The Effects of the Supracondylar Humerus Fracture Malreduction on the Elbow Carrying Angle

INTRODUCTION:
Supracondylar humerus fractures are the most common pediatric elbow fracture. The supracondylar humerus fracture is a transverse fracture of the distal humerus just above the elbow joint. The supracondylar humerus fracture malreduction involving fracture extension and internal rotation cause changes in the elbow carrying angle and also problems in the elbow workspace 1. When the normal elbow is extended in the anatomic position, the forearm has valgus angulation relative to the humerus known as the carrying angle with range of 10-15 degrees for men and 20-25 degrees for women 2. Elbow flexion extension movements are about an offset axis of rotation located just distal to the epicondyles 3. The angle of offset is reflected in the carrying angle. The supracondylar humerus fracture malreduction most commonly involves fracture extension and internal rotation and these produce changes in the elbow carrying angle and in the elbow workspace. There is controversy about the importance of both rotational misalignment in management of both acute fractures and malunions.

We have used a wooden elbow model and a computer simulation 4 to measure the effects of fracture extension and internal rotation deformity and the currently favored valgus osteotomy on elbow carrying angle and motion path.

METHODS:
A balsa wood elbow model with the humerus and the forearm is connected by an offset hinge 20 degrees in the coronal plane and 20 degrees in the axial plane (Figure 1). A transverse cut across the humerus above the offset hinge simulated the supracondylar humerus fracture. Two hinges were placed on the back of the model to allow fracture longitudinal rotation or extension. An external fixator was used to hold the “humerus” fragments in position so that the carrying angle and motion path could be measured. The carrying angle was measured for each 10 degree increment of extension and for each 10 degree increment of fracture internal rotation with a protractor.

Using the Kimsim interactive 3D kinematic simulation developed in UTMB orthopaedic research 5, the bones and joint axes of rotation for the elbow are defined. Bone polygons for the simulation are derived from axial computerized tomography (CT) slices of the National Library of Medicine Visible Human (male and female). The origins and insertions of the triceps and biceps are defined. A transverse supracondylar osteotomy is produced with axes to allow fracture flexion extension and internal external rotation. A third axis allows simulation of a valgus osteotomy. With standard graphic interactive tools, the simulated fracture is extended in 10 degree increments to maximum 60 degree extension and then the simulated fracture is internally rotated in 10 degree increments to 60 degrees internal rotation (Figure 2 shows the simulation with the normal and two example deformity positions). The carrying angle was measured for each interval with ImageJ (NIH freeware). The valgus osteotomy was simulated with the fracture at 60 degrees internal rotation.

RESULTS:
Both fracture extension and internal rotation contribute to carrying angle loss (Figure 3). The internal rotation contribution is greater and produces most of the perceived varus. Extension deformity had little effect on motion path but resulted in decreased total range of motion and had little effect on muscle direction of pull. The internal rotation deformity had significant effect on motion path as the hand could not be brought to the mouth without shoulder abduction and flexion. The internal rotation deformity had a significant three dimensional effect on triceps direction of pull which may account for the elbow instability associated with these malunions. Valgus osteotomy improved motion path but did not correct the tendon alignment.

DISCUSSION:
Both fracture internal rotation and extension contribute to the carrying angle with internal rotation being the biggest contributor. Internal rotation deformity produced an abnormal motion path requiring shoulder compensation in activities of daily living.

REFERENCES: