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Original article

Reliability of radiographic measurements for acromioclavicular joint separations

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ABSTRACT

Introduction: The treatment of acromioclavicular (AC) joint separations is controversial, particularly for Rockwood type III injuries. Rockwood type IV injuries, which correspond to horizontal instability, are very likely under-diagnosed. The objective of this study was to evaluate the inter- and intra-observer reproducibility of the Rockwood classification through an evaluation of standard radiographs, as described in the original article.
Material and methods: This was a prospective radiographic study using protocol-based data from the 2014 symposium of the French Society of Arthroscopy (SFA). Fifteen anonymized radiological records were analysed by six independent examiners on two occasions, 1 week apart. The records consisted of a comparative A/P view of the two acromioclavicular joints (Zanca view), an axillary lateral view and dynamic lateral views (Tauber protocol) to uncover dynamic horizontal instability. A detailed analysis protocol was implemented that included absolute and relative measurements on each view; the relative measurements were used to account for radiographic magnification.
Results: The inter- and intra-observer reproducibility on the A/P radiographs was good to excellent. The reproducibility was fair to good on the lateral views, but the measurements varied greatly from one subject to another, and significant errors were found with certain records. The reproducibility of the dynamic views proposed by Tauber was poor to fair.
Discussion: Radiographic analysis of AC joint separations is reproducible in the vertical plane, which makes it possible to diagnose Rockwood type II, III and V injuries. On the other hand, static and dynamic analyses in the horizontal plane do not have good reproducibility and do not contribute to make an accurate diagnosis of Rockwood type IV injuries.
Level of evidence: Level I, Diagnostic study.

1. Introduction

The treatment of acromioclavicular (AC) joint separations is controversial. Most recent studies have focused on comparing various treatment options. Several classification systems are available to help a physician during the decision-making process. But to be effective, a classification system must be reproducible and lead to a treatment decision. The most commonly used system is the one first described by Rockwood in 1984 [1]. This classification is based on two radiographic views: the Zanca view of the AC joints [2] and an axillary lateral view. This classification system has been widely adopted and is used in published studies. Rockwood's original article included 520 cases; a very small number of these cases (4/520) had a type IV injury, which correspond to horizontal instability that is theoretically detectable on the axillary lateral view [1]. This observation has been confirmed, and it is now accepted that horizontal plane (anteroposterior) instability is under-diagnosed and can negatively impact the functional outcomes [3]. Only three published studies have evaluated the reproducibility of this classification system so far [4–6].

The main controversy surrounds type III, IV, and V injuries. On radiographs, a Rockwood type III injury corresponds to a 25% to 100% increase in the coracoclavicular distance, while a type V injury corresponds to a 100% to 300% increase [1]. A type IV injury (horizontal instability) is similar to type II and III injuries on the AP view, but with posterior displacement of the clavicle (or more

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specifically, anterior translation of the scapula, since the clavicle is fixed to the sternum) visible on the axillary lateral view.

The French Society of Arthroscopy (SFA) symposium in 2014 specifically reviewed the results of various treatment options for acute and chronic AC separations. This led us to explore our ability to reproducibly analyse vertical and horizontal plane displacements on standardized radiographic views, using a well-defined protocol-based on published measurements methods.

The primary hypothesis of this study was that measurements made on standardized radiographs were reproducible between and within observers. The secondary hypothesis was that a patient's Rockwood injury type could be determined with certainty using his/her radiographic record.

2. Material and methods

This was a prospective radiographic study using a radiological protocol defined for the 2014 SFA symposium. This protocol, which was based on published data, sets out exactly how the radiographs should be performed. A set of 15 radiographic records were then selected from the symposium database that each included:

- an AP view of both clavicles as described by Zanca [2];
- an axillary lateral view as described by Bernageau and Patte [7];
- dynamic axillary lateral radiographs with the arm in 0° and 60° forward flexion [8].

The Zanca view [2] was performed with the patient's arm hanging down and the X-ray beam tilted upward 10°; the source was placed as far back as possible so that both shoulders were in the same radiographic field of view.

The Bernageau view [7] was performed with the patient standing at a 60° angle to the plate and the forearm resting on the head [9], with the X-ray beam tilted downward 30°. In a valid image, the anterior and inferior two-thirds of the glenoid are superimposed over the coracoid process and the glenoid surface is oriented laterally.

