An Evaluation of the Accuracy of Computer Assisted Surgery in Preoperatively Three Dimensionally Planned Periacetabular Osteotomies

+\text{Abraham, C; Rodriguez, J; Buckley, J.M; Diab, M; Burch, S}
+University of California, San Francisco, San Francisco CA
BurchS@orthosurg.ucsf.edu

**INTRODUCTION**

Adults with unresolved developmental dysplasia of the hip (DDH) often warrant Pelvic Periacetabular Osteotomy (PAO). Making the correct osteotomies, and then finding the "ideal" position of the acetabular fragment is difficult, even for the experienced surgeon. Computer Assisted Surgery (CAS) with improved imaging hardware, and intra-operative navigation systems has the potential to reduce complication rates, lessen the learning curve, and make PAO available for more patients. PAO osteotomies have been made using intra-operative navigation and acetabular fragments have been positioned in pre-operative computer models. The aim of this study is to prove the utility of pre-operative 3D osteotomy planning and acetabular fragment positioning in completing intraoperatively navigated PAOs.

**METHODS**

Five fresh-frozen human cadaveric pelvises (3 male, 2 female) were selected for this study. For each pelvis, five 3.5 mm stainless steel microbeads were implanted in the acetabulum to provide a measure of error in the orientation of the acetabulum. Comparison was made between 3D pre-operative planned images and reconstructed post-operative CT scans (1 mm slice thickness) of the osteotomized cadaveric pelvises. Using an image processing and editing software and CT scans of the intact pelvises (Mimics, Materialise, Belgium) the virtual PAOs were created (osteotomies and fragment positioning increasing anteversion by 15°) yielding a virtual CT to use as a 3D pre-operative plan. (Figure 1)

The pre-operative plan was imported into a “passive” navigation system. (Treon, Medtronic, Colorado) The osteotomies in the cadaveric pelvises were made using a drill hole osteoclasis technique with a navigated drill bit guide precisely mapping out the holes. The acetabular fragment was then positioned by matching the landmarks on the fragment to their corresponding locations on the pre-operative plan. Each landmark was correctly positioned and fixed with a flexible k-wire through the located point.

**RESULTS**

By all measures, the error between the post-operative PAO scans and the planned pre-operative scans was small relative to expected values. Mean error of the osteotomies was $1.97 \pm 0.73$ mm for the iliac cut. (Table 1) The mean difference between post-operative and pre-operative plan CE angle was $4.9 \pm 6.0^\circ$, with three of the specimen having a CE within 1° of the preoperative plan. The last specimen in the study had a CE angle of 0.1 degrees. (Table 2) The mean rotational error in positioning of the fragment was $2.39 \pm 1.01$ mm. (Table 2)

**CONCLUSIONS**

CAS with pre-operative planning and intra-operative surgical navigation shows promise in improving the accuracy of PAO surgeries. For the majority of specimens in this study, the center-edge angles were matched within $\pm 1^\circ$ of the pre-operative angle. This deviation is well within the margin of surgical accuracy, and within CE angle measurement error. Rotational accuracy was found to be within clinical parameters and may prove to be more important than CE angle in predicting clinical outcomes. The major obstacles to the techniques employed in this study revolve around consistency, intra-operative time and ease of use. For two of the specimen the CE angle error was greater than ten percent. This inconsistency was attributed to the manual challenges of holding an acetabular fragment without soft tissue and ligament support. Also, there was a substantial learning curve in using the CAS software and navigation system, as evidenced by the initial procedure taking 4 hrs to complete (final procedure took 1 hr). Further research will focus on using pre-operative planning and CT manipulation to create custom guides and implants. With the accuracy we were able to achieve we envision this method of completing PAO surgeries to be applied to clinical cases in the near future.