INTRODUCTION

An oblique, single-cut osteotomy can be used to correct multi-planar deformities of the long bones. A single cut is made such that rotation in the plane of the cut corrects all aspects of the deformity. Although the theory of the oblique plane is well established [1], determining the orientation of the plane can be cumbersome. Several efforts have been made to facilitate oblique osteotomy planning. Mathematical formulas were developed to determine the orientation of the oblique plane from radiographic measurements of the deformity [2], as an extension of these formulas, look-up tables were created to facilitate the mathematical calculations [3]. Quite recently, a mechanical device was constructed to determine the orientation of the oblique plane [4]. Despite these efforts, oblique osteotomy planning remains a clinical challenge.

A computer-based planning tool is proposed as an improved means to assist surgeons in planning an oblique osteotomy. The objectives of this tool are to utilize the advantages of computer graphics to provide visualization of the oblique plane and to simulate the outcome of the osteotomy procedure. The surgical plan could then be readily integrated with image-guided surgical techniques in order to intraoperatively guide the osteotomy.

METHODS

Commercial computer-graphics animation software (Maya 6 Complete, Alias/Wavefront, Toronto Canada) was used to develop a number of software tools that were used to plan an oblique osteotomy. The oblique osteotomy was planned in four steps:

1) 3D surface models of the deformed bone and its normal counterpart were manually aligned in order to visualize the deformity in three dimensions [Fig. 1(a)].
2) A graphical plane was used to define the anatomical position of the osteotomy site [Fig. 1(b)].
3) The surface model of the deformed bone was separated along the osteotomy plane to create two independent models; and
4) A graphical user interface permitted the user to rotate the osteotomized bone-models in three dimensions to best correct the deformity. (The normal bone-model was used as a target for deformity correction.)

RESULTS

Two malunited-femur examples are presented here to demonstrate the use of our computer-assisted, oblique-osteotomy planner in a clinical scenario. Bone-models were obtained by CT-scanning foam models of bones (Pacific Research laboratories, Vashon WA).

The orientation of the oblique-osteotomy plane is depicted in Fig. 2 for malunited femurs with:

- Forty-five-degree medial rotation and 30-degree angulation of the distal third {Fig. 2(a)}.
- Midshaft malunion with 45-degree anteverision medially angulated and malrotated {Fig. 2(b)}.

DISCUSSION

To our knowledge, this is the first attempt to integrate the use of computers with oblique osteotomy planning. This computer-assisted technique can improve the accuracy of oblique osteotomy planning because it eliminates errors associated with traditional characterization of the deformity in terms of radiographic measurements. This is in contrast to existing planning methods involving mathematical formulas [3], look-up tables [4] and a mechanical device [2]. The accuracy of the current implementation could be further enhanced by using automated registration techniques to determine the ideal transformation needed to correct the deformity.

For the example in Fig. 2(a), the oblique plane that completely corrects the deformity is not clinically feasible since it would result in an extremely oblique and long osteotomy plane. Our computer-assisted implementation allows surgeons to interactively experiment with the outcome of the oblique procedure to produce an optimal plan. In this case, the surgeon could design an operative plan to give both feasible geometry and sufficient deformity correction. It is difficult to do this with the existing approaches, as the relationship between the parameters used to represent the deformity and the orientation of the osteotomy plane is not straightforward.

REFERENCES


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