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CLINICAL INNOVATIONS

The inhibition effects of zinc-loaded SLM titanium surface on staphylococcus aureus

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Abstract

Implants printed by selective laser melting(SLM) have many clinical advantages due to their customized sizes and shapes. The peri-implantitis was the main cause of implant failure, indicating that implants with antibacterial property may raise the survival rate. Now Zinc was widely used for antibacterial modifications but never has been loaded on SLM titanium for customized implant modification previously, and the effects of zinc-coated surface on S.aureus, the typical pathogen of pre-implantitis, is unknown. The aim of this study was to create a micro porous structure by micro-arc oxidation and successfully load Zinc ions. After operating micro-arc oxidation(MAO) on the SLM titanium surfaces, micro-sized TiO_2 coating was formed and loaded with different concentration of the zinc ions (1mM and 100uM). S.aureus suspension were diluted to about 1×10^7 colony forming units (CFU) /ml, the same amount of S.aureus were loaded on the titanium disks of different groups. The adhesive condition of S.aureus was detected by CFU counting after 24 hours and the proliferating condition of S.aureus was detected by micro-plate reader after 48 hours. To reveal bacteria adherence, after 24 hours' incubation, samples were observed by SEM. The SEM results showed that bacteria were colonized on SLM and MAO groups with a large quantity, while just few separated bacteria were observed on Zinc-loaded group. The early adhesion showed when comparing with SLM control group (55601/cm2), MAO and zinc-loaded groups had lower adhesive bacteria numbers. In experiment groups, 1mM and 100uM zinc-loaded groups had significant reduction on bacterial adhesion when comparing with MAO group.($p<0.05$), and this reduction effect was more remarkable in higher zinc concentration of 1mM group (25031/cm2) than 100um group (31050/cm2). The proliferation assay showed the MAO group and Zinc-loaded group had lower proliferation rate than control group (0.421), and MAO group (0.37) had lower bacterial inhibition activity than zinc-loaded group. High concentration group of Zinc (0.278) have better inhibition effect on proliferation than low concentration group (0.304). We gained a modified anti-bacterial surface by loading zinc ion on micro-arc oxidation SLM titanium. Comparing with SLM and MAO surfaces, this zinc-loaded surface was able to limit S.aureus adhesion and proliferation activity.

Results

The SEM results showed that bacteria were colonized on SLM and MAO groups with a large quantity, while just few separated bacteria were observed on Zinc-loaded group. The early adhesion showed when comparing with SLM control group (55601/cm2), MAO and zinc-loaded groups had lower adhesive bacterial numbers. In experiment groups, 1mM and 100uM zinc-loaded groups had significant reduction on bacterial adhesion when comparing with MAO group.($p<0.05$), and this reduction effect was more remarkable in higher zinc concentration of 1mM group (25031/cm2) than 100um group (31050/cm2). The proliferation assay showed the MAO group and Zinc-loaded group had lower proliferation rate than control group (0.421), and MAO group (0.37) had lower bacterial inhibition activity than zinc-loaded group. High concentration group of Zinc (0.278) have better inhibition effect on proliferation than low concentration group (0.304).

