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Pre-operative Visualization of Remaining Bone after Robotic Cutting

THINK Surgical, INC

Pre-operative Visualization of Remaining Bone after Robotic Cutting

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Introduction

A robotic surgical system for total joint arthroplasty generally includes: a pre-operative planning software program to generate a surgical plan having a desired position for an implant relative to a bone; and a surgical robot to prepare the patient's bone to receive the implant as planned. One such robotic surgical system is the TSOLUTION ONE® Surgical System manufactured by THINK Surgical, Inc., which assists surgeons in total hip (THA) and total knee arthroplasty (TKA). During pre-operative planning, a surgeon may position a model of an implant on a 3-D model of the bone to designate the best fit, fill, or alignment for the final implants on the bone. A cut-file having instructions for the robot to mill the bone may be generated based on the geometry of the implant model, where the position of the cut-file is designated on the bone model when the user designates the best position for the implant. In the operating room, the surgical plan is registered to the bone, which maps the cut-file to the position of the bone such that the surgical robot can accurately cut the bone according to the plan.

In certain situations, it may be necessary for the surgeon to remove small pieces of bone that the robot did not cut. For example, FIG. 1 shows a prepared tibia having a resurfaced tibial plateau with some remaining bone around the edge. This remaining bone may be uncut because: 1) the cutting instructions in the cut-file do not extend beyond the implant geometry by design; and 2) the planned position for the implant did not intersect with those portions of the bone. Currently, these uncut portions of the bone are only revealed after the robot has finished cutting the bone. There may be several advantages to provide the surgeon with this information prior to the procedure to prepare accordingly. The following is a method that allows a surgeon to pre-operatively visualize the bone that may remain after robotic cutting.

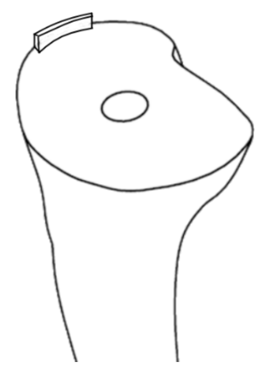

FIG. 1

Methods

In the 3-D pre-operative planning environment, it is currently common to visualize an idealized definition of the cutting surfaces once the plan is complete. However, this is only an estimate and may not include the uncut bone that remains after robotic cutting. A new method is proposed which more accurately displays the bone required for management (e.g., removal) after robotic cutting to provide better information for the surgeon pre-operatively. The method requires a 3-D bone model, a 3-D implant model or a portion thereof, and a volume of bone to be removed (referred to as a cut volume) as defined by the cut-file. In general, the method includes the planning of an implant model relative to a bone model, splitting the bone model at the planar definitions between the implant model and the bone model, and then subtracting the cut volume from the planar removal elements. This creates a set of volumes that define the bony ridges that will be left after robotic cutting. These are then displayed to the user where different colors may be used to display the main bone model with the ideal bone preparation removed.

Example:

The surgeon in a pre-operative planning software program positions an implant model relative to a bone model to designate the best alignment for the final implant on the bone. FIG. 2 depicts a 3-D model of a tibial implant in a planned position relative to a 3-D bone model (on the left), and a cut volume to mill the bone to receive the tibial implant (on the right). Next, the 3-D bone model is split at the ideal plane definition. Here, the ideal plane definition is the plane on which the base plate of the implant will be implanted. In other words, the ideal plane definition is where the inferior planar surface of the implant base plate intersects with the 3-D bone model. FIG. 3 depicts the 3-D bone model split at the ideal plane definition, with the bone distal to the ideal plane definition shown on the left, and the bone proximal to the ideal plane definition shown on the right. The cut volume is then subtracted from the volume of bone proximal to the ideal plane to obtain a set of bone volumes that will remain after robotic cutting. A visualization of the remaining bone is shown in FIG. 4. This allows the surgeon to visualize the bone that will remain after robotic cutting to prepare accordingly. The more accurate representation of the cut may also help the surgeon plan the procedure to achieve the desired planar cuts of the bone.

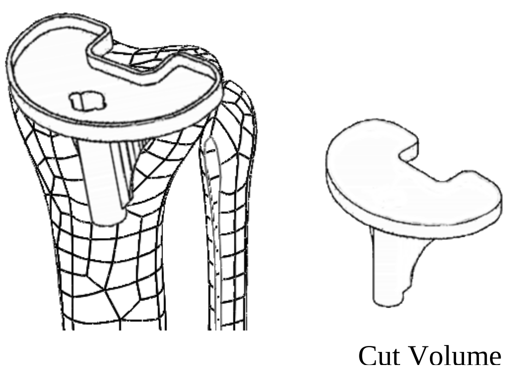

FIG. 2

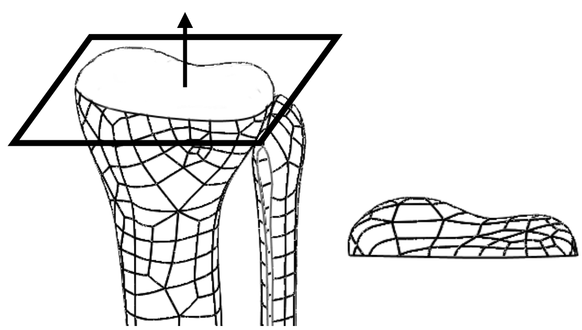

FIG. 3

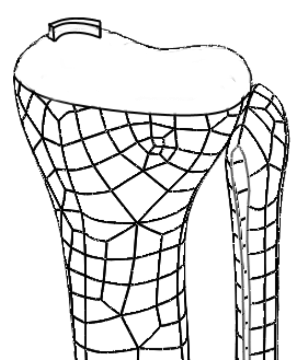

FIG. 4