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ORIGINAL ARTICLE

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Standardized ultrasound examination for evaluation of instability of the acromioclavicular joint

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Abstract Anteroposterior X-ray views of both acromioclavicular (AC) joints with 10-kg weights held in each hand are the generally accepted procedure for diagnosis of Tossy I–III grades of AC joint separation. An analogous diagnosis can be made by standardized ultrasound examination. Ten individuals with Tossy-I, 11 with Tossy-II and 8 with Tossy-III instability were examined both radiographically and by B-mode ultrasound. The degree of AC joint separation was uniformly determined on the basis of a calculated index (AC Index = AC joint width of uninjured side/AC joint width of injured side). The mean AC Index for Tossy-I instability determined by ultrasound was 1.0; mean indices of 0.49 and 0.5 were determined for Tossy-II injury by ultrasound and X-ray, respectively, and of 0.21 and 0.2, respectively, for Tossy-III instability. Statistical analysis showed significant differences between the mean AC indices of all three groups ($P < 0.0001$). We conclude that the reliability of ultrasound examination of AC joint instability is equal to that of radiographic measurement. Standard X-rays of the shoulder remain mandatory only to exclude fracture. The indication for operative stabilization of the AC joint can be established on the basis of the grade of AC joint instability measured by the side-effect-free and cost-effective method of ultrasound examination (AC Index < 0.3 equivalent to Tossy-III instability).

Introduction

With the increasingly widespread use of diagnostic ultrasound for the evaluation of injuries of the musculoskeletal system, ultrasound examination has also been described as a new, side-effect-free and cost-effective procedure for examination of the injured acromioclavicular (AC) joint [9]. However, for methodological reasons, there has so far been no precisely quantifiable ultrasonographic procedure analogous to the conventional radiological panorama views of the shoulder girdle with 10-kg weights held in each hand, which permitted a therapeutically relevant classification of AC joint injuries according to the grades Tossy I–III. Thus, AC joint instability could not hitherto be divided ultrasonographically into different grades of severity as a basis for deciding on conservative or surgical management of the injury corresponding to the radiological classification described by Tossy [10].

A newly developed ultrasound procedure (quantitative measurement of the injured AC joint in relation to the patient's uninjured AC joint) is examined here in comparison with the X-ray procedure (panorama view with 10-kg weights) currently regarded as the standard method. The two procedures are compared with regard to their practical diagnostic value for establishing the indication for surgical AC joint stabilization.

Patients and methods

Patients

At the Department of Trauma Surgery of Essen University Hospital, we have, since 1991, performed ultrasound examination of the AC joint according to the hitherto usual procedure in the frontal plane only [3, 4]. This gave rise to further questions as to the possibility of standardization and quantification of ultrasonography and led to the examination of normal subjects and patients with acute and chronically unstable AC joints of varying severity according to Tossy I–III described below.

In the Tossy-I group, the AC joints widths of 10 normal subjects without measurable AC joint instability (5 men, 5 women, right-handed) were determined ultrasonographically by a single investigator by contralateral comparison. The AC joint widths of 11 patients with radiographically demonstrated Tossy-II instability of the AC joint (8 men, 3 women) were measured sonographically and radiographically by two different investigators. In the group of 8 patients with Tossy-III type injuries, the widths of the AC joints with complete joint instability (6 men, 2 women) were also determined ultrasonographically and radiographically by two different investigators.

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Methods of measurement

The ultrasonographic examinations and measurement of AC joint widths were carried out with a 7.5-MHz linear transducer (ultrasound scanner Al 3200, Dornier Deutsche Aerospace). A P66 videoprinter (Mitsubishi) was used for documentation of the findings. As the reference method, routine panorama X-rays of the shoulder girdle with 10-kg weights held in each hand were performed in all patients with Tossy-II- and Tossy-III AC joint injuries. A commercial joint goniometer was used for measurement of the radiographic AC joints widths by contralateral comparison [11].

The AC joint widths in millimeters measured sonographically (Figs. 3a, 4a, 5a) and radiographically (Figs. 3b, 4b, 5b) on both sides in all cases were used to calculate the AC Index (= quotient of AC joint width in mm on the injured side/AC joint width in mm on the normal side). A statistical analysis of variance was carried out for the mean indices of the three groups Tossy I–III.

