

Comparison of Gleno-humeral Kinematics obtained using Bone Pins and Skin Mounted Markers – A Preliminary Validation Study

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INTRODUCTION

Accurate and valid characterization of glenohumeral kinematics plays a critical role in facilitating our understanding of pathology at the shoulder joint.

In vivo strategies to quantify glenohumeral kinematics have used two main techniques:

- Use of skin mounted sensors [1]
- Use of a skin mounted jig (scapula tracker) [2]

The purpose of this study was to compare glenohumeral kinematics obtained using bone pins to those obtained with skin mounted markers and a scapula tracker, in a cadaver model.

The null hypothesis was that no differences exist in glenohumeral kinematics between the three different tracking methods.

METHODS

Instrumentation: One cadaver (two upper limbs) with no known musculoskeletal pathology was mechanically grounded to a vertical steel stanchion, allowing unrestrained motion of the upper extremities.

Tracking Methods:

- 1) Bone Pin – Steinmann pins in scapula and humerus, four retro reflective markers was affixed to each bone pin
- 2) Skin Mounted - cluster of four retro reflective markers
- 3) Scapula Tracker - conforming to the mid portion of the scapular spine [2]

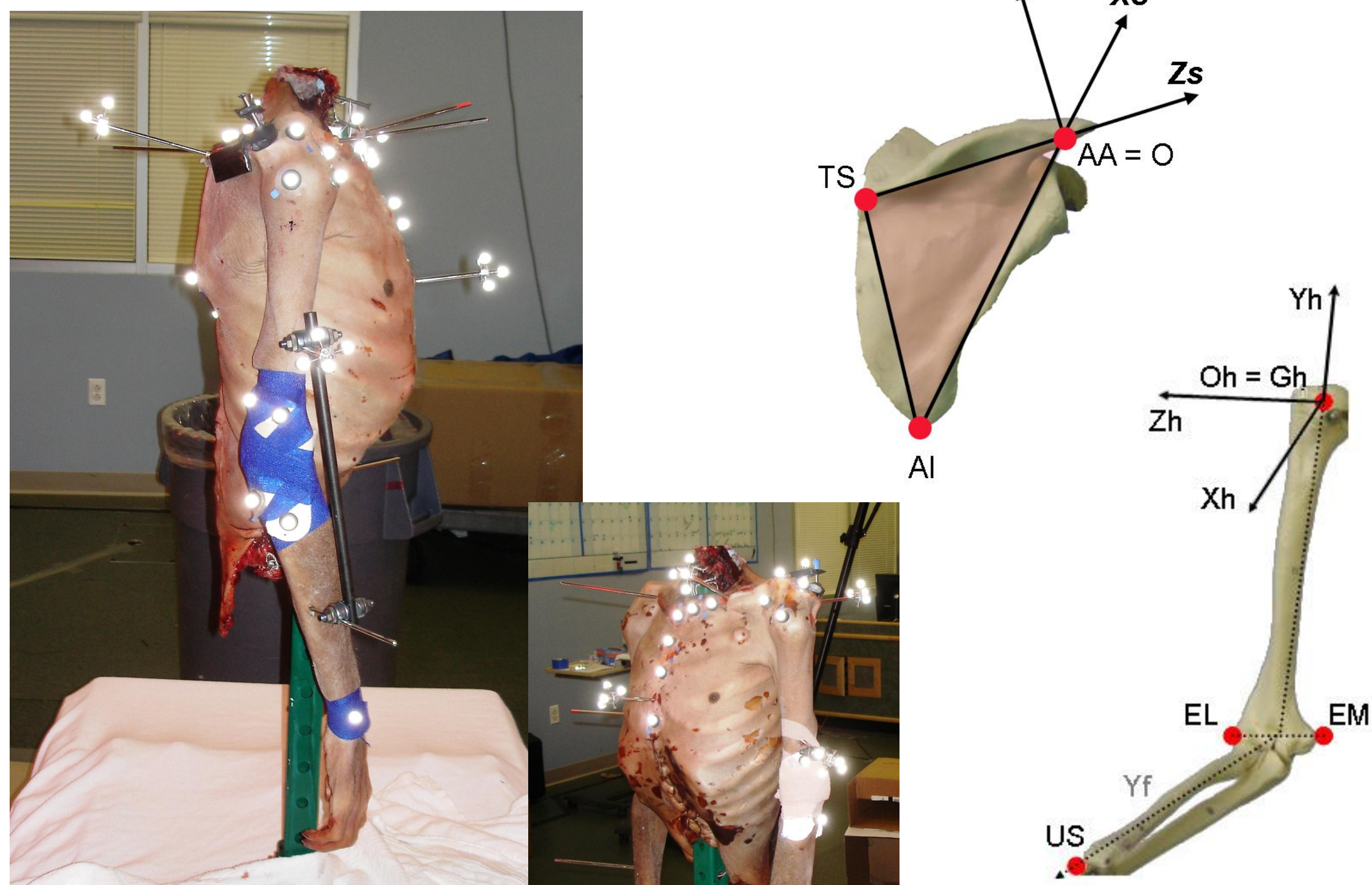


Figure 1. Scapula and humerus co-ordinate systems

Anatomical coordinate systems were defined, according to ISB recommendations, [3] for the scapula and humerus with a digitizing pointer. Coordinate systems depicted in Fig. 1.

