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CORR Insights®: Antibacterial and Biocompatible Titanium-Copper Oxide Coating May Be a Potential Strategy to Reduce Periprosthetic Infection: An In Vitro Study

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Where Are We Now?

Despite the recent development and success of standard perioperative protocols to prevent postoperative infection, about 1% to 2% of patients will develop periprosthetic joint infection (PJI) [6, 7], and these numbers have proven difficult to reduce. The predominant opinion in the field maintains that early organism adhesion to the prosthesis, followed by the formation of a more sophisticated biofilm structure [2], causes these PJIs. It follows that technologies that might inhibit organism viability, adhesion, and biofilm formation should successfully prevent and possibly treat PJI. This is exactly what many in the field have been attempting to accomplish [1, 8, 9], experimenting with passive surface treatments that inhibit bacterial adhesion and active surface treatments, which elute bactericidal agents. Researchers have applied antibiotics, organic and inorganic antimicrobial agents, and adhesion-resistant coatings to implants in an attempt to inhibit the formation of a biofilm. While these coatings have demonstrated variable success in the lab, few have come close to making the translation to clinical utilization.

Where Do We Need To Go?

Copper alloys can provide antibacterial properties. In fact, the US Environmental Protection Agency approved hundreds of such alloys for use on touch surfaces, such as door knobs, push plates, and railings. Interestingly, few studies have worked to extend the use of copper alloys to the surfaces of arthroplasty implants [3–5]. In this paper, Narambuena and colleagues have demonstrated as a "proof-of-concept" that coating a titanium alloy with a thin film of titanium-copper oxide does provide antibacterial properties, with minimal osteoblast cell-line toxicity. This combination of efficacy with potential safety is critical to the success of any surface coating potentially used on implants. The

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authors have provided another potential strategy to the armamentarium of solutions that will almost certainly one day lead to biofilm-resistant implants. However, more work needs to be done. The technology that Narambuena and colleagues have demonstrated not only provides for early elution of antibacterial copper concentrations, but also retains a copper alloy surface. Future studies might explore whether its antimicrobial properties are durable enough to prevent late-hematogenous or chronic PJI infections from developing. How would the copper alloy effect early implant stability and eventual bone ingrowth? Could local copper concentrations cause cancer? Alternatively, are there other local adverse reactions due to implants coated with a copper alloy? How difficult or costly would it be to coat all implants with this alloy? Would this coating be a prophylactic strategy for primary implants, or also useful for the treatment of existing PJIs?

How Do We Get There?

Animal models using intramedullary implants are likely the first steps in evaluating copper alloy coating technology. These would reveal any major local toxicity, ingrowth effects, and establish in-vivo antibacterial and antibiofilm efficacy. If such studies demonstrated promise, the first clinical use of such an implant would likely be in the setting of revision for PJI, as the risk-benefit ratio is enhanced in this group of patients.

Finally, there are a number of other considerations: Would the regulatory requirements of such an implant (which might be considered both a device and a drug), or the cost implications of coating implants, be prohibitive in gaining the interest of company to manufacture and market the product? Given the importance of infection prevention, the steps necessary to begin developing biofilm-resistant coatings should be of highest priority. The success of these projects could lead to practical eradication of the most feared complication after total joint arthroplasty.

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