Examination procedure

The ultrasound examination begins with the patient seated with his arms hanging down. By definition, the clavicle is always shown on the left side of the sonographic image [3]. The examiner sits or stands behind the patient and begins the examination on the uninjured side by determining the AC joint width in the frontal plane. This is followed by examination of the injured AC joint, first in neutral position and then with the arm adducted. Finally, examination of the injured and the uninjured joints is repeated with the relaxed patient standing and holding a 10-kg weight in each hand. The width of each AC joint is measured from the most lateral cortex reflex of the clavicula to the most medial cortex reflex of the acromion and the two sides compared at the shortest distance between acromion and clavicle.

Statistical methods

The 'index values' based on side comparison showed sufficiently normally distributed values. Therefore, statistical description and tests could be done parametrically using arithmetic mean, standard deviation and one-way analysis of variances with the multiple comparisons test according to Scheffe [2].

Results

Tossy I group

In the group of 10 normal subjects the mean AC joint width measured by ultrasound while holding 10-kg weights was 5.3 mm (4.6–5.9 mm) on both the left and the right sides (Table 1, Figs. 1–3). The mean quotient of the right and left sides (AC index) and its reciprocal were 1.0 (0.96–1.07; SD 0.04).

Tossy II group

In the group of 11 patients with Tossy-II instability of the AC joint (Fig. 4) the mean AC joint width measured by ultrasound while holding 10-kg weights was 4.6 mm (3.0–8.0 mm) on the uninjured side and 10.2 mm (5.8–18.0 mm) on the injured side. The mean quotient of the uninjured and injured sides (AC Index) was 0.48 (0.23–0.78; SD 0.18).

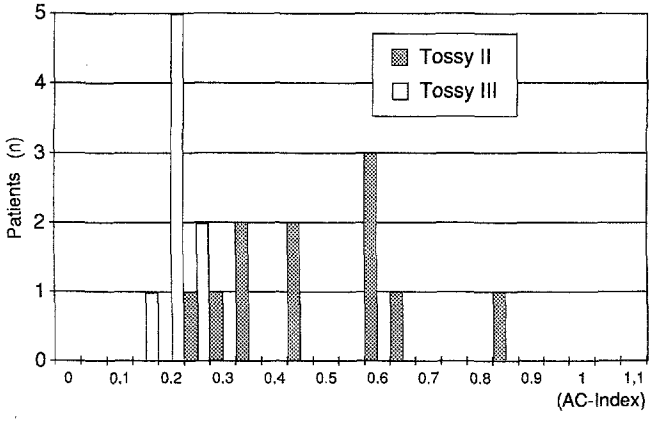


Fig. 1 Calculation of acromioclavicular (AC) Indices (AC joint width of the uninjured side/AC joint width of the injured side) in patients with radiographically shown Tossy II and III instability

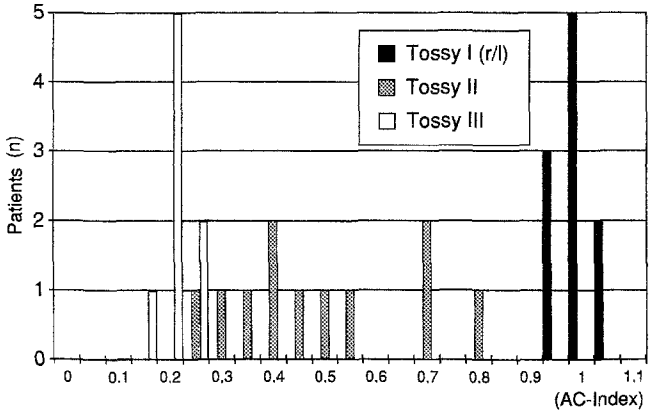


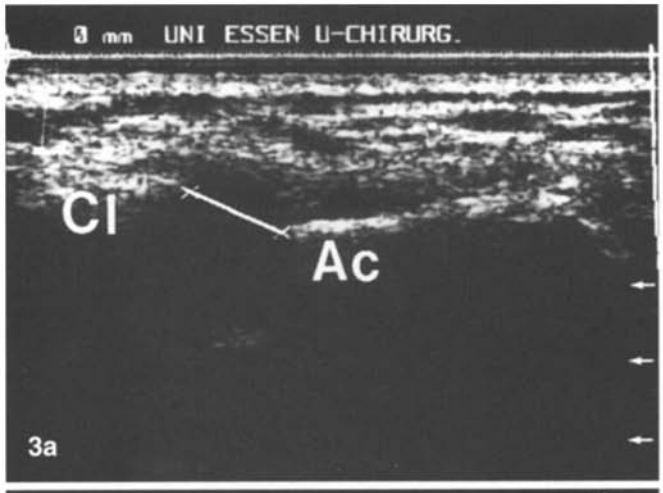
Fig. 2 Calculation of AC Indices in patients with sonographically shown Tossy I, II and III instability

