6 Evaluation of the Stability and Function of the Sternoclavicular and Acromioclavicular Joint

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6.1 Acromioclavicular Joint

6.1.1 Introduction

Acromioclavicular joint (ACJ) injuries account for 11–12% of all shoulder injuries in the overall population, with the highest prevalence in 20- to 30-year-old male patients in high contact sports [1–3]. Indications for surgery remain highly variable among surgeons and are based on evaluation of clinical examination and patients' concern regarding cosmetic deformity of the shoulder [4]. Thus, a detailed physical examination completed with accurate diagnostic imaging is needed in order to decide between a non-operative care or an interventional procedure. Rockwood described the worldwide best accepted radiographic classification system based on six injury types (Rockwood I–VI) [5]. Non-operative treatment is recommended for patients with type I or II ACJ injury according to the Rockwood classification [6] while high-grade instabilities such as type IV to VI may be addressed surgically. However, it remains under debate if patients with type III injuries benefit from either treatment, with non-operative or surgical treatment showing good, comparable outcomes [7–11]. Thus, in 2014, the Upper Extremity Committee of the International

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Table 6.1 Diagnostic tests for ACJ and SC Joint instabilities

Diagnostic test	Description	Positive test
O'Brien-Test	1. Patient's arm in 90° of forward flexion with the examiner positioned behind the patient 2. Passive adduction into 10–15° of adduction in complete internal rotation 3. Applying force toward the floor and the patient attempts to resist the downward force	Pain at the ACJ
Hawkins-Kennedy Test	1. Patient's arm in 90° of forward flexion with the elbow flexed to 90° and fixed scapula 2. Internal rotation of the glenohumeral joint	Pain when arm is brought into internal rotation
Cross-body Test	1. Patient's arm is passively abducted in 90° (Fig. 6.5) 2. Cross arm across the patient's chest with arm in internal rotation	Pain when patient's arm is moved across the chest
Paxinos sign [15]	1. Examiner's hand is placed on the affected shoulder with the thumb under the posterolateral aspect of the acromion 2. Index and long fingers rest superior to the clavicle 3. Examiner exerts a force superiorly and inferiorly on the clavicle simultaneously	Pain upon compression of ACJ
Shoulder Shrug-Sign Test	1. Patient is asked to lift the arm to 90° of abduction without elevating the scapula	Inability to lift the arm to 90° of abduction without elevating the whole scapula
Push-Down Test	2. Examiner applies a posteriorly directed force on the medial clavicle	Pain at the SC joint
SC Joint Provocation Test	1. Examiner tries to dislocate clavicular head anteriorly by extending the abducted arm (in 90°) with the elbow in 90° of flexion	Pain at the SC joint, aggravated by any movement of the upper extremity

Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) suggested adding Rockwood IIIA and IIIB-type injuries to the historical Rockwood classification with IIIB injuries being classified as unstable ACJ with therapy-resistant scapular dysfunction and persistent horizontal instability [4]. In contrast, type IIIA injuries have been defined as stable without overriding of the clavicle on the cross-body adduction view and without significant scapular dysfunction. However, a definitive consensus regarding non-operative versus operative treatment in patients with type III ACJ injuries is still lacking [7, 8, 10, 11]. Some authors advocate that surgical intervention may be indicated in type III injuries in young, active, highly demanding athletes or manual laborers as well as chronically symptomatic patients [8, 12–14]. Non-operative treatment was shown to restore shoulder kinematics without functional impairment even in elite-level, overhead-throwing athletes [8, 12–14]. Additionally, non-operative management may lead to quicker recovery, including return to sports or work [7].

Thus, clinical examination should focus on detecting pain, vertical and/or horizontal (and rotational) instability and scapulothoracic dysfunction.

Several diagnostic tests have been described in the literature with varying sensitivity (14–79%) and specificity (26–92%) (Table 6.1) being reported [15–18]. However, specificity can be raised to 95–97% by combining two or more diagnostic tests [16, 18].

6.1.2 Clinical Evaluation

Patients should be examined in a standing or sitting position with a downward load being placed

on both arms putting an inferior directed stress on the ACJ, making any deformities more visible (Figs. 6.1, 6.2, and 6.3) [4]. Pain, swelling, and point tenderness at the ACJ can be the first indicator for traumatic pathology of the ACJ

Fig. 6.1 Patients should be examined in standing or sitting position with both arms being pulled downward with stress on the ACJ, making any deformities more visible

Fig. 6.2 Excessive external rotation may help make any deformities at the ACJ more visible

Fig. 6.3 Positive shoulder shrug sign

Fig. 6.4 Swelling and a prominent lateral clavicle can be the first indicator for traumatic pathology of the ACJ

Fig. 6.5 The cross-body test

(Fig. 6.4). As traumatic ACJ dislocations require excessive forces to the shoulder and mostly occur while by falling on an adducted outstretched hand or elbow, intra-articular injuries are found in up to 20% of ACJ Types III–V with superior labral anterior posterior lesions (SLAP) being reported by Tischer and Imhoff as high as 14% in this population [19, 20]. Thus, a thorough clinical evaluation of the shoulder including an examination for neural and vascular injuries should be performed. To this, focus should be on testing vertical and horizontal instability (Fig. 6.5). As slight persistent horizontal instability was shown to have no signifi-

cant effect on clinical outcomes, any dysfunction to the scapulothoracic joint has to be taken into account [21].

