SOURCES OF ERROR IN TOTAL KNEE REPLACEMENT

THE USE OF STANDARD FIXATION PINS versus THE MATRIX PRECISION PINS FOR PLACEMENT OF CUTTING BLOCKS

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Computer navigation utilizes a PC computer combined with light-emitting diodes and a camera. This system enables real-time analysis of each step during knee replacement. Computer navigation has shown that error can occur during each step of a knee replacement:

- placement of extramedullary and intramedullary guides
- pinning cutting blocks into position
- moving cutting blocks
- performing bone cuts
- placement of trials
- final placement of implants.

PURPOSE OF THIS STUDY

The purpose of this study was to use computer navigation to quantify the error inherent in placing cutting blocks during a knee replacement on the femoral and the tibial side.

During knee replacement intramedullary and extramedullary guides are used to place cutting blocks. Cutting blocks are then fixed to the bone using 1/8th inch drill bits. Most cutting blocks allow for repositioning and for re-cuts based on the original position of those drill bits. Occasionally, surgeons will remove drill bits and then put them back in their original hole with the idea that these will guide further cuts and re-cuts.

The first goal of this study was to quantify how precise these drill bits are and assess whether or not they allow the cutting blocks to be placed and replaced in an accurate way.

The second goal of this study was to assess the Matrix Precision Pins and quantify whether they decrease the error related to cutting block fixation.

EXPERIMENTAL DESIGN

Four fresh frozen cadaver knees were mounted on the EORL cadaver table (figure 1). The usual soft tissue dissection was done. The Matrix Femoral Cutting Jig was used to position the femoral cutting block, and the Triathlon External Tibial alignment jig was used to position the tibial block. The Stryker Navigation system was used to monitor and quantify each step.

FIGURE 1

Cutting blocks were positioned with the jig and their position was checked with computer navigation. Cutting blocks were then fixed with 1/8th inch drill bits. The position of the cutting block was then verified with computer navigation. The EM or IM guide was them removed, and the position of the cutting block was then reassessed. Next, cutting blocks were moved up and down in their various positions to see if positions changed. Finally, the drill bits were removed and replaced and changes in position were quantified.

The same steps were then repeated with The Matrix Precision Pins.

RESULTS

Cutting block position was quantified using computer navigation in terms depth, varus/valgus, and flexion/slope. This was done sequentially in four cadaver knees. The change in position measured with each step is shown in tables 1 and 2. Table one shows the changes seen on the femoral side, and table 2 shows the tibial side.

Note that there is roughly twice as much error seen with standard 1/8th inch drill bits compared to the use of Matrix Precision Pins.

TABLE 1: FEMORAL CUTTING BLOCK

Fixation Method	Change in Var/Val	Change in Flexion	Change in Depth
1/8” Drill bits	4.3 degrees	4.1 degrees	1 mm
Matrix Precision Pins	2.0 degrees	1.2 degrees	0.25 mm

TABLE 2: TIBIAL CUTTING BLOCK			
Fixation Method	Change in Var/Val	Change in Flexion	Change in Depth
1/8” Drill bits	4.2 degrees	3.7 degrees	1 mm
Matrix Precision Pins	2.2 degrees	1.91 degrees	1 mm

CONCLUSIONS

Our results show that 1/8th inch drill bits can be reasonably reliable for the initial placement of blocks. However on occasion, those drill bits will skive and end up in some degree of disorientation relative to each other (figure 2). This non parallel orientation contributes to error in the block position. Also, removing the drill bit and trying to replace it for subsequent repositioning of the block proved to be difficult and fraught with error. Considerable deviations in block position were noted.

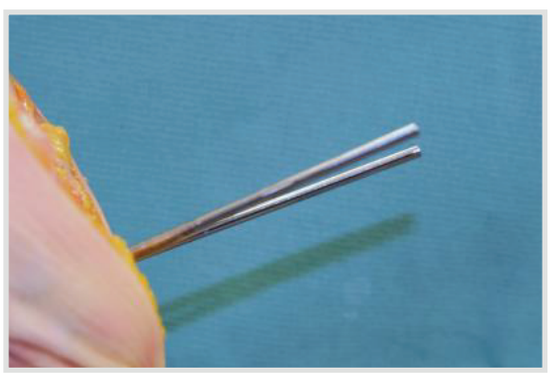

FIGURE 2: NON-PARALLEL ORIENTATION OF STANDARD DRILL BITS

The Matrix Precision Pin offers significant advantages over tradition drill bits during knee replacement:

- The tip of the Matrix Pin is quite sharp.
- It is pulled into the bone by threads.
- As a result, positioning of the precision pin is very precise and very consistent (figure 3).
- This allows accurate and reproducible positioning of the block.

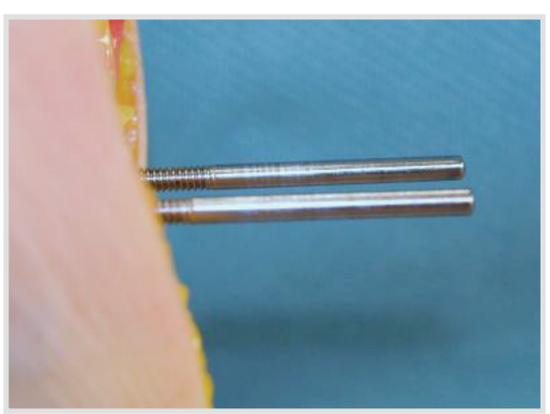

FIGURE 3: PARALLEL ORIENTATION OF MATRIX PRECISION PINS

Drill bits create holes in the bone by removing bone. Also, the hole left in the bone is equal to the diameter of the 1/8th inch drill bit. Conversely, the Matrix Precision Pin is a threaded device. It essentially compresses bone to the side as it is placed. The hole left behind as the pin is removed is determined by the inner diameter of the thread (figure 4). As a result, the effective size of the hole in the bone is less. Also, the threaded pin is more stable in bone and does not require two cortices. *These features decrease the potential for stress fractures.*

FIGURE 4: THE MATRIX PRECISION PIN COMPRESSES BONE LEAVING A SMALLER HOLE IN BONE

DISCUSSION

When utilizing 1/8th inch drill bits, it is not uncommon during knee replacement to notice that the drill bits have been oriented in a nonparallel way. When surgeons are using cutting blocks without computer navigation, it is impossible to notice how much this nonparallel positioning contributes to error in block positioning. This simple step probably contributes to some of the lack of precision noted in non-navigated knees. It is difficult to replace 1/8th inch drill bits in the original hole. Also, the effective hole size is determined by the outer diameter of the drill bit as a drill bit excavates a bone during placement. On the other hand, precision threaded pins do not remove bone they simply compress it out of the way of the threads as the pin is placed. The effective hole diameter is the inner diameter of the pin as opposed to the 1/8th inch drill bit. This smaller hole size combined with the fact that a precision pin only requires one cortex should result in fewer problems with stress fractures related to pin placement. Use of precision pins will also contribute to improved position and accuracy. The Matrix Precision Pins will help save time during navigated cases and help with non-navigated cases by eliminating some of the inherent error doing the operation.

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