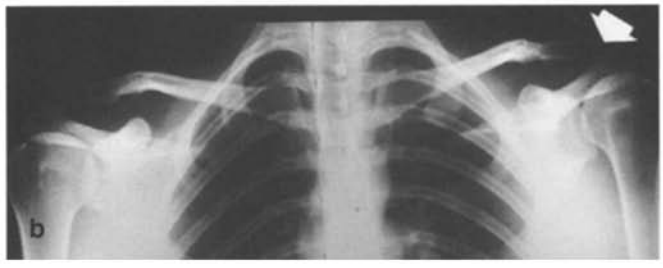
In this group the measurements made on the X-ray panorama views showed a mean width of 4.3 mm (3.0–6.0 mm) for the uninjured side and of 9.6 mm (5.0–18.0 mm) for the injured side. The mean quotient of the uninjured and injured sides (AC Index) was 0.5 (0.23–0.83; SD 0.19).

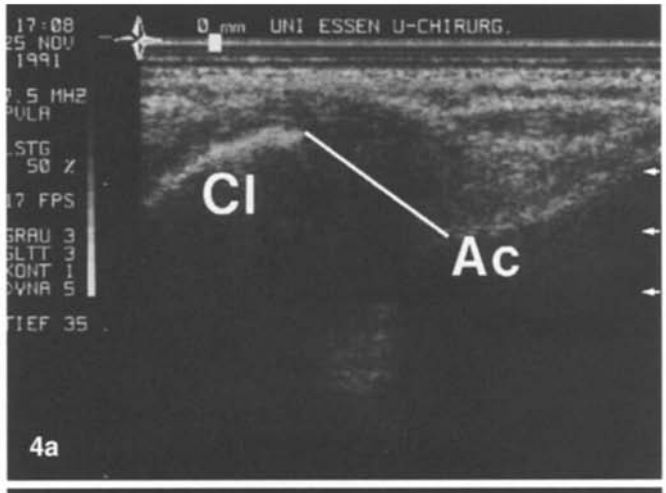
Tossy III group

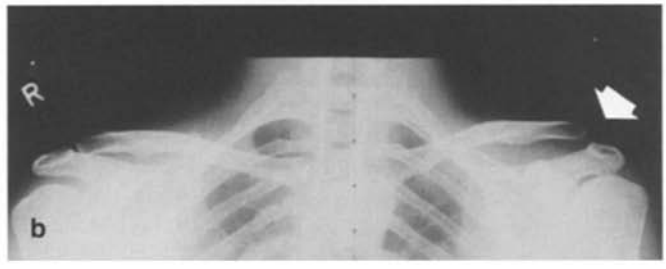
In the group of 8 patients with Tossy-III instability of the AC joint (Fig. 5), the mean AC joint width measured by ultrasound while holding 10-kg weights was 4.5 mm (3.0–5.5 mm) on the uninjured side and 22.3 mm (19.0–27.0 mm) on the injured side. The mean quotient of the uninjured and injured sides (AC Index) was 0.2 (0.13–0.24; SD 0.03).

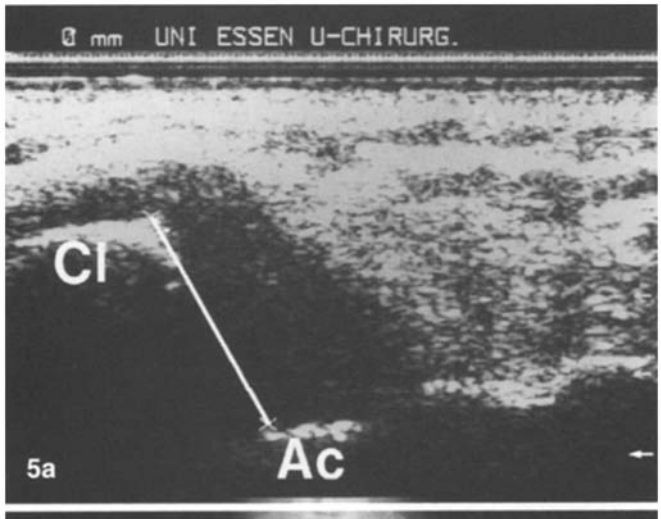
The measurements made on the X-ray panorama views in this group showed a mean width of 4.4 mm (3.0–5.0 mm) for the uninjured side and of 22.6 mm (19.0–26.0 mm) for the injured side. The mean quotient of the uninjured and injured sides (AC Index) was 0.2 (0.13–0.23; SD 0.03).











