A Novel Radiographic Index for the Diagnosis of Posterior Acromioclavicular Joint Dislocations

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Background: Posterior acromioclavicular (AC) joint dislocations are frequently misclassified because posterior translation of the clavicle is difficult to evaluate in Zanca radiograph views. A novel radiographic index was used in this study to accurately diagnose posterior dislocations of the AC joint.

Hypothesis: This novel index has a high degree of accuracy for the diagnosis of posterior AC joint dislocations.

Study Design: Cohort study (diagnosis); Level of evidence, 2.

Methods: This was an analytic, descriptive study of 150 patients with different grades of AC injuries according to the Rockwood classification (30 patients for each grade of injury: I, II, III, IV, and V). The diagnosis of an AC injury was made both clinically and radiographically by using comparative Zanca and axillary views. Two measurements were performed in Zanca views: the coracoclavicular distance and the AC width distance. A width index was calculated for each patient. The Student t test, Bonferroni test, logistic regression, linear regression, and receiver operating characteristic (ROC) curves were used for statistical analysis. Forty cases were impartially selected to obtain a k concordance value.

Results: The average value of the AC width index per group (according to the Rockwood classification) was as follows: type I, 2.1% (range, –12% to 25%); type II, 4.2% (range, –19% to 29%); type III, 19.1% (range, –59% to 91%); type IV, 110.3% (range, 47% to 181%); and type V, –3.8% (range, –71% to 62%). There was a significant difference between the average width index in the patients with type IV injuries and those in the remaining groups (P < .05). The ROC curve showed that a width index of 60% has a sensitivity of 95.7% and specificity of 97.5%, with a positive predictive value of 96.7% and negative predictive value of 95.6% to predict a type IV injury. Intraobserver reliability was rated as substantial agreement for each of 3 observers; the interobserver reliability of the 3 independent raters was almost perfect.

Conclusion: An AC width index of >60% is highly accurate for the diagnosis of a posterior AC joint dislocation, with high intraobserver and interobserver concordance.

Keywords: acromioclavicular joint dislocation; shoulder; radiographic index; radiograph; sport-specific injuries; instability; diagnosis

Acromioclavicular (AC) lesions represent 40% to 50% of athletic shoulder injuries.12,17 To properly assess this injury, a 3-grade injury classification, based on the radiographic findings in comparative AC joints of the same patient, was first introduced in the 1960s by Tossy et al19 and Allman.2 Later, with the recognition that many AC joint instabilities were not properly assessed by this classification, Rockwood et al15 introduced a modification, classifying these injuries as types I to VI: type I, AC ligament sprain with the AC joint congruence intact; type II, disruption of the AC ligaments with sprains of the coracoclavicular ligaments; type III, AC and coracoclavicular ligament tears with the coracoclavicular distance increased between 25% and 100% more than in the normal shoulder; type IV, complete dislocation with posterior displacement of the distal clavicle into or through the trapezius muscle; type V, increase of the coracoclavicular distance from 100% to 300% as compared with the normal shoulder, including disruption of the delto-trapezius fascia; and type VI, complete dislocation with inferior displacement of the distal clavicle into a subacromial or subcoracoid position.15
Historically, the diagnosis of AC joint injuries has relied upon radiographic evaluations, which include the anteroposterior Zanca view with a 10° to 15° cephalic tilt of the x-ray, and an axillary view, which helps to reveal any posterior displacement of the distal clavicle.5-7,9-12 For most of the cases, the diagnosis is properly made, and adequate treatment can be advocated. However, Rockwood type IV AC joint dislocations can frequently be misdiagnosed.10,11 This is related to the lack of standardization for axillary views, with no clear published recommendations regarding the position of the patient when the radiograph is taken and no objective measurements to define the pathological lesion. Moreover, patients with an acute AC joint injury may suffer discomfort while being positioned for this view, which can alter the correct position of the cassette and result in a poor-quality radiograph.7 All of these factors can cause a misclassification of these injuries. Erroneous categorization of AC joint dislocations may lead to inadequate management of the lesion with subsequent poor functional results for the patient.

Because of this diagnostic variability among observers, some authors have proposed the use of computed tomography, magnetic resonance imaging (MRI), or even dynamic or stress radiograph projections of the AC joint, instead of plain radiographs, to certify the degree and direction of the clavicle’s displacement and the stabilizing ligaments’ status.1,3,4,12,13,16,18 In spite of this, plain radiographs continue to be the initial, most useful test for these injuries because of their wide availability and low cost.3,4,16 As a result of our experience, a widening of the AC joint’s clear space in comparative Zanca views has been systematically noticed in posterior AC joint dislocations. Although often discussed among surgeons, to our knowledge, this phenomenon has never been mentioned in the literature. The purpose of this study was to introduce and to validate a novel radiographic index, in plain bilateral Zanca views, for the accurate diagnosis of posterior AC joint dislocations.

