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Preventive measures of biofilm formation on orthopedic implants

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Editorial

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EDITORIAL

Orthopedic implants include joints prostheses, external and internal fractured bone fixation systems and other materials. Several types of alloys are employed for orthopedic implants assembly such as stainless steel, titanium alloy, commercially pure titanium, oxidized zirconium-niobium alloy, and cobalt-chromium-molybdenum alloy. Biofilms formation on the surface of biomaterials can cause intractable implant-related infections. Bacterial adherence and early biofilm formation are influenced by the type of biomaterial used and the physical characteristics of implant surface [1]. The biofilm layer serves as a protectant for the bacterial colonies on the implant making them more resistant and difficult to eradicate when using standard antibiotic treatment [2]. Infection of the implant is devastating sequelae that lead to tremendous cost, morbidity and mortality. The rates of periprosthetic joint infection after primary procedures range from 1 to 9%, depending on the types of arthroplasty, are being less than 1% in hip and shoulder prostheses, about 2% in knee prosthesis, and about 9% in elbow prosthesis. The rates of periprosthetic joint infection reach a significant higher level of about 40% after revision procedures [3]. Mousa found that the most frequent causative pathogens of postoperative implant infections were *Pseudomonas aeruginosa* and *Staphylococcus epidermidis* whereas anaerobic bacteria were isolated from 34% of cases provided that anaerobic routine culture was carried out for all cases with infection [4]. The high rate or recovery of anaerobic organisms in orthopedic infections was most likely related to proper collection, inoculation and cultivation of the specimen under anaerobic condition by bedside [5,6]. The difference in bacterial species that recovered from implant infections in previous studies may be related to the varieties of endemic pathogens in the medical facilities, and the application of adequate microbiological methods for isolation of aerobic and anaerobic mico-organisms. However, *Staphylococcus* species were found to be the most causative agents of implant-related infections [7,8]. *Staphylococcus epidermidis* is part of skin microbiota which has been recognized as the prominent pathogen in orthopaedic implant-related infections. It is particularly capable of adhering to biomaterial surfaces and can form biofilms on many implants [9,10]. The bacterial biofilms can expand to reach thicknesses of 10 cm [11]. Eventually, many physical, chemical, and biological modifications for these implants have been developed to reduce or prevent the incidence of post-operative infection and biofilm formation. Biofilm is initiated by adhesion of bacteria to implant surfaces which is the first step in the pathogenesis of implant related biofilm infections, forming the colonization of biomaterial surfaces. Biofilms are developed by bacterial capability to attach to an orthopedic implant through their surface structures such as flagella, pili, fimbriae, and glycocalyx [12]. The biological behavior, such as osseointegration and its antibacterial activity, essentially depends on both the chemical composition and the morphology of the surface of the orthopedic implant. Surface treatment of medical implants by various physical and chemical techniques are attempted in order to improve their surface properties so as to facilitate bio-integration and prevent bacterial adhesion [13]. To prevent biofilm implant infections, new strategies are being developed, such as anti- infective or infective-resistant materials. Infection-resistant implants are also produced by modifying the biomaterial surface to give anti-adhesive properties, coating the material with antimicrobial substances, combining antiadhesive and antimicrobial effects in the same coating and designing materials able to oppose biofilm formation and support bone repair [14]. Koseki et al. evaluated the early Staphylococcal biofilm