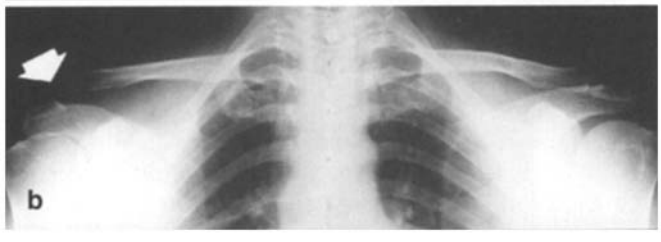


Fig. 3 **a** Ultrasound scan of a patient with Tossy I AC joint injury (7.5-MHz transducer; *Cl* clavicle, *Ac* acromion). The sonographically measured AC joint width is 5.1 mm for the injured left AC joint. **b** Conventional radiological panorama view of the same patient (*arrow* indicates injured left side)

Fig. 4 **a** Ultrasound scan of a Tossy II AC joint injury. The sonographically measured AC joint width of the injured left side is 13 mm. **b** Conventional radiological panorama view of the same patient (*arrow* indicates injured left side)

Fig. 5 **a** Ultrasound scan of a Tossy III AC joint injury. The sonographically measured AC joint width of the injured right side is 24 mm. **b** Conventional radiological panorama view of the same patient (*arrow* indicates injured right side)

Parametric one-way analysis of variance as well as Scheffe multiple comparison test between the separate groups of the sonographic data (Tossy I, II and III groups) showed significance between them ($P < 0.0001$).

Discussion

Comparison of ultrasonography and radiography

Since the first description of a pilot study on arthrosonography in the diagnosis of Tossy injuries of the AC joint [9], there have been occasional reports of clinical ex-

Table 1 Acromioclavicular (AC) joint distance (mean; range) in sonographically and radiographically measured Tossy I–III instability

Patient	Sonography			Radiography		
	Uninjured side [mm]	Injured side [mm]	AC Index	Uninjured side [mm]	Injured side [mm]	AC Index
Group Tossy I						
1	5.9	5.9	1			
2	4.9	5.1	0.96			
3	5.5	5.5	1			
4	5.9	5.5	1.07			
5	5.1	5.3	0.96			
6	5.1	5.3	0.96			
7	5.8	5.5	1.05			
8	5.5	5.5	1			
9	4.6	4.6	1			
10	4.6	4.6	1			
Mean ± SD	5.3 ± 0.4	5.3 ± 0.4	1 ± 0.04			
Range	4.6 – 5.9	4.6 – 5.09	0.96 – 1.07			
Group Tossy II						
1	4	13	0.31	4	13	0.31
2	3	7	0.43	3	5	0.6
3	4.5	5.8	0.78	4	6	0.67
4	5.4	7.5	0.72	5	8	0.63
5	6	8.8	0.68	5	6	0.83
6	4.2	8.7	0.48	5	8	0.63
7	3	13	0.23	3	13	0.23
8	8	15	0.53	6	14	0.43
9	6	18	0.33	6	18	0.33
10	3.2	7.9	0.41	3	8	0.38
11	3	7.6	0.39	3	7	0.43
Mean ± SD	4.6 ± 1.6	10.2 ± 3.9	0.48 ± 0.18	4.3 ± 1.19	9.6 ± 4.17	0.5 ± 0.19
Range	3.0 – 8.0	5.8 – 18.0	0.23 – 0.78	3.0 – 6.0	5.0 – 18.0	0.23 – 0.83
Group Tossy III						
1	5.1	27	0.19	5	26	0.19
2	5.5	23	0.24	5	24	0.21
3	4.8	22.5	0.21	5	23	0.22
4	3	24	0.13	3	24	0.13
5	4	19	0.21	4	19	0.23
6	4.3	21	0.20	4	22	0.18
7	5.1	22	0.23	5	22	0.23
8	4.5	20	0.23	4	21	0.19
Mean ± SD	4.5 ± 0.79	22.3 ± 2.5	0.2 ± 0.03	4.4 ± 0.73	22.6 ± 2.1	0.2 ± 0.03
Range	3.0 – 5.5	19 – 27	0.13 – 0.24	3.0 – 5.0	19 – 26	0.13 – 0.23