- 1) Kinematic data collected at 100 Hz, using a 10-camera system
- 2) Three tasks (glenohumeral flexion, abduction and external rotation)
- 3) Two conditions (elbow flexed and elbow extended)

Data Analysis:

Data were analyzed using Visual 3D. The following segments were defined: bone pin humerus, skin marker humerus, bone pin scapula, skin marker scapula and scapula tracker. Euler angles were defined using a y-x'-z" sequence of rotations, where y=SI axis, x=AP axis and z=ML axis. [1]

RESULTS

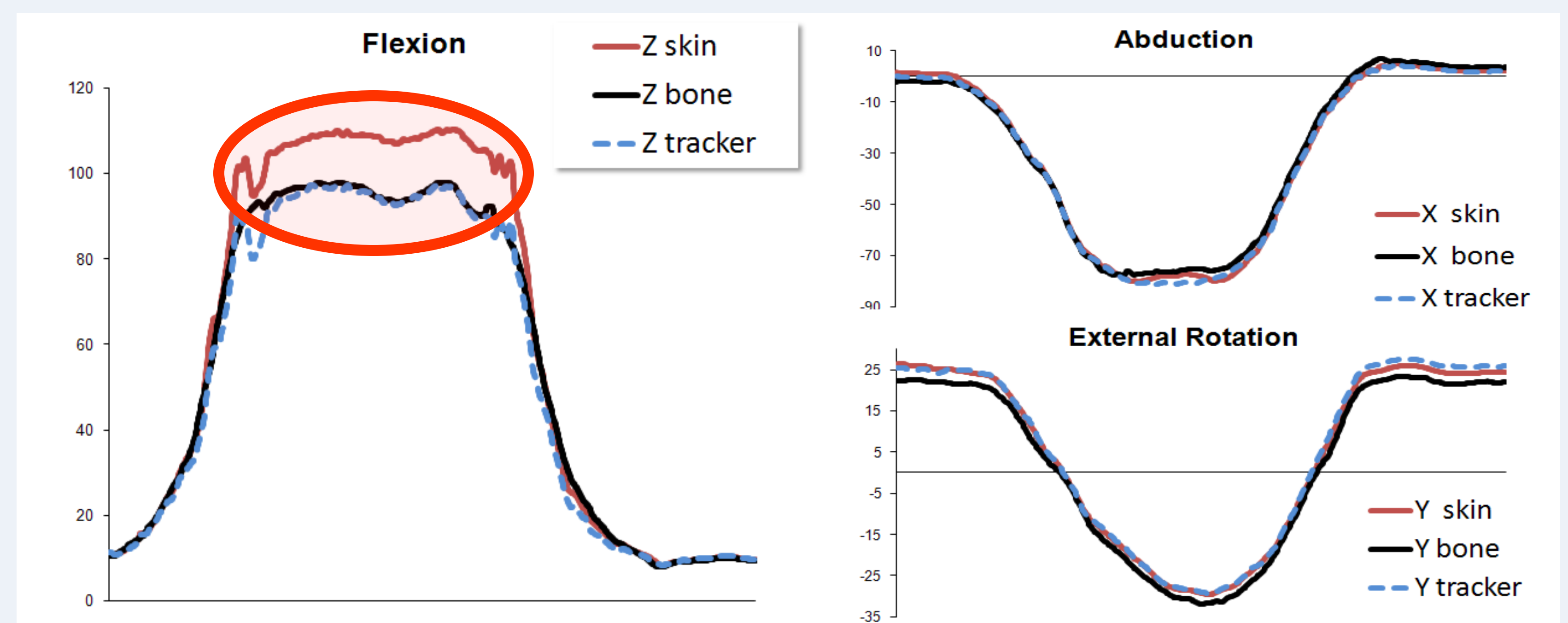


Figure 2a. Sagittal plane glenohumeral motion using the three tracking methods during a flexion trial in Specimen R. Shaded ellipse at $>90^\circ$ flexion highlights areas of least agreement between tracking methods, with good agreement noted with flexion $<90^\circ$.

Figure 2b (top) and 2c (bottom). Frontal and transverse plane glenohumeral motion using the three tracking methods during an abduction and external rotation trial, respectively in Specimen R, showing good agreement between methods through out range of motion.

Bone pin versus skin mounted markers	Specimen L	Specimen R	Bone pin versus scapula tracker markers	Specimen L	Specimen R
	Elbow extended			Elbow extended	
Flexion	13.6°	6.1°	Flexion	6.3°	2.0°
Abduction	2.4°	2.1°	Abduction	4.4°	2.1°
Ext Rtn	2.9°	7.3°	Ext Rtn	3.4°	3.0°
Elbow flexed		Elbow flexed			
Flexion	17.6°	10.0°	Flexion	8.3°	5.3°
Abduction	3.2°	5.9°	Abduction	3.0°	5.0°
Ext Rtn	4.5°	5.5°	Ext Rtn	4.8°	11.5°

Table 1. Average Root Mean Square Error (in degrees) in glenohumeral kinematics between tracking methods (bone pin versus skin mounted markers on the left, bone pin versus scapula tracker on the right)

CONCLUSIONS AND DISCUSSION

Preliminary results from two upper extremities indicate that skin tracking methods of characterizing glenohumeral kinematics have an RMSE $<10^\circ$ in abduction and external rotation, when compared to bone pins.

While good agreement occurred with flexion $<90^\circ$, the largest RMSEs were found with flexion $>90^\circ$.

With the exception of external rotation, elbow flexion did not alter RMSE by $>3.9^\circ$. These results are consistent with previous reports. [2, 4]

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ACKNOWLEDGEMENTS:

David Adar from the Psychomotor Skill Laboratory at Hospital for Special Surgery for assistance with the cadaveric specimen.