formation by experimental study. They have suggested that bacterial adherence and early biofilm formation are influenced by the type of biomaterial used and the physical characteristics of implant surface. The study revealed that surface properties, such as hydrophobicity or the low surface free energy of cobalt-chromium-molybdenum alloy, may have some influence in inhibiting or delaying the two-dimensional expansion of biofilm on surfaces with a similar degree of smoothness [15]. It was demonstrated that Staphylococcus species had less ability to adhere and create a biofilm layer on titanium in comparison to stainless steel or polymethyl-methacrylate [16]. This effect revealed the ability of titanium to keep the bacteria dispersed on the implant surface making the bacteria more susceptible to antibiotics [17]. This dispersing antimicrobial effect makes titanium alloy to become one of the most popular alloy used in orthopaedic implants [2]. Silver nanoparticle technology is receiving much interest in the field of orthopaedics for its antimicrobial properties. Antimicrobial effects of silver nanoparticles were noticed in trauma implants, tumour prostheses, bone cement, and also when combined with hydroxyapatite coatings [18]. Van der Horst et al. was suggested that systemic ceftriaxone and high concentration of local antibiotics might eradicate peri-implant sepsis. Their experimental study on rats that including combinations of systemic ceftriaxone and local administration of tobramycin or gentamicin showed a significant efficiency in prevention of *Staphylococcus aureus* biofilm formation [19]. Administration of newly developed quadrivalent vaccine against *Staphylococcus aureus* in combination with antibiotics demonstrated a clearance rate up to 87.5% of the bacterial biofilm infections in comparison to 22% in those who were given vaccine alone [20]. The employment of bacteriophages, which are viruses that infect and destroy bacteria, have been recently investigated for their effects to eliminate biofilms in orthopaedic implants. Yilmaz et al. found that bacteriophages enhanced the effects of antibiotics in eliminating orthopaedic implant infections of MRSA and *Pseudomonas aeruginosa* in rat models [21].

REFERENCES

1. Koseki H, et al. Early Staphylococcal Biofilm Formation on Solid Orthopaedic Implant Materials: In Vitro Study. PLoS One. 2014; 9: e107588.
2. Connaughton A, et al. Biofilm Disrupting Technology for Orthopedic Implants: What's on the Horizon? Front Med (Lausanne). 2014; 1: 22.
3. Corvec S, et al. Epidemiology and new developments in the diagnosis of prosthetic joint infection. Int J Artif Organs. 2012; 35: 923-934
4. Mousa HA. Infection following orthopaedic implants and bone surgery. East Mediterr Health J. 2001; 7: 738-743.
5. Mousa HA, Bakr SS, Hamdan TA. Anaerobic osteomyelitis. Eastern Mediterranean Health Journal. 1996; 2: 494-500.
6. Mousa HA. Bone infection. Eastern Mediterranean Health Journal. 2003; 9: 208-214.
7. Zimmerli W and Ochsner PE. Management of infection associated with prosthetic joints. Infection. 2003; 31: 99-108.
8. Chu VH, et al. Staphylococcus aureus bacteremia in patients with prosthetic devices: costs and outcomes. Am J Med. 2005; 118: 1416.
9. Gotz F. Staphylococcus and biofilms. Mol Microbiol. 2002; 43: 1367-1378.
10. Mack D, et al. Microbial interactions in Staphylococcus epidermidis biofilms. Anal Bioanal Chem. 2007; 387: 399-408.
11. Zoubos AB, et al. Orthopedics and biofilm – what do we know? A review. Med Sci Monit. 2012; 18: RA89-RA96.
12. Renner LD and Weibel DB. Physicochemical regulation of biofilm formation. MRS bulletin. 2011; 36: 347-355.
13. Veerachamy S, et al. Bacterial adherence and biofilm formation on medical implants: a review. Proc Inst Mech Eng H. 2014; 228: 1083-1099.
14. Arciola CR, et al. Biofilm-based implant infections in orthopaedics. Adv Exp Med Biol. 2015; 830: 29-46.
15. Koseki H, et al. Early staphylococcal biofilm formation on solid orthopaedic implant materials: in vitro study. PLoS One. 2014; 9: e107588.
16. Gad GFM, et al. In-vitro adhesion of Staphylococcus spp.to certain orthopaedic biomaterials and expression of adhesion genes. J Appl Pharm Sci. 2012; 2:145-149.
17. Lauderdale KJ, et al. Biofilm dispersal of community-associated methicillin-resistant Staphylococcus aureus on Orthopaedic implant material. J Orthop Res. 2010; 28: 55-61.
18. Brennan SA, et al. Silver nanoparticles and their orthopaedic applications. Bone Joint J. 2015; 97-B: 582-589.
19. van der Horst AS, et al. Combined local and systemic antibiotic treatment is effective against experimental Staphylococcus aureus peri-implant biofilm infection. J Orthop Res. 2015; 33: 1320-1326.
20. BradyRA, et al. Resolution of Staphylococcus aureus biofilm infection using vaccination and antibiotic treatment. Infect Immun. 2011; 79: 1797-1803.
21. Yilmaz C, et al. Bacteriophage therapy in implant-related infections: an experimental study. J Bone Joint Surg Am. 2013; 95: 117-125.