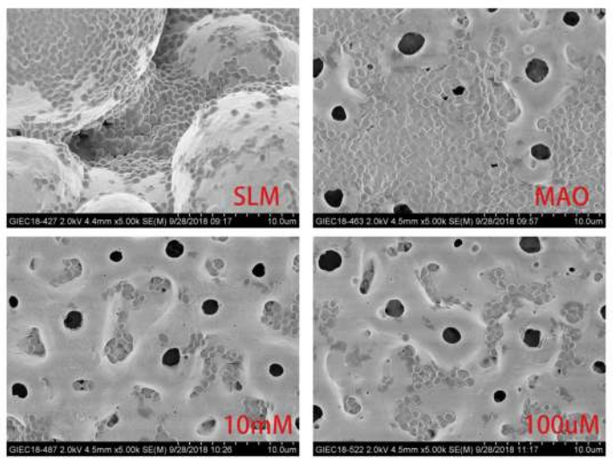

Figure 1
SEM of S.aureus adheresion in four groups.
（Scale bar=10um）

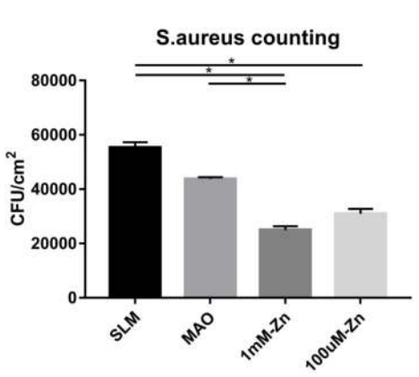

Figure 2. The adheresion of S.aureus on different titanium surface after 24h.(/cm2)

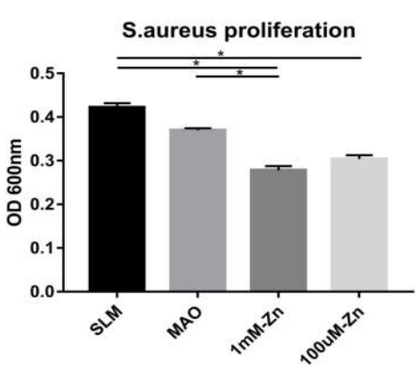

Figure 3. The proliferation of S.aureus on different titanium surface after 48h. (OD value)

Background and Aim

Implants printed by selective laser melting have many clinical advantages due to their customized sizes and shapes. The peri-implantitis was the main cause of implant failure,indicating that implants with antibacterial property may raise the survival rate. Now Zinc was widely used for antibacterial modifications but never has been loaded on SLM titanium for customized implant modification previously,and the effects of zinc-coated surface on S.aureus,the typical pathogen of implantitis, is unknown.

The aim of this study was to create a micro porous structure by micro-arc oxidation and successfully load Zinc ions. We predicted that Zinc-loaded titanium surfaces may inhibit S.aureus adhesion and proliferation, and the inhibition effects were enhanced with higher Zinc ion concentration.

Conclusion

We gained a modified anti-bacterial surface by loading zinc ion on micro-arc oxidation SLM titanium. Comparing with SLM and MAO surfaces, this zinc-loaded surface was able to limit S.aureus adhesion and proliferation activity and the limit effect was enhanced by increasing the zinc concentration. This Zinc-loaded modification technique enhanced the antibacteria ability of SLM implants, which may help to produce a shape customized implant with better biological properties.

Methods and Materials

The SLM titanium plates were designed by SolidWorks and manufactured by an SLM machine, after operating MAO on the SLM titanium surfaces, micro-sized TiO_2 coating was formed and loaded with different concentration of the zinc ions (1mM and 100uM). S.aureus suspension were diluted to about 1×10^7 CFU /ml, the same amount of S.aureus were loaded on the titanium disks of different groups. The adhesive condition of S.aureus was detected by CFU counting after 24 hours and the proliferating condition of S.aureus was detected by micro-plate reader after 48 hours. To reveal bacteria adherence, after 24 hours' incubation, samples were observed by SEM.

References

Buser D, Sennerby L, Bruyn HD. Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions. Periodontol 2000. 2017;73(1):7-21

Al-Johany SS, Al Amri MD, Alsaeed S, Alalola B. Dental Implant Length and Diameter: A Proposed Classification Scheme. J Prosthodont. 2017;26(3):252-260.

Chen JY, Zhang ZZ, Chen XS, Zhang CY, Zhang G, Xu ZW. Design and manufacture of customized dental implants by using reverse engineering and selective laser melting technology. J Prosthet Dent. 2014;112(5):1088-1095.

Figliuzzi M, Mangano F, Mangano C. A novel root analogue dental implant using CT scan and CAD/CAM: selective laser melting technology. Int J Oral Surg. 2012;41(7):858.-862

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