Customized Scaffold Fabrication with Solid Free Form Technique

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Abstract - **Design and fabrication of customized scaffolds requires a control in the internal and external geometrical features down to 100 to 1000 µm. Therefore, fabrication of scaffolds especially made of bioceramic is a challenging problem in the fabrication. In this work, solid free form technique was used to fabricate the customized scaffolds.**

Keywords – **Scaffold, Bioceramics, Solid Free Form Technique, Customized Scaffolds.**

I. INTRODUCTION

Since biocompatible surfaces are needed for new bone regeneration, bone cannot deposit or filled by jump over large empty space during bone healing process. Therefore, the dimensions of the cavity that should filled by bone during the healing becomes very important. The cavity may be generally filled by graft materials in the form of granules or scaffolds in medical operations. Scaffolds fabricated considered design criteria have considerable advantages over granules.

The primary purposes in scaffolds design in tissue engineering are to maximize nutrient diffusion, interstitial fluid and blood flow, to control cell growth and function, to manipulate tissue differentiation, and to optimize scaffold mechanical function and regenerated tissue mechanical properties. So in the design of an ideal scaffold that functions to insure the primary purposes, a control in the architectural features down to 100 to 1000µm becomes crucial.

Solid free form fabrication technique is one of the very attractive methods in advanced ceramic processing enabling to fabricate ceramic components with complex internal and external architecture designed in CAD environment [1-3].

The purpose of this study is to develop a procedure to design customized scaffolds with controlled internal and external geometries to apply on healing for particular patient. A patient with a hemi facial microsomi was chosen as the case study. In the first, the CT data of the patients was used to build CAD models of their defected bone structures. In the second, appropriate scaffolds was designed in the CAD environment. In the last, these scaffolds were fabricated from calcium phosphate bioceramics with solid free form technique. Fabricated scaffolds were tested by assembling on the 3D bone model of patient fabricated with rapid prototyping method.

II. METHODOLOGY

A schematic of scaffold fabrication methods is outlined in Fig. 1. Five steps are involved: (1) The CT data of the respected patient was needed to design scaffold in CAD environment, (2) design of CAD model scaffold and its corresponding mold; (3) building of the mold with solid ink-jet printing; (4) casting of ceramic suspension into mold and curing (5) dissolution of the mold in EtOH; (6) Pirolizing of the binder and following sintering process.

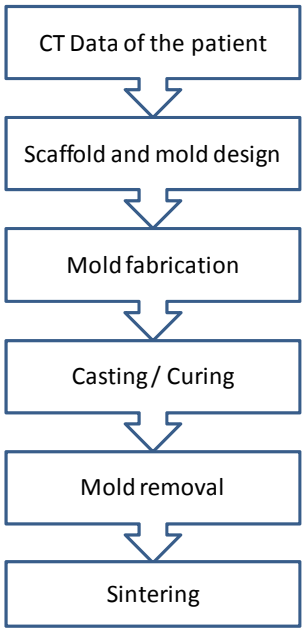

Fig. 1. Schematic chart of the fabrication of customized scaffold via indirect solid freeform procedure.

III. RESULTS

Figure 2 shows the patient who has hemifacial microsomi and its jaw bone fabricated via rapid prototyping based on his CT data. The reason of the distortion on his face is the asymmetry in his jaw.

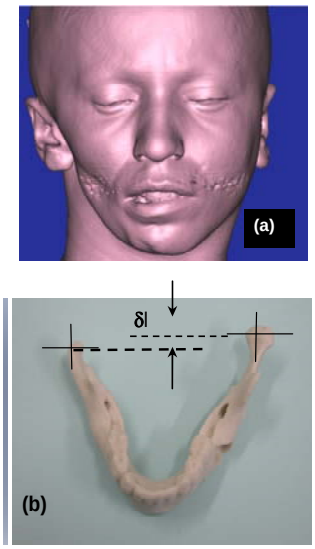

Fig. 2. (a) A typical appearance of the patient having hamifacial microsomi: (b) 3D Model fabricated via rapid prototyping (δl: the missing distance causing the shortness of the bone at one side consequently the distortion on the face)

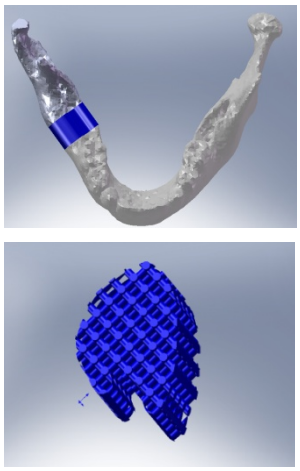

Fig. 3. (a) The jaw bone of the patient with a missing geometry to insure the symmetry like in a healthy jaw bone; (b) CAD modeled a scaffold needed for the treatment.

Figure 3 shows the CAD model of the scaffold needed to treat this patient.

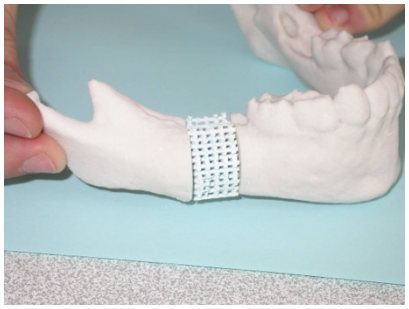

Fig. 4. Fabricated scaffold

Figure 4 shows the fabricated scaffold via the procedures given in Figure 1.

IV. DISCUSION

The procedure developed in this study based on solid freeform technique can successfully be applied to fabricate customized scaffolds. Thus, internal and external architecture convenient to the patient physiological geometries can be insured with a better accuracy than the treatment using granule based space filling materials.

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REFERENCES

[1] D. M. Liu, 1997. Fabrication of hydroxyapatite ceramic with controlled porosity, Journal of Materials Science, 8, 227-232.

[2] Cheng Yu Lin, N. Kikuchi, S. J. Hollister, 2004. A novel method for biomaterial scaffold internal architecture design to match bone elastic properties with desired porosity, Jounal of Biomechanics 37, 623-636.

[3] T. M. G. Chu, J. W. Halloran, S. J. Hollister, S. E. Feinberg, 2001. Hydroxyapatite implants with designed internal architecture, Journal of materials science, 12, 471-478.

[4] S.J. Hollister, R.D. Maddox, J.M. Taboas, 2002. Optimal design and fabrication of scaffolds to mimic tissue properties and satisfy biological constraints, Biomaterials 23, 4095-4103.