INTRODUCTION: Scapular movement is widely thought to be an important component of shoulder pathology, though its measurement is a problem that has long-plagued both researchers and clinicians alike. The shoulder is a very complex and mobile joint which relies on movement of the thorax, clavicle, scapula and the humerus. Measuring the movement of the complete shoulder complex is relatively easy by looking at the position of the arm with respect to the thorax. A problem arises when trying to determine how much of the motion is occurring at the movement of the thorax, clavicle, scapula and the humerus. Measuring this difficulty is that the scapula is a relatively flat bone and it moves with considerable sliding under the skin. This makes it difficult to use skin markers to monitor its movement. Most of the current gold standards are invasive, involving the use of metal implants with or without radiation. One non-invasive technique which has been used to measure scapular position is the digitization of bony landmarks. The reliability of this method has been previously published, but no one has published the accuracy of this method. The goal of this study was to determine the accuracy of this digitization technique as a part of its validation.

METHODS: The digitization of bony landmarks as a measure of scapular motion was compared to percutaneous bone pins which were chosen as our gold standard. All markers were tracked with an optoelectronic camera system [Optotrak 3020, Northern Digital, Waterloo, ON]. Five healthy subjects were recruited from our institution (mean age of 29). All subjects chose to have their non-dominant (left) shoulder tested.

Local anaesthetic was injected into the lateral scapular spine where the bone pins were to be placed. The subcutaneous tissue down to and including the periostuem was anasthetized. Two 1.6mm bone pins were then inserted into the spine of the scapula by an orthopaedic surgeon. An optoelectronic marker carrier was secured to the exposed pins. Subjects were seated on a stool with feet shoulder width apart and in firm contact with the ground. In this position, with the arms hanging by the side, points on the thorax, scapula and humerus were digitized by a physiotherapist to create the reference frame and anatomical axis. The following points were digitized on the scapula with the Optotrak probe: the medial root of the scapular spine, posterolateral corner of the acromion and inferior angle of the scapula (Figure 1). The four active movements tested in this study were glenohumeral abduction, glenohumeral horizontal adduction (H.Add), hand behind back (HBB; upward rotation, external rotation) and forward reaching (grabbing a pole placed just inside the fingertips when the arm is flexed to 90°). These movements put the scapula through nearly full range of motion. Three bony landmarks (medial root of the scapular spine, inferior angle and posterolateral acromion) were digitized six times, during each of movement (i.e 1/3 ROM, 2/3 ROM, 2x full ROM, 2/3 ROM, 1/3 ROM). The subjects were given several practice trials to ensure that they understood the proper movement pattern before holding the static positions. Ethics approval was obtained from the clinical ethics review board of the university.

The Optotrak system measures the three dimensional position of all of the markers. Scapular kinematics were calculated using a custom Matlab script following the equations described in Soderkvist and Wedin. The axis system and the cardan angle sequence recommended by the shoulder group of the ISB were used. The angles calculated using the digitization process were compared to the angle calculated from the markers attached to the bone pins. An rms error was calculated for the techniques as a whole as well as for each different movement.

RESULTS: The overall rms error ranged between 4.2-5.3° while the rms error for specific movements ranged between 2.5-6.5°.

DISCUSSION: Various techniques based on palpating scapular bony landmarks have been used in the literature. Palpation of bony landmarks does not require prohibitively expensive equipment and is relatively easy to perform. This makes it attractive for measuring changes in scapular position.

The quoted accuracy of this study represents the change in position of the scapula and not the absolute accuracy of measuring scapular position. This is because the gold standard we used relies on an initial digitization process. Another possible limitation was that the bone pins were located fairly close to the posterolateral acromion. This may have had the effect of landmarking the posterolateral acromion. This effect was probably not significant since this was consistently the easiest landmark to find.

When the accuracy results of this study are combined with the reliability results of other studies, it appears that the digitization of bony landmarks may be a valid method for measuring changes in scapular attitude.

ACKNOWLEDGMENTS: Supported by a PGSA scholarship from the Natural Sciences and Engineering Research Council of Canada.

REFERENCES