MATERIALS AND METHODS

An analytic, descriptive study in 150 patients with different types of AC joint injuries, according to the Rockwood classification (30 patients for each type of injury: I, II, III, IV, and V), was performed at the authors’ institutions between 2004 and 2011. The data were collected retrospectively. The inclusion criteria were adult patients (aged ≥18 years) with a recent unilateral AC traumatic event who arrived at the emergency room and underwent complete and standardized radiographic assessments. Patients with a degenerative disease of the AC joint or associated acromion, coracoid, or clavicle fractures, or a previous AC joint surgery were excluded from this study.

The diagnosis of an AC injury was made both clinically and radiographically by using comparative Zanca and ipsilateral axillary views. For the bilateral Zanca view, each patient was standing upright at a distance of 1 to 1.2 m from the x-ray tube, with his or her back against a hard surface to keep a straight position of the spine and shoulders (Figure 1). For the axillary view, the patient was in the sitting position, and the affected shoulder was abducted as close to 90° as possible until pain was felt, with the x-ray tube located at approximately 0° to 20° of lateral inclination depending on the abduction achieved by the patient (Figure 2).

The coracoclavicular distance in both shoulders was digitally measured (Synapse Enterprise, FUJIFILM Medical Systems USA Inc, Stamford, Connecticut) in the anteroposterior view, as advocated by Rockwood, and registered for each patient (Figure 3). In the same view, we measured the new AC width index: to obtain this index, the observer has to mark the upper most lateral aspect of the clavicle and the upper most medial aspect of the acromion in both shoulders (Figure 4A). A straight vertical line is then drawn from these 2 marks, parallel between each other, and the distance between them is measured in each shoulder, determining the AC width (Figure 4B). The width index is then calculated by the following formula:

\[
\frac{(\text{Width of Injured Side} - \text{Width of Normal Side})}{\text{Width of Normal Side}} \times 100\%.
\]

This index was calculated for each patient. The presence or absence of posterior displacement of the clavicle was also
assessed in the axillary view (Figure 5). Type IV and V injuries were treated surgically, and the diagnosis was reconfirmed intraoperatively.

To validate the intraobserver and interobserver agreement of this new index, we impartially selected 40 cases with Rockwood classifications type I (n = 3), type II (n = 3), type III (n = 8), type IV (n = 20), and type V (n = 6). Three independent observers, who were blinded to patient data, were trained to use the width index. The observers included a first-year orthopaedic surgery resident (observer 1), a general orthopaedic surgeon with 3 years in practice (observer 2), and a shoulder surgeon with more than 5 years of experience (observer 3). Each observer classified the cases according to the Rockwood classification but complemented the “classic” coracoclavicular measurement with this new diagnostic tool. Measurements were performed on printed radiographs with the same graded ruler on 2 separate days separated by 1 week and the observers registered their classification of the injuries on both occasions. A blinded researcher changed the order of appearance but kept the same cases for the second evaluation.

Statistical Analysis

Descriptive statistics with paired and unpaired t tests and the Bonferroni test were used to analyze the overall data. To validate the classification of groups in relation to the magnitude of the width index, we used a logistic regression and linear regression model. The accuracy of the width index was evaluated using receiver operating characteristic (ROC) curve analysis. A P value <.05 was considered statistically significant.

For all statistical analyses, plain variable descriptions of Rockwood types I to V and the percentage values of the width index were used. To validate this new index, the κ index of agreement for intraobserver and interobserver reliability was used. All analyses were performed with the data analysis and statistical software Stata V11.0 (StataCorp LP, College Station, Texas).

The institutional review board approved the study. However, because of the nature of our study in which the clinical data were anonymous and the radiographs and surgical procedures for each case were indicated for medical purposes, with no investigation intervention whatsoever, no informed consent was collected for this study.
RESULTS

The AC width index for each group is expressed in Table 1. All of the groups were validated with logistic regression \( (P < .05 \text{ in each group}) \). The width index for type IV lesions (posterior AC joint dislocations) was significantly higher when compared with the other types of injury by using linear regression \( (P < .05) \).

Accuracy of the Index

The ROC curve (Figure 6) showed that a width index of 60% has a sensitivity of 95.7% and a specificity of 97.5% and a positive predictive value of 96.7% and a negative predictive value of 95.6% for the diagnosis of a type IV AC joint dislocation.

Intraobserver and Interobserver Reliability

The intraobserver reliability was rated as substantial agreement for each of the 3 observers (\( \kappa \) values = .68 [observers 1 and 2], .64 [observer 3]). The interobserver reliability of the 3 independent raters for the width index was almost perfect, with a \( \kappa \) value of .82.

DISCUSSION

The key factor to properly approach an AC joint injury is its adequate classification. If an injury is misclassified, incorrect treatment will be advocated, with poor final functional results.\(^8,14\) One of the most common problems when classifying an AC joint injury is that posterior dislocations may be inconsistently detected on plain radiographs.\(^{18}\) Multiple factors can be related to this phenomenon and could be divided into 2 groups: first, problems related to the radiographic technique, and second, problems related to the interpretation of the images.

Problems related to the radiographic technique include improper positioning of the patient or the cassette, which may be caused by great patient discomfort while taking these views in the acute setting. Problems related to the interpretation of the radiographs include the lack of an objective definition of AC joint displacement in the axillary views; frequent anatomic variations between patients or within the same individual patient, which may considerably influence the radiological relations between the distal clavicle and the acromion; and a poor concordance between observers.

