a low dose inoculum of either *Staphylococcus (S.) aureus,* or *S. epidermis* for 24 hours. Colony forming units (CFUs) were then quantified on Mueller-Hinton agar plates. No statistically significant differences were seen between the number of CFUs for either antimi-

crobial or antibiofilm activity in either group, thereby raising doubt regarding the latter two hypotheses stated above [15].

As the majority of reported studies are single-center with a limited study population, a large registry data approach may provide more insight. Matharu et al. reviewed the use of TM acetabular components in primary THA and compared their subsequent revision rates to non-TM coated prostheses [16]. The group performed a propensity score matched study from the National Joint Registry for England and Wales and report that five-year revision rates were significantly lower in the TM cohort compared to the control for: 1) all-cause (1.0% vs. 1.8%, $p < 0.001$), 2) aseptic acetabular loosening (0.1% vs. 0.2%, $p = 0.029$), and 3) infection (0.5% vs. 0.9%, $p = 0.001$) [16].

Laaksonen et al. report on a collaborative study by reviewing both the Australian and Swedish National Joint Registries in order to assess the risks of re-revisions between Ta and other cementless revision THAs. Included were 2,442 first-time THA revisions with porous Ta cups, and 4,401 first-time revisions with other uncemented cups. Survivorship with re-revision for any reason was comparable up to seven years between the two groups [86% (Ta) and 87% (control) ($p = 0.64$)]. Overall survivorship up to seven years with second revision for PJIs as the end-point was 97% for both groups ($p = 0.64$). Implant survival for a porous Ta cup in first-time THA revision was similar to the uncemented cup control. No benefits in survival with re-revision for infection as an end-point could be ascribed to the Ta group [17].

In summary, the results for the use of highly porous Ta components in revision THA procedures are promising with seemingly lower rates of PJIs than that for their Ti alternatives. The reasons for this reduction in infection rates are not yet known and more work needs to be done in this area.

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5.8. TREATMENT: SALVAGE

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QUESTION 1: Are there differences in outcomes and survivorship between knee arthrodesis (KA) and above-knee amputations (AKA) for chronic knee periprosthetic joint injections (PJIs)?

RECOMMENDATION: Yes, an AKA for the treatment of chronic PJI in total knee arthroplasty (TKA) has a lower functional outcome, and higher mortality rate than KA.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 82%, Disagree: 13%, Abstain: 5% (Super Majority, Strong Consensus)

RATIONALE

One of the earliest studies on the outcomes of the salvage procedures was published in 1988 by Pring et al. They reviewed 23 patients who were treated with AKA following a failed TKA and showed that more than half of the patients were ultimately confined to a wheelchair [1]. Isiklar et al. reviewed nine AKAs that were performed after failed multiple revision surgeries for TKA in eight patients. After an average 2.5 years of follow-up, only two out of nine patients were ambulatory with walker, and one patient required wearing a prosthesis. They