

## COMPUTER AIDED PRE-OPERATIVE PLANNING OF FRACTURE REDUCTION AND DEFORMITY CORRECTION IN TIBIA WITH HEXAPOD EXTERNAL FIXATOR

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### INTRODUCTION

When the Ilizarov external fixator is used for fracture reduction and deformity correction, the planning for correction of 3-D multiple deformities is difficult due to the lack of information on required joint rotations and translations in order to correct the deformities [1, 2]. In addition, if the rotational axis is not placed exactly with respect to axis of the deformity, the rotation may generate the unwanted translational shift at the fracture site [1, 2]. Hexapod external fixator, which is also known as the Taylor spatial frame, has an advantage to kinematically calculate the necessary translations of the telescopic struts in order to correct any 3-D deformities at the fracture site. The purpose of this study was to perform computer aided pre-operative planning of fracture reduction and deformity correction in tibia with single or double hexapod fixator system and to compare the results with the clinical ones.

### METHODS

Our procedure consisted of four steps (Figure 1). The 3-mm CT data of a tibia in pseudoachondro-plasia was digitized and transformed to the graphic model using the custom made program. Radiographic examination was performed to check the AP and lateral deformities at the proximal and distal bone segments before and after the deformity correction. We used conventional hexapod fixators or modified ones to a double hexapod system, which consists of three rings of 170 mm diameter and twelve telescopic struts of 90 mm length. We developed the CAD model of the fixator system using the CAD software, Solid Works®(Solidworks, USA). The necessary positions of six or twelve telescopic struts to correct given deformities were calculated using the program developed by the authors based on the forward kinematics of parallel manipulators [2-4]. From the calculated values of the telescopic struts, the computer graphic simulation of correction process was performed by simultaneous change of the struts based on simulation software, RecurDyn™ (FunctionBay, Inc, Korea). Finally, the results of planning were compared with clinical outcomes to evaluate the developed analysis and simulation techniques.

### RESULTS AND DISCUSSION

A fracture case with 15° of deformity in the AP plane and 15° of deformity in the lateral plane and a deformity correction case with 49° of proximal and 39° of distal deformities in the AP plane and 12° of proximal and 9° of distal deformities in the capital plane were corrected by the pre-operative planning. The graphic simulation could visualize the fracture reduction and deformity correction process by adjusting the telescopic struts simultaneously and showed possible clinical problems such as ring collision and excessive soft tissue distractions (Figure 2).

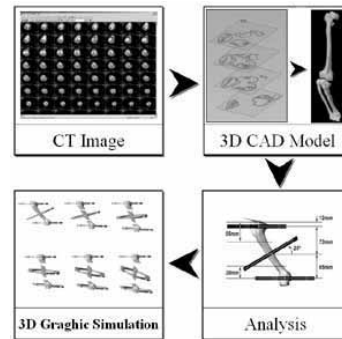


Figure 1: Procedure of computer aided pre-operative planning with double hexapod external fixator system

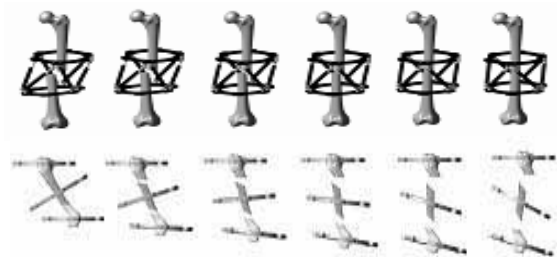


Figure 2: Graphic simulation of sequential adjustment for the fracture reduction (a) and the deformity correction (b)

Pre-op planning for correction of complex multiple deformities is often unavoidable and very difficult. The main reason for this difficulty is the six deformity parameters, which are three translations and three rotations, are coupled. The computer modeling and simulation techniques presented in this study could successfully perform the pre-op planning of tibia with hexapod fixators based on the kinematics analysis. The results showed that the computer simulation could visualize the fracture reduction and deformity correction procedure and check any surgical problems. This results support the feasibility of the computer-aided planning of fracture reduction and deformity correction.

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