



Short communication

Effects of attachment position and shoulder orientation during calibration on the accuracy of the acromial tracker

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ABSTRACT

The acromial tracker is used to measure scapular rotations during dynamic movements. The method has low accuracy in high elevations and is sensitive to its attachment location on the acromion. The aim of this study was to investigate the effect of the attachment position and shoulder orientation during calibration on the tracker accuracy. The tracker was attached to one of three positions: near the anterior edge of the acromion process, just above the acromial angle and the meeting point between the acromion and the scapular spine. The scapula locator was used to track the scapula during bilateral abduction simultaneously. The locator was used to calibrate the tracker at: no abduction, 30°, 60°, 90° and 120° humerothoracic abduction. ANOVA tests compared RMS errors for different attachment positions and calibration angles. The results showed that attaching the device at the meeting point between the acromion and the scapular spine gave the smallest errors and it was best to calibrate the device at 60° for elevations $\leq 90^\circ$, at 120° for elevations $> 90^\circ$ and at 90° or 120° for the full range of abduction. The accuracy of the tracker is significantly improved if attached appropriately and calibrated for the range of movement being measured.

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1. Introduction

At present, the most accurate non-invasive method of measuring scapular motion is the scapula locator method. The locator is used to statically capture the orientation of the scapula (Johnson et al., 1993) or to track its motion at slow/medium speeds (Shaheen, 2010), but has not been shown to be able to do so during fast dynamic activities.

Whereas, the acromial tracker is a single sensor that can be conveniently attached to the acromion and is used to measure scapular dynamic movements (McQuade and Smidt, 1998; Ludewig and Cook, 2000; McCully et al., 2005). The tracker has low accuracy at high elevation angles (Karduna et al., 2001; Meskers et al., 2007; van Andel et al., 2009) and it is sensitive to where it is placed on the acromion. The optimal location on the acromion has not yet been established.

The calibration of the tracker with the locator to reduce errors caused by skin deformation was suggested (Meskers et al., 2007) and carried out at the anatomical position (van Andel et al., 2009), but high errors above 90° of abduction were still found.

The aim of this study was to improve the accuracy of the acromial tracker by identifying the optimal position of attachment on the acromion as well as the best shoulder orientation during calibration.

2. Methods

2.1. Study population and instrumentation

7 male subjects with a mean age of 23.9 ± 3.9 years, a fully functional shoulder as assessed by the Oxford Shoulder Score (Dawson et al., 2009), and no history of shoulder pain or surgery participated in the study.

An Optical Motion Tracking system was used to track the trajectories of reflective markers attached to landmarks on the thorax and the humerus according to Wu et al. (2005) and on the scapula locator and the acromial tracker.

The locator had three pins adjusted to fit the acromial angle, the inferior angle and the root of the scapular spine (Johnson et al., 1993). Pressure-sensors attached to the tips of the pins provided feedback to the observer, which was used to maintain low and equal pressures on the landmarks whilst tracking their motion, hence reducing any possible effects on the physiological scapular movement (Shaheen, 2010). A custom-designed tracker shown in Fig. 1A was attached to the acromion and was also used to obtain scapular measurements.

2.2. Data capture

The tracker was attached to one of three positions on the acromion (Fig. 1B):

- Position A—near the anterior edge of the acromion as suggested by Matsui et al. (2006).
- Position B—just above the most latero-caudal point of the acromion (the acromial angle) as used by Karduna et al. (2001) and Meskers et al. (2007).
- Position C—the meeting point between the acromion and the scapular spine. This position has not been previously documented.

At each of these positions, the subjects performed three trials of bilateral elevation in the scapular plane. Measurements of the dominant shoulder only

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