EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF MESHED TITANIUM PLATES FOR REINFORCEMENT TRICALCIUM PHOSPHATE BONE IMPLANTS

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Summary In this study, experimental investigations on mechanical properties of designed meshed titanium plate implants with excellent 3-dimensional flexibility were executed for bone graft applications. Sample meshed titanium plates were manufactured through the wire-cut discharge processing having different fundamental design parameters like thicknesses of titanium plate/mesh line and the curvature of the mesh patterns and mechanical properties of the meshed titanium plates were examined.

INTRODUCTION

Tailor-made tricalcium phosphate bone implants used in clinical trial were fabricated using a 3D ink-jet printer. Because the Tailor-made tricalcium phosphate bone implants have very poor mechanical properties such as stiffness & fracture strength, reinforcement are needed for many implant cases under loading. On the other hand, the present titanium plates for implants have the problems like heavy, mismatch-elasticity with human bones and excessive-strength problems. In this study, meshed titanium plates with higher 3-demensional flexibility were interested to solve such kind of problems. Experimental assessment of mechanical properties on the meshed titanium plate structure for reinforcement of tricalcium phosphate was executed. The fundamental mesh patterns were designed using three dimensional CAD tool from the light-weight and higher flexibility view points.
Based on the designed mesh patterns, the specimens of the meshed titanium plates with different thickness were manufactured through the wire-cut discharge processing. The mechanical properties of the meshed titanium plates like density and the bending stiffness were experimentally evaluated through three-point bending tests and tensile tests. Experimental results showed that mechanical properties of meshed titanium plates were close to the human bones. More detail studies on the other mechanical properties like compress, torsion and durability etc. are needed and should be executed in future study.

ULTRA-FLEX MESHED TATINIUM PLATES WITH DIFFERENT MESH PATTERNS

Mesh patterns for ultra-flex meshed titanium plates are developed under the following conceptions:

(1) Single one basic pattern shape architectonics which leads to easier forming and lower costs
(2) Having easily controllable elastic modulus, bending stiffness etc. by changing the design parameters
(3) Stress-concentration avoided structures resulting higher strength and longer operating life
(4) Ensured optional spaces for screw fixing

Fig.1 shows the designed basic mesh patterns for meshed titanium plates with two kinds of mesh line width at 0.8mm and 1.2mm for experimental investigations.

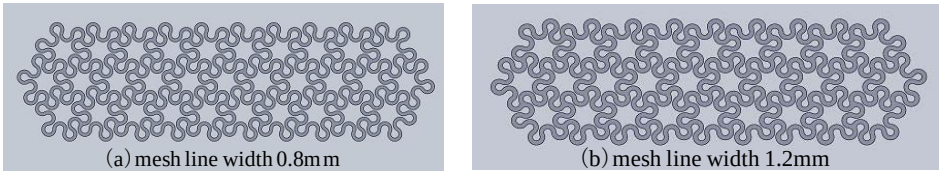


Fig.1 Designed mesh patterns with different mesh line widths

EXPERIMENTAL EVALUATION FOR MECHANICAL PROPERTY OF MESHED TITANIUM PLATES

Ultra-flex meshed titanium plates were 3-dementionally formed using ESF (Electrical Spark Forming) method and the experimental machine is shown in Table 1. Titanium plates with two kinds of thickness (0.3mm, 0.8mm) and 14 layers for each thickness were introduced with combined two mesh line widths as mentioned above and formed specimen images are shown in Fig.2.

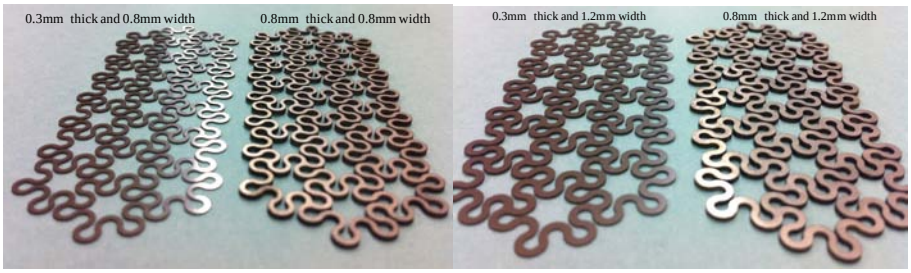
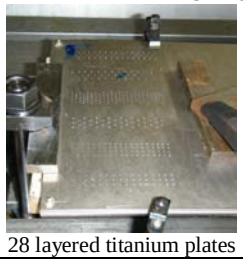


Fig.2 Formed meshed titanium plate specimens through ESF method

Table 1 ESF machine and titanium plates for meshing formation

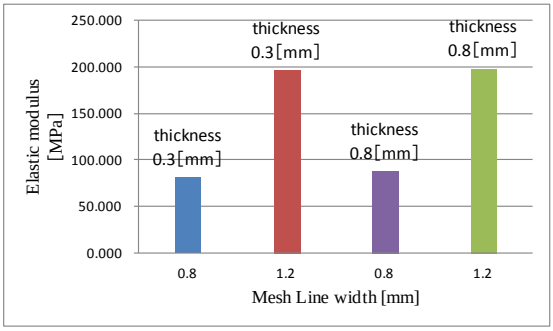
FUNUC ROBOCUT α-OC Machine for ESF	
 ESF machine  28 layered titanium plates	No-load Voltage: 1[V] Process Voltage: 6[V] ON/OFF time: 10/16[μs] Serve Voltage: 30[V] Power Control: 6; OFF Time Control: 2 AC/DC Process: 1; Process Liquid: 10 Wire Tensile Force: 1700[g] Wire Speed: 10[mm/min] Sending Speed: 6.2[mm/min] Resistance Ratio×10^4 : 5.0[Ωcm]

Tensile tests and three-point bending tests shown in Fig.3 were carried out for elastic modules and bending stiffness examinations. The obtained results of elastic modulus and bending stiffness are shown in Fig.4.


tensile test

3-point bending test

Fig.3 Tensile tests and three-point bending tests



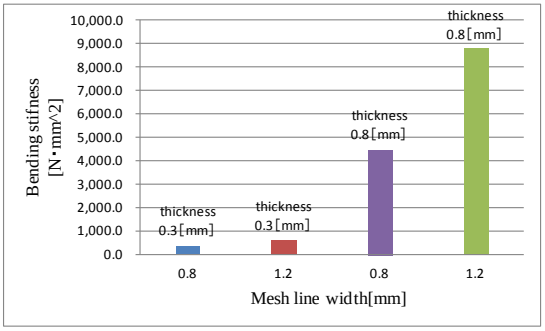


Fig.4 Experimental results for meshed titanium plates

CONCLUSIONS

(1) The density of the meshed titanium plates are reduced compared with the unmeshed titanium plates. Any desired mass property to near the human bones' densities can be closely approached by changing the basic mesh pattern, plate thickness and mesh line widths of the meshed titanium plates.

(2) Compared to the unmeshed titanium plates, the bending stiffness of the meshed titanium plates was reduced, and become very lower compared to the elastic modulus of human cortical bones. More detail evaluations on the relationship between these mechanical properties (density, bending elastic modulus) of the meshed titanium plates and each design parameters such as basic mesh pattern, plate thickness, mesh line width and spline curvatures etc. need to be done to approach different cases of human bones.

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