Promoted Osteoconductivity of Titanium with Chessboard-patterned Surface Nano Topography Fabricated by Femtosecond Laser Irradiation

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Introduction: The next generation surface modification on medical and dental implants is coatings of tissue or stem cells on them.[1] To promote cellular attachment and formation of tissues on materials, the control of patterned surface topography is necessary, as the surface topography of a material governs its biocompatibility. For example, in the case of titanium (Ti), nanometer scale topographical features influence cell spreading and micrometer scale topography promotes stem cell differentiation *in vitro*.[2-4] To clarify the role of patterned nano topographies on the biocompatibility and osteoconductivity of metal implant, we investigated the adhesion and calcification of mouse preosteoblast (MC3T3-E1) to Ti surfaces with three surface patterned nano-ripples topography fabricated by single-shot femtosecond laser irradiation.

Methods: Ti (grade 2) was mirror-polished (mTi) and the surface was scanned with a femtosecond laser. As a result, Ti surfaces with three patterned periodic nano-ripples were fabricated: full surface pattern (fTi), half surface pattern (hTi), and chessboard pattern (cTi). The surface morphology and chemical state of the Ti surfaces before and after laser irradiation were characterized using SEM and XPS, respectively. The cell extension morphology after 6 h incubation was visualized by fluorescent staining. The osteogenic differentiation was induced with induction medium.[2] The calcification of MC3T3-E1 cultured on Ti substrates was evaluated with alizarin red S staining.

Results: The surface morphologies of Ti specimens with and without femtosecond laser processing were characterized by SEM (Fig. 1). A clear nano-ripples with 600 nm periodic interval was observed. In addition, there was no significant difference of surface compositions and chemical states among Ti specimens with and without laser irradiation.

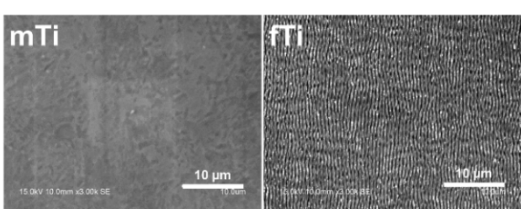

Fig. 1. Surface morphologies of Ti plates. SEM images of Ti with and without surface topography.

Cells cultured on surface pattern with nano-ripples were highly aligned (not shown here). Larger extracellular calcified deposition areas were observed by fTi and cTi compared with that observed by mTi and hTi, indicating that the periodic nano-ripples topography promoted calcification *in vitro*. Interestingly, similar calcified deposition areas were obtained by mTi and hTi, and also fTi and cTi, respectively.

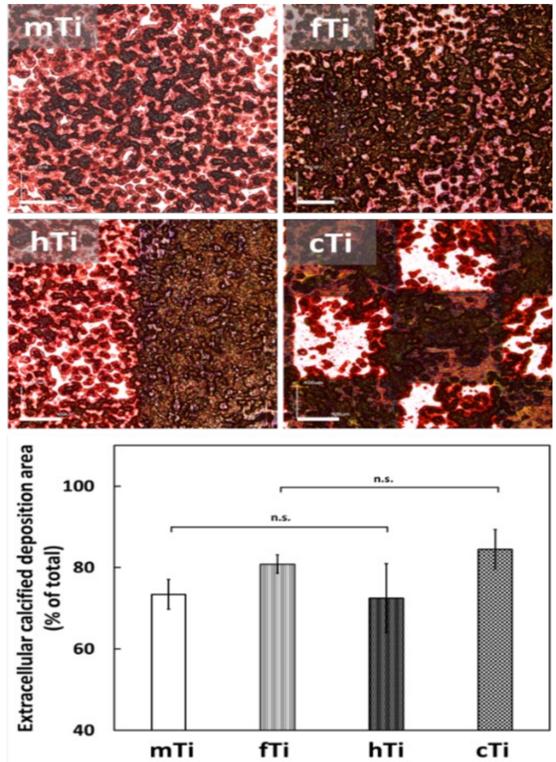

Fig. 2. Calcification of MC3T3-E1 on Ti with different patterned nano-topographies after alizarin red s staining. Results were statistical analyzed. n.s., non-significant.

Conclusions: Ti with a chessboard-patterned surface with nano topography was fabricated by femtosecond laser irradiation. A high orientated cellular morphology showed by cells on Ti surface with patterned topography. Notably, compared with mirror surface, cells cultured on the periodic nano-ripples topography showed a larger calcified area, which indicated superior osteoconductivity. This chessboard-patterned surface nano topography fabricated by femtosecond laser is expected to provide a basis for designing novel biomaterial–cell interfaces to promote the osteoconductivity of medical and dental implants.

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