FREEHAND NAVIGATED BONE CUTTING FOR TKR WITHOUT JIGS - ASSESSMENT OF FIRST CUTS

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INTRODUCTION
Conventional bone cuts with image-guided navigation. Would the TKR distal femur cuts done freehand with graphical feedback guiding a conventional bone saw be fast enough and good enough to even warrant research/development of such systems? How they compare with those using conventional cutting jigs is not only an important question, but leads to the need to quantitatively assess the “quality” of cutting by conventional TKR jigs. In this study, the time taken and “quality” of freehand navigated cutting were objectively, quantitatively, assessed observing at the same time the surgeons' subjective assessments about such implementation to guide its future progress.

MATERIALS & METHODS
An experimental CT-image based CAOS system fully developed and coded in-house was used. It utilized an NDI Polaris infra-red optical tracker for direct navigation of instrumentation and bones. 18 identical physical bone models were cast with foam from a single mold. The mold itself was set around a Stereo Lithographic Rapid Prototyping model, whose STL file was generated in-house from CT data of the female right femur from the Visible Human Project. Therefore, all the cast bone replicas made for cutting, and the computer virtual models in the user graphical interface were based on identical anatomic geometry.

The experimental cuts were the five planar fixation distal femur plateau for a popular TKR implant. A standard combination cutting jig by the same implant manufacturer was used for alignment and cutting for comparison. For the freehand cutting, optical reference frames were fastened and registered to the saw and the cast bone specimen. The system displayed 3D realistic models of the saw, bone, and the planes along which the blade should be orientated. The user was able to see the cutting on the physical bone following its desired path from the PC screen. Alternatively the user could follow the progress of the cut on the screen on the virtual bone (Fig 1) as described in [2].

Direct measurements with a digital caliper and protractor were made to evaluate all the cuts. Four important angles of the orientation of the five cut surfaces were measured treating the most inferior horizontal cut surface as a reference (Fig. 5). The orientation (angle) of each surface was measured along 6-8 predetermined Anterior-Posterior (AP) planes, at constant intervals Medial-Laterally (ML). Additionally, the length of three of the plateau surfaces was measured, each at the same 6-8 predetermined planes (Figs. 2-4). To simple enable interpretation and comparison of quality from the large number of measurements, the results for each cut surface were averaged to depict the shape of the resulting bone graphically from a sagittal viewpoint through 3 mean lengths and 4 mean angles of its cut surfaces.

RESULTS
Two experienced arthroplasty surgeons and one engineer performed the experiments with a strict protocol. Each user performed all 5 main cuts on ONE cast bone sample using the conventional TKR jig. Each user was then allowed only one (non-documented) practice attempt on a cast bone sample using freehand navigation. FIVE separate cast bone samples were then cut in turn by that user freehand with navigation and no jigs. The time for each experimental run was recorded.

DISCUSSION & CONCLUSIONS
The surgeon’s comments about the utility of this technique, and their qualitative assessments of the cuts were most encouraging for the concept’s feasibility and potential. It took both surgeons almost the same time of about 16.5 min to cut with the jigs. However, it took them an average of just under 10 min to cut freehand. The engineer took more than 30 min with the jigs, and about 12 min freehand. The profiles for each surgeon and the engineer were plotted separately in Figs 6-8. Each shows the desired (ideal) profile, the cuts made using jigs and the profile of each bone cut freehand. The shaded area surrounding the curves shows the outer-most envelope within which the worst ever deviations were measured anywhere on the ML depth before averaging. Of course, no such extreme profile was ever present, as that would have had to combine the worst possible deviations in cutting from all the tests, into one.

REFERENCES

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