The dynamic lateral views described by Tauber et al. [8] were performed with the patient supine and the arm abducted 90°; the X-ray beam was aimed at the axillary fossa and the cassette placed on the superior aspect of the shoulder. Two images were taken, one with the arm at 0° of forward flexion and one with 60° of flexion. As explained in the original article, this view helps to expose dynamic horizontal (AP plane) instability to make sure that Rockwood type IV injuries are not missed.

A comprehensive analysis protocol was defined before starting the study. The radiographs were digitized, made anonymous and then placed in a shared online folder (Dropbox Inc., San Francisco, CA, USA). An OsiriX DICOM viewer (Pixmeo, Switzerland) was used during the analysis. A detailed written and visual tutorial was made available to each participant (observer) and explained during a virtual meeting to eliminate any misunderstanding.

On the Zanca view, the coracoclavicular (CC) distance was measured on both sides and the ratio of injured to healthy CC calculated. This relative value was used to get around measurement variations related to distance from the source (Fig. 1). The D/A ratio was also calculated on the injured and healthy sides using this same view. This made it possible to evaluate the vertical displacement of the acromion relative to the clavicle, based on the thickness of the acromion. This measure is important because a type II injury in the Rockwood classification is defined as one where the vertical displacement is less than half the acromion's thickness. In a type III injury, the displacement is equal to the acromion's thickness, while in the type V injury, it is greater than its thickness. A reference line was drawn through the inferior margin of the acromion.

Fig. 1. Measurement of CC distance and ratio between healthy CC and injured CC.

Distance "A" was the height of the acromion, between its inferior and superior margins. Distance "D" was the distance between the line through the inferior margin of the acromion and a parallel line passing through the lowest and most lateral point on the clavicle. A D/A ratio of 2 corresponded to vertical displacement of 200% of the acromion's height, where the clavicle is on the superior margin of the acromion, as described by Rockwood [1] (Fig. 2). We also found a published measurement analogy that was based on Rockwood's original description [5].

On the axillary view, we calculated the X/Y ratio of the acromion's horizontal displacement relative to the clavicle, consistent with our goal of not using absolute values. This measurement was based on the Rahm and Gerber article published in 2013 [10]. The goal was to quantify horizontal instability. The first reference line was drawn through the middle of the outer quarter of the clavicle. Next, a parallel line was drawn through the most anterior and lateral margin of the clavicle to define the "Y" distance. A third line, parallel to the other two, was drawn through the most anterior margin of the acromion; this line was used to calculate distance "X", between the anterior edge of the acromion and the anterior edge of the clavicle (Fig. 3).

For the dynamic axillary lateral views defined by Tauber et al. [8], the gleno-acromio-clavicular angle (GACA) was calculated between a line passing through the glenoid articular surface and a line passing through the anterolateral borders of the clavicle and acromion. These views were taken with the arm in 0° and 60° flexion (Fig. 4).

To obtain sufficient statistical power, the symposium's statistician recommended having six independent observers (three senior surgeons and three residents in their final year) from five different healthcare facilities perform the radiographic analysis twice, 1

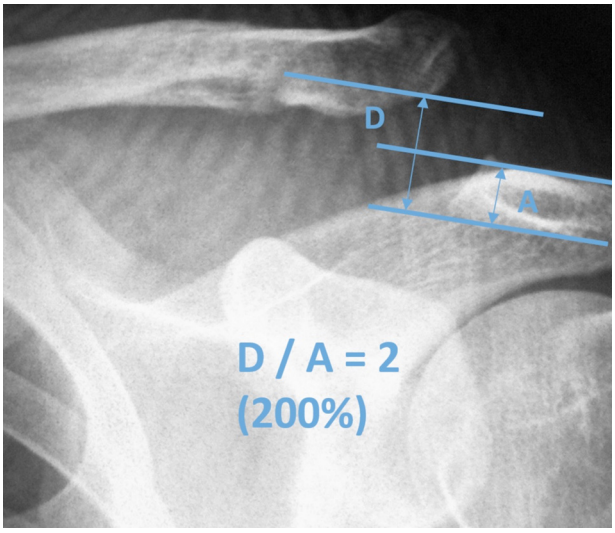

Fig. 2. Measurement of D/A ratio; in this example, the ratio is 2, which corresponds to a 200% vertical displacement.