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The Reconstruction of Paprosky by the Three-Dimensional Method

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Description

Pelvic ring injury is growing in incidence among the general population, and severe pelvic fractures are associated with high mortality in elderly people and high morbidity in young people. Surgical techniques are used to rebuild the stabilization of an injured pelvis using a plate/screw fixation structure for pelvic bone reduction. Pelvic symmetry is taken for granted as a surgical rule when creating a patient-specific repair model for the injured pelvic bone in terms of the contralateral geometric shape. Due to the geometric and anatomic complexity of the pelvis, morphological symmetry might be clinically beneficial in the design and 3D-printing fabrication of a customized fixation plate. Furthermore, several studies employed the concept of morphological symmetry of the pelvic ring to evaluate the reduction grade of injured pelvic bones, such as Sagi's inlet/outlet ratio10 and Lefaivre's cross measurement. These two evaluations have higher intra- and interobserver reliability than Matta's scoring system, which is commonly used for the assessment of morphological features of hip bone and joints after surgery.

3D Digital Pelvic Ring Model

CT images of 159 pelvises were imported into Mimics (Materialize, Leuven, Belgium) software using DICOM files. Image segmentation was performed using the bone automatically segmentation tool and split mask tool on Mimics. Mimics then reconstructed 3D models of pelvises and saved them into STL file format for export into Geomagic Studio software (3D Systems, Rock Hill, SC, USA) for further smoothing those models for digital analysis. In this study, the pelvic ring model referred to two hip bones without covering the sacrum model since the morphological analysis targeted the symmetrical features of the alignment of hip bones.

Total Hip Arthroplasty (THA) has been one of the most successful surgeries in the 20th century and has been used for easing pain, correcting deformity, and improving hip joint function. The management of severe acetabular bone defects in primary or revision THA is challenging and the ideal reconstruction of the defect represents one of the critical factors for a successful THA. The basic principles of acetabular defect reconstruction include restoring Hip Center of Rotation (HCOR) and acetabular ring integrity, preserving acetabular bone stock, and establishing normal biomechanics of the hip, which could accomplish immediate and long-term stability of acetabular components.

Implantation Surgery

First, CT scans of pelvis were obtained to establish the 3D reconstruction model of 3D printed porous augment. Then, a nylon pelvis model was printed to simulate operation with the surgeons. At this time, the augment was designed and modified according to the surgeon's suggestions and the 3D printing principles. Eighteen patients with paprosky type III acetabula defects receiving reconstructive surgery by 3D printed porous augments were included in current study. Their data, including general information, intra-operative findings, imaging results, functional scores, and complications were retrospectively analyzed.

Traditionally, major acetabular defects have been reconstructed by impaction bone grafting, metal augments, and cup/cage constructs. Different implant designs and sizes are available for THA acetabula revisions, which include mainly reinforcement devices (roof-reinforcement rings and anti-protrusio cages), custom-made triflanged acetabular components, jumbo cups, and Tantalum Metal (TM) systems. Each designs and methods has various success rates as well as various complication rates. Recently, given the excellent biocompatibility and biomechanical properties of TM, TM augments and cups are most commonly employed and they yielded good clinical mid-term outcomes. Since TM augments are mass-produced in standard sizes and shapes, they do not always fit in with the morphology of acetabular bone defects, and reaming the residual bone stock of acetabular defects is required in most cases. Therefore, individualized augments are needed in these cases to better reconstruct the acetabular bone defects.

The HHS was often used to evaluate hip function in adult population preoperatively and postoperatively. The HHS score system mainly includes four aspects as pain, function, absence of deformity, and range of motion. The score standard had a maximum of 100 points (best possible outcome). A total score <70 is considered a poor score, 70–80 fair, 80–90 is good, and 90–100 excellent.

All the statistical analyses were performed using SPSS for Windows (version 18.0, SPSS Inc., Chicago, IL, USA). Gender, type of paprosky acetabular bone defect, and radiological loosening or radiolucent lines of the acetabula components and augments were of a categorical nature. Age, Body Mass Index (BMI), preoperative laboratory examination, LLD, HCOR vertical position, and HHS were numerical data. Rates were compared by using chi-squared test while numerical data were compared by employing paired sample t test (normal distribution and homoscedasticity) or Wilcoxon rank test. A P value less than 0.05 was considered statistically significant.

The influence of porosity, pore size, and pore shape on the biological behaviors of porous Ti6Al4V prosthesis has been previously investigated. Heinl et al. demonstrated that three-dimensional structures with a mean interconnected porosity of 61.3% and pore size of 450 μm were suitable for tissue ingrowth and vascularization.

They also demonstrated that the cubic design had the lowest elastic modulus and could lead to the fastest new bone formation. Another study investigated the influence of the pore shape on mechanical properties and showed that the cubic scaffold was conductive to Osseo integration and tissue integration. Considering that the surface of severely defective acetabula bone was not entirely chancellors, the defect surface of many patients receiving revision would be partially cortical zed due to long-term wear. Therefore, the pore parameters in the present study represented a compromise between mechanical and biological properties, that is, a cubic-shaped lattice structure, a pore size of 400 µm, a strut size of 200 µm, and a porosity of 60%.