2.2. TREATMENT: ONE-STAGE EXCHANGE

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QUESTION 1: Does the use of iodine-coated or silver-coated implants make one-stage exchange arthroplasty possible in the management of patients with infected oncologic endoprosthesis?

RECOMMENDATION: Unknown. Current literature has advocated the advantages of surface-modified coating (e.g., silver-coated, iodine-supported implants). Recently, there have been several low-quality, small-scale studies showing promising results for using surface-modified implants in one-stage exchange arthroplasty to treat infected oncologic endoprosthesis. However, to date there remains unsubstantiated evidence and large-scale, high-level evidence studies are necessitated.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

The basic treatment for malignant musculoskeletal tumors is a combination of surgical treatment with adjuvant radiation and chemotherapy. Specifically, limb salvage surgery is becoming the standard treatment for oncologic patients, because the effectiveness of chemotherapy has immensely improved in recent decades [1]. Prosthetic reconstruction using an endoprosthesis provides the best possible level of functionality in patients who require a wide excision for a malignant bone or soft tissue tumor because of improved surgical techniques and implant devices. However, periprosthetic joint infection (PJI) continues to be a serious complication after the placement of an endoprosthesis and is not uncommon to observe [2]. Prior literature has demonstrated that the infection rate of an endoprosthesis ranged from 4-36% [3–6]. Therefore, prevention of PJI becomes an essential task for success, particularly in this patient population. An increasingly popular method used in preventing PJI is the utilization of surface-modified implants with antimicrobial effects, such as iodine-coated or silver-coated implants.

Silver has been widely investigated because of its strong broad-spectrum antibacterial properties, anti-biofilm potential and low cytotoxicity [7–11]. Currently, there are several case series and a few case control studies that examine the success of one-stage revision arthroplasty using silver-coated implants for infected oncologic endoprostheses [12–17]. In a case series of four infected endoprostheses, Zajonz et al. demonstrated that one-stage revision arthroplasty resulted in no subsequent reinfection of the endoprostheses [17]. Wafa et al. [16] conducted a case-control study comparing outcomes for silver-coated prosthesis versus unmodified prosthesis in oncologic patients. In terms of single-stage revisions, they noted a lower rate of infection in the silver group compared to the control group, although this was not statistically significant (5.1% vs. 12.5%; $p = 0.249$). There was, however, a marginally significant decrease in infection rate for two-stage revisions with silver-coated implants (15% vs. 42.9%; $p = 0.05$). Hardes et al. reported that patients who initially underwent placement of a silver-coated prosthesis ($n = 51$) had reduced total infection rates [13]. In addition, the infections that did develop required less aggressive treatment compared to the titanium implant control group ($n = 74$). Similar findings were later produced by the same team for endoprostheses involving the proximal tibia in patients with sarcoma [18].

Iodine-supported implants also exemplify strong inhibition of biofilm formation by preventing antibacterial attachment on metal surfaces similar to silver-coated implants [19–21]. There are three clinical reports that suggest the effectiveness of iodine-supported implants for patients with malignant bone or soft-tissue tumor [19–22]. Shira et al. showed that both one-stage ($n = 11$) and two-stage ($n = 15$) exchange arthroplasty with iodine-supported implants were sufficient to treat infection without need for additional surgery in all cases [19]. However, it is noted that one-stage revision surgery was employed for inactive or quiescent infections and two-stage revision surgery was indicated for active infections (defined by "active sinus discharge or abscess formation or C-reactive protein (CRP) > 0.5 mg/dl"). Nevertheless, there is a need for prospective case-control studies or randomized controlled trials investigating the use of iodine-supported implants in one-stage revision arthroplasty.

In conclusion, it is uncertain whether silver- or iodine-modified implants are effective for one-stage revision arthroplasty in infected oncologic endoprosthesis based on limited literature. There are a few studies in circulation that are promising and advocate for their success in one-stage revision surgery for eradicating infection. This investigative team believes that additional larger-scale investigations involving randomized control trials, prospective cohort and case-control studies are warranted.

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QUESTION 2: Is there a role for single-stage exchange arthroplasty for patients with infected oncologic endoprosthesis?

RECOMMENDATION: In principle, despite the lack of sufficient evidence, single-stage exchange arthroplasty can be performed in patients with infected oncologic endoprosthesis if the general requirements to perform a single-stage procedure are fulfilled. However, a single-stage revision without removing the anchorage components is not recommended, since better infection control can be achieved when prostheses were removed rather than salvaged.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

Periprosthetic joint infections (PJIs) are serious complications of reconstruction of defects created by tumor resection. The reconstruction in tumor surgery usually involves the use of modular endoprostheses. Infection following tumor surgery and reconstruction is relatively common, occurring in 8 to 35% of primary implants [1–3]. As limb salvage surgery has gained popularity over the recent years, the number of reconstruction procedures after tumor resection, and the ensuing infections, have increased [1–3].

Despite the high incidence of PJI following oncologic reconstruction, and perhaps because of the relatively low volume of tumor reconstruction cases, there is a universal lack of high-quality studies related to PJI following oncologic reconstructions. The review of current available literature reveals only 12 relevant articles on infections following oncologic reconstructions using tumor endoprostheses. Only six published articles reported the outcomes of single-stage exchange arthroplasty [2,4–8]. However, it must be noted that some of the authors perform a single-stage revision with removal of all exchangeable and polyethylene components with debridement of surrounding soft tissues but without removal of the fixation anchoring components [2,4–8].

As presented by Buchholz et al. in the 1970s, the concept of classic single-stage exchange arthroplasty after infected total joint replacement is the radical debridement and removal of all foreign materials [9]. Morii et al. found that infection control rates were significantly higher when prostheses were removed rather than salvaged in a series of 57 patients with PJI of tumor endoprostheses [4]. According to Hardes et al., an optimal soft tissue condition is imperative for a successful limb salvage procedure [7].

Currently, there is no concrete evidence in the literature to answer the question, "What role, if any, does one-stage exchange arthroplasty play in the management of PJI after oncologic reconstruction using modular endoprostheses?" However, borrowing from the hip and knee adult reconstruction literature, one can state that the rate of infection control is usually better when all prosthetic and foreign material are removed and new implants used either at the same time (one-stage exchange) or at a later date. It is also an agreed principle that the rate of infection control correlates with the extent of debridement and bioburden reduction. Applying these principles, we can state that one-stage exchange arthroplasty does have a role in the management of acute or chronic PJI following oncologic reconstruction. The question that remains and is somewhat unique to oncologic reconstruction is whether all foreign material needs to be removed during one-stage exchange or some parts, such as the anchoring portion of the prosthesis in the bone, can be retained. The tendency would be to advocate that all foreign material should be removed during one-stage exchange. However, removal of the anchoring part of the prosthesis may not be possible or removal of this part may preclude a later reconstruction. Under these circumstances, sub-radical resection arthroplasty may be performed. It is critical, however, that the retained prosthesis is cleaned physi-