3D and 4D based applications in orthopaedics has not been pioneered

Orthopaedic 3D and 4D application

Orthopaedic 3D is driving major innovations in many areas, such as manufacturing, engineering, art, education and medicine (1). Especially, the orthopaedic field is greatly becoming interested in this technology with the ability to create solutions specific tailored to the patient. From the creation of 3D models that help surgeons plan operations to the fabrication of patient-specific titanium implants, 3D printing is already changing traditional musculoskeletal industry (2).

Musculoskeletal imaging and modeling procedures for solid organ 3D printing

Musculoskeletal images from hospitals consist of a 2D dataset and provide human body information as a slice, but the human body has 3D morphology. If we should simulate this 3D morphology, we might be able to obtain more information about the body as well as contribute in the clinical environment to both treatment and surgical outcomes. The objective for solid organ 3D printing is to generate 3D musculoskeletal data from 2D images. Although doctors expend a great deal of time and effort in this process, the resultant 3D data are different in each institute. This procedure, therefore, provides standard, easy, and accurate 3D data for solid organ 3D printing.

Personalized artificial joint implant 3D model design

The goal of musculoskeletal 3D printing in the orthopedic field is to replace the normal biomedical functions of missing bones. It is necessary to output and apply the artificial joint replacement as the presently feasible intermediate step. This standard is to apply the output to the operation by individually optimizing the shape of the implants of the lost joint based on the rotation data of the positional rotation of the mirrored motion in the normal joint. The use of CAD based on medical image is essential, and a designing technique that minimizes the modeling error is needed. Therefore, definition of optimal design elements for orthopaedic 3D printing and development of technical standards based on the analysis of musculoskeletal elements of artificial joint output are required for analysis of patient's 3D model data, artificial joint template and other technical factors (3). In order to maximize the patient and physician's satisfaction with implant surgery, the accuracy of artificial prosthesis placement is important, and surgical guide model design techniques are required to minimize errors.

In vivo evaluation of 3D printed polymeric scaffolds in bone defects

The *in vivo* experimentation required for the biological assessment of 3D bioprinted polymeric scaffolds intended for use in bone regeneration. 3D bioprinted scaffolds are gaining increased attention, and animal experiments are fundamental in assessing their performance prior to potential clinical use (3). This international standard can be applied to the preclinical assessment such as animal experiments to evaluate the *in vivo* performance of 3D bioprinted porous polymeric scaffolds.

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