Some authors agree that a plain radiographic assessment of an AC joint dislocation is too limited, proposing the use of stress or dynamic radiograph views. Regarding this issue, Alexander\(^1\) described a modified stress lateral view to demonstrate the displacement of the clavicle that occurs when true ligament disruption is present. With the patient sitting or standing, the shoulders are thrust forward at the time when the radiograph is taken. In cases of AC ligament disruption, the distal clavicle is superiorly displaced and overlaps the acromion. Even with this special lateral stress view, the problems of drooping of the shoulder and subsequent anteroinferior rotation of the scapula and patient discomfort in the acute setting have to be considered. Moreover, the original publication described just 3 cases, and there is no statistical validation of this technique.

On the other hand, Tauber et al\(^{18}\) proposed a supine, dynamic axillary lateral shoulder view with the arm in 90° of abduction and 60° of flexion and extension to detect horizontal instability of the distal clavicle in patients with acute AC joint dislocations. The researchers described a new angle defined as the glenoacromioclavicular angle (GACA), which is measured in the axillary view with the shoulder in 2 different positions. A GACA difference of 12.3° is associated with a sensitivity of 93% and a specificity of 92% for the diagnosis of posterior AC joint instability. However, the GACA is measured in the axillary view, which is often poorly standardized. Moreover, to obtain the different views, the patient has to move the abducted injured shoulder into different positions, which will be painful in the acute setting, and more views imply more irradiation for the patient and a higher cost. In our study, using only 1 bilateral Zanca view, we found that with a width index of \( \geq 60\% \), we could recognize a posterior dislocation of the AC joint with a sensitivity of 95.7% and

<table>
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<tr>
<th>Type of AC Joint Injury</th>
<th>Average Width Index, %</th>
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<tr>
<td>I</td>
<td>2.1 (–12 to 25)</td>
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<tr>
<td>II</td>
<td>4.2 (–19 to 29)</td>
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<tr>
<td>III</td>
<td>19.1 (–59 to 91)</td>
</tr>
<tr>
<td>IV</td>
<td>110.3 (47 to 181)</td>
</tr>
<tr>
<td>V</td>
<td>–3.8 (–71 to 62)</td>
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\(^a\)Injury categorized according to the Rockwood classification. AC, acromioclavicular.

Figure 6. Receiver operating characteristic (ROC) curve showing a high sensitivity and specificity when the width index is at least 60%.
a specificity of 97.5%. The widening observed in type IV injuries could be explained by the fact that posterior displacement of the clavicle generates a “shortening” of the clavicle in anteroposterior views, increasing the distance between the lateral aspect of the clavicle and the medial aspect of the acromion when compared with the uninjured side, but this is only a theory. However, this index is easily measured in plain Zanca views, with high intraobserver and interobserver concordances, and does not require the patient to adopt difficult or painful positions. Furthermore, with this novel index, the axillary view could be obviated, bearing in mind that the very uncommon coracoid fracture, usually recognized in this view, could be misdiagnosed.

There are other radiographic stress views for AC joint injuries utilizing weights with wrist straps, but apart from adding discomfort to the patient the real utility of this radiographic technique has been questioned in the literature. To improve the diagnostic accuracy of AC joint dislocations some authors have proposed that MRI should be routinely performed. Nemec et al reported a 52.2% correlation between radiographs and MRI after evaluating 40 patients with type I to IV AC joint dislocations.

Although MRI can accurately show both osseous and soft tissues involved with an AC joint and directly detect ligament injuries, it is well known that it may also overestimate these lesions, inducing other types of error in the diagnosis. Additional drawbacks of routinely taken MRI scans are the elevated cost and the limited availability of this examination.

Computed tomography can aid in the proper diagnosis of acute AC joint injuries. Nevertheless, if we consider that, at the present time, its accuracy has not been well validated in the literature and that it can expose patients to a high dose of radiation when compared with simple radiographs, we cannot recommend its routine use in the clinical setting as a first-line diagnostic tool.

To our knowledge, plain radiographs are still considered to be the most common diagnostic method defined in the literature. However, one major drawback of any diagnostic study of AC joint injuries is defining the “true positive” type IV injury. Our study is not the exception. We used plain radiographs and intraoperative findings as our method of confirming the proper diagnoses of type IV and V injuries, but we are aware that there is a chance that we might have missed “true” type IV injuries in the nonoperative group. Interestingly, we found a higher interobserver agreement than an intraobserver agreement, which means that the observers made the same misdiagnoses, agreeing even when being wrong. A high interobserver agreement, however, suggests a high reliability of this index.

The AC joint width index is a novel tool that can complement the classic measurements used in the Rockwood classification of AC joint injuries. It is simple to use, with low discomfort, low cost, and minimum irradiation for the patient. Its high accuracy and intraobserver and interobserver concordance may help to identify patients who need surgical treatment by indirectly detecting posterior AC joint dislocations independent of the grade of vertical displacement of the distal clavicle in the coronal plane. Further prospective clinical studies are needed to demonstrate this issue.

REFERENCES