periences which are, however, limited mainly to the description of various examination procedures using different ultrasound transducers [1, 6, 8]. In view of the relatively infrequent occurrence of AC joint separation, which accounts for about 4% of all injuries of the musculoskeletal system, this is not surprising. In addition, ultrasound examination of injuries of the musculoskeletal system in trauma surgery and orthopaedics has only recently become more widespread, so that along with the relative rarity of AC joint injuries, the examination of large cohorts has hardly been possible to date.

The quantitative measurements of AC joint instability described so far by the respective first authors all take into account the maximum notch in the contour of the AC joint in millimeters as a reliable parameter for the extent of AC instability. In a further paper the extent of AC joint instability was precisely objectified by additional measurement of the coracoclavicular (CC) distance in the standardized examination procedure with the patient holding weights [1]. In our opinion, this procedure involving ultrasound examination in two planes is rather elaborate, and the use of a high-resolution 7.5 MHz linear array transducer for exact visualization of the CC distance often presents problems even in non-obese patients. We therefore decided to limit ourselves to examination only of the AC joint in the frontal plane using a 7.5-MHz transducer [5].

Despite the advancing development of the standardized sonographic examination procedure in the last 5 years, the

problem of exact classification into the therapeutically significant types Tossy I, II and above all III, with the indication for surgery derived from this degree of injury, still remain unsolved. Many hospitals therefore continue to use panorama views with weights as a standard additional procedure for determination of AC joint instability following exclusion of fracture of the injured shoulder by X-rays in two planes. Radiographic classification of AC instability is generally considered the established and easily performed decision aid for clinical therapy [7, 11]. On the other hand, the radiation exposure and the costs and time required for the examination are indisputable disadvantages of the radiographic procedure.

Classification by ultrasound

Our results show that the problem of exact ultrasonographic classification of the severity of AC joint injury in analogy to the radiological classification Tossy I–III can now be solved by expressing the AC distances measured on the injured side in relation to those on the uninjured side (AC Index).

The measurements obtained by radiographic and ultrasonographic examination of patients with radiologically confirmed Tossy II and III injuries show that, with the quantification of AC instability in the form of the described AC Index, we have for the first time a sufficiently precise parameter for classification of the instability of the injured AC joint as measured by ultrasound alone in analogy to the classification based on radiographic parameters [10, 11]. By relating the values to the measurements on the uninjured side, the index also takes into account individual features in the respective patient such as differences in height and ligament laxity.

Critical evaluation

Assuming corroboration of our results in larger patient cohorts with AC joint injuries, the customary panorama X-rays of both shoulder joints while holding weights in each hand can be dispensed with completely and replaced by ultrasound examination with 10-kg weights held in the hand. Thus, the use of ultrasound examination for distinguishing between stable and unstable AC joints appears to be a cost-effective examination procedure with a low rate of side-effects which causes little discomfort to the patient. Moreover, the accuracy of the method in distinguishing between the various grades of injury is similar to that achieved by X-ray examination. The examination technique and the calculation of the degree of instability on the basis of the AC Index are simple, easy to learn and clinically applicable. The use of ultrasound for measurement of joint stability limits the radiation exposure necessary for complete diagnosis to that resulting from the shoulder X-rays in two planes required for exclusion of fracture.

In conclusion, the procedure of ultrasound examination of the AC joint presented in this paper has the following practical implications:

1. Standardized ultrasonographic examination of AC joint stability by contralateral comparison holding weights in the hands has an informative value equal to that of the Tossy classification.
2. X-rays are only necessary for exclusion of fracture on the injured side.
3. The indication for surgical stabilization of the AC joint can be established by ultrasound determination of the degree of instability (AC Index < 0.3, corresponding to Tossy III instability).
4. Ultrasound examination is free of side effects and cost-effective.

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