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Revisit to scapular dyskinesis: three-dimensional wing computed tomography in prone position

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Background: Three-dimensional (3D) wing computed tomography (CT) showed a high inter-rater reliability in assessing scapular dyskinesis.
Methods: The 330 scapular movements of 165 patients were classified into 4 types by 7 blinded observers. Then, 3D wing CT was performed with patients prone, and 4 blinded observers measured 5 angles, consisting of upward rotation (UR) superior translation (ST), anterior tilting (AT), protraction (PRO), and internal rotation (IR). The inter-rater reliability (IRR) of 2 methods was calculated, and cutoff values were determined for the 5 angles on the 3D wing CT images.
Results: The IRR was 0.783 for the observational method of scapular dyskinesis and 0.981 for 3D wing CT in the prone position. UR and ST angles were significantly larger in type 3 more than in the other types ($P < .001$, $P < .001$), and the AT angle showed a similar pattern in type 1 ($P < .001$). The PRO angle was significantly larger in types 1, 2, and 3 more than in type 4 ($P < .001$, $P < .001$, $P = .013$), and the IR angle was significantly larger in type 2 more than in the other types ($P < .001$). The cutoff values of the 5 angles were UR, 117°; ST, 90°; AT, 8°; PRO, 99°; and IR, 51°. The UR angle showed a significant correlation with glenohumeral internal rotation deficit (odds ratio, 0.436; $P = .029$) and the IR angle with MDI (odds ratio, 8.947; $P = .048$).
Conclusion: The patients with a high UR angle showed a low rate of glenohumeral internal rotation deficit and those with a high IR angle had a high rate of the MDI in affected shoulder by the determinant of the cutoff value of the 5 angles.
Level of evidence: Level III, Development of Diagnostic Criteria with Nonconsecutive Patients, Diagnostic Study.

Keywords: Scapular dyskinesis; 3D wing CT; prone position; inter-rater reliability; cutoff value; observational method; concomitant disease

This study was approved by the Konkuk University Medical Center Institutional Review Board (IRB reference No.: KUH1060045).

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The scapula is anatomically and biologically closely involved with shoulder function. During the process of shoulder and arm movement to achieve a change in glenohumeral position, as well as during motions required for athletic and daily activities, the two are linked.[11] Scapula dyskinesis is defined as observable alterations in the position of the scapula and the patterns of scapula motion in relation to the thoracic cage.[11,30] Scapular dyskinesis most frequently occurs as a result of alteration of muscle activation or coordination.[11]

Scapular dyskinesis has been found in patients with various shoulder pathologies, including impingement, instability, and labral and rotator cuff injuries,[2,10,15,17,21,28] and in various elbow pathologies, including ulnar collateral ligament rupture, valgus extension overload syndrome,[1,18] among others. Scapular dyskinesis has been thought to affect normal scapulohumeral rhythm (SHR) and shoulder arthrokinematics, and therefore, to contribute to producing the dysfunctions associated with these pathologies.[6,30]

It is important that a proper rehabilitation is performed according to the type of scapular dyskinesis, especially for elite athletes. To assess scapular dyskinesis accurately, Kibler introduced the observational typing method, which is considered the gold standard.[9,11,30] Another clinical assessment method is the ''yes/no'' method, which collapses 3 dyskinesis categories (types 1 to 3) to a single category of ''yes'' (an abnormal pattern was observed), and designating the normal pattern as ''no.''[21,27,30] Our previous study in 2013 showed a correlation between the scapular angles, which was gauged using a 3-dimensional (3D) wing computed tomography (CT) image with the patient supine, and the types of scapular dyskinesis.[25]

The observational typing method (4 types) has shown a relatively low inter-rater reliability (IRR; $\kappa = 0.186$-0.780)[3,12,25] but the measurement of angles in 3D wing CT showed a relatively high IRR ($\kappa = 0.972$).[25] The observational assessment of scapular dyskinesis has several problems that result in a low IRR.[21] First, the overlying muscles and soft tissues are obstacles to the assessment.[5,26] Second, assessment methods should consider 3 rotational movements and 2 translations of the scapula, but clinical observational assessment should use static measures to evaluate the scapula in 1 plane or, at most, 2 planes.[5,30]

However, the previous assessments using 3D wing CT in the supine position had some limitations.[25] First, the protraction (PRO) and internal rotation (IR) angles possibly decreased due to the gravity and mechanical impediment in the supine position. Second, there were no criteria to classify the several types of scapula dyskinesis. Third, there was no explanation regarding a correlation between the measured angles and concomitant diseases.

We therefore hypothesized that the assessment of scapula dyskinesis using 3D wing CT imaging in the prone position will be more accurate than that in the supine position, especially for PRO and IR angles, that the cutoff value can be determined from the measured angles, and that there will be a correlation between the newly classified scapular dyskinesis, according to the cutoff value, and concomitant diseases.

Therefore, the aims of this study were to (1) compare the 3D wing CT analysis in the prone position with observational assessment; (2) determine the cutoff values for the 5 angles that show a significant correlation with the 4 observational types; and (3) analyze a correlation between the affected 165 scapula and concomitant diseases of the affected side, according to this classification based on the cutoff value.

Materials and methods

Study design and demographics

This study was a diagnostic case series and prospectively designed, repeated-measurement study of 165 patients (150 males and 15 females) from April 2011 to December 2011. All patients gave written informed consent to participate in this study. Patients were an average age of 20.6 years (range, 12-66 years), an average height of 175.1 cm (range, 155.0-193.8 cm), and an average weight of 78.1 kg (range, 54.0-101.3 kg). A total of 141 participants were right-hand dominant; 162 patients showed some shoulder or elbow pain on the dominant side and 3 on the nondominant side. Among the 165 patients, 127 were baseball players (27 professional, 20 university, 43 high school, 31 middle school, and 1 elementary school), 5 were athletes of other overhead sports (1 swimming, 1 javelin throw, 2 handball, and 1 basketball), 5 played golf, 2 played table tennis, 1 was a diver, 1 participated in bowling, 1 was an archer, and 26 enjoyed occasional sports activities.

Exclusion criteria

Patients were excluded if they had (1) a previous shoulder surgery,[14] (2) a previous fracture of scapula, humerus, or clavicle,[30] (3) a clinical reproduction or evidence of shoulder symptoms with any cervical spine movement, (4) a history of systemic disease,[31] (5) a history of neurologic symptoms, including descriptions of numbness, tingling, or other sensory disturbance in the shoulder and upper limb in the presence of upper limb weakness,[15,30] and (6) a scoliosis producing a visible rib hump in the neutral standing posture.[19]

Observational assessment

The participants underwent a physical examination, including tender points, range of motion, and some tests for the shoulder and elbow. Diagnostic imaging studies such as X-ray, magnetic resonance imaging, magnetic resonance arthrography, CT, and CT arthrography were performed to detect underling pathologies. The pathologies are sorted in Table I.

The 330 scapular movements of 165 patients were videotaped and classified into 4 types by 7 blinded observers. Patients were instructed on shoulder flexion (about a coronal axis), scapular