As the integrity of the acromioclavicular (AC) and coracoclavicular (CC) ligaments ensures a physiological motion of the scapula, the scapulohumeral rhythm is highly reliable on proper function of the ACJ [22–24] In high-grade ACJ (IIIB–VI) instabilities, the scapula lacks an anterior strut, and this may result in scapular malfunction such as scapular asymmetry, excessive scapular protraction and internal rotation, and/or anterior tilt [4]. Clinically, this was shown by Gumina et al., whereas almost 70% of the patients (with chronic type III injuries) presented with scapular dyskinesia, and almost 60% of those had a SICK scapula syndrome (scapular malposition, inferior medial scapular winging, coracoid tenderness, and scapular dyskinesis). Of interest, the SICK syndrome was associated with inferior shoulder function [25]. However, in the acute setting, scapular dyskinesia may be able to be assessed due to severe pain which may lead to false-negative results. Thus, any malfunction to the scapula should be assessed at a minimum of 10 days to 3 weeks following injury [4]. Additionally, local infiltration with anaesthetics is a valuable diagnostic tool as relieving pain in the ACJ allows accurate detection of scapular dyskinesia. If patients suffer from disruption of both AC and CC ligaments (Type III), physical therapy may help restore range of motion (ROM) of the glenohumeral (GH) joint as well as improve scapulothoracic rhythm. In case of therapy-resistant scapular malfunction, stabilization of the ACJ is indicated [4, 17, 26].

6.1.3 Imaging of the Acromioclavicular Joint

6.1.3.1 Radiographic Imaging

In current literature, (bilateral) Zanca or panoramic view, (dynamic) modified axillary or Alexander views, stress imaging or specific imaging such as the stryker view may be used for accurate diagnosis of ACJ dislocations [27, 28]. However, a gold standard has still not been proposed [28]. The modified Rockwood classification (Table 6.1) is widely recognized and used for (radiographic) classification of ACJ dislocations. In acute ACJ injuries, radiographs are the preferred diagnostic method due high availability, low costs, and examiner-independence [28].

6.1.3.2 Assessment of Vertical Instability

Current literature shows high inter- and intra-observer reliability for diagnosing vertical instability using bilateral panoramic view with measurement of the CC-distance according to the classification of Rockwood (Figs. 6.6, 6.7, 6.8, and 6.9) [4, 28–30]. Bilateral views allow direct visualization of both CC-distance and

Fig. 6.6 Preoperative panoramic bilateral view, allowing for direct visualization of both CC-distances and direct comparison in both in pre- and postoperative examinations

Fig. 6.7 Postoperative panoramic bilateral view using the anatomic coracoclavicular reconstruction technique according to Mazzocca and additional distal clavicle excision (due to ossifications at the lateral clavicle)

Fig. 6.8 Recurrent ACJ Instability (Rockwood IIIB, right side) after failed AC/CC-reconstruction using an arthroscopic-assisted high-tensile suture and Endobutton technique

Fig. 6.9 Postoperative plain a.p. radiograph displaying correct CC-stabilization and Endobutton position

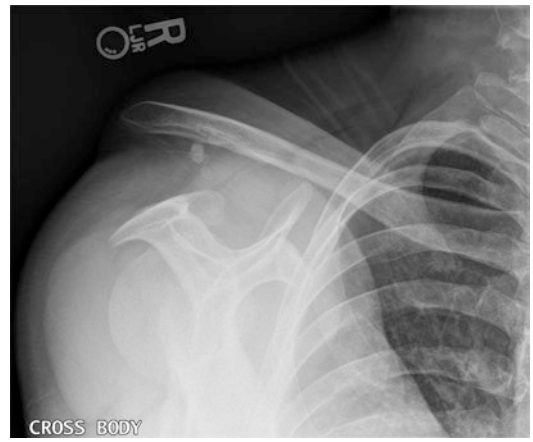

Fig. 6.10 Preoperative modified y-view (cross-body) for detection of dynamic horizontal instability. Note: heterotopic ossification around the chronic insufficient trapezoideum ligament

direct comparison in both in pre- and postoperative examinations.

6.1.3.3 Assessment of Horizontal Instability

Accurate assessment of horizontal instability is shown to be more demanding in clinical practice than vertical displacement with heterogeneous inter- and intra-observer reliability being reported [28]. This is mainly due to the fact that horizontal instability is a dynamic pathology contrary to static radiographic imaging. Therefore, bilateral cross-body adduction view, as proposed by Alexander in 1949, can detect dynamic overriding clavicle (Fig. 6.10) in high-grade ACJ (IIIB) instabilities [31]. However, axillary views (Fig. 6.11) may be more accurate for diagnosis of static horizontal ACJ instability (Rockwood IV).

Fig. 6.11 Postoperative axillary view after reconstruction of the AC-joint using the ACCR technique according to Mazzocca

6.1.4 Magnetic Tomography Imaging

Magnetic tomography imaging (MRI) can be a useful tool for detecting intra-articular injuries such as lesions to the long head of the biceps or SLAP-lesions [19, 20]. In the acute setting, MRI may not add additional significant information about vertical and horizontal instability, mostly due to the fact that the examination is performed in supine position contrary to radiographs [28]. However, if necessary, MRI can help differentiate between AC-, CC-, and/or fascia sprain or rupture.

6.1.5 Computer Tomography

Computer tomography (CT) plays a minor role in acute ACJ dislocations [28]. However, concomitant bony injuries such as coracoid or clavicle fractures can be reliable detected. In chronic situations, CT might help surgeons to detect tunnel position and/or widening, insufficient fixations in order to guarantee optimal re-stabilization (Figs. 6.12, 6.13, 6.14, and 6.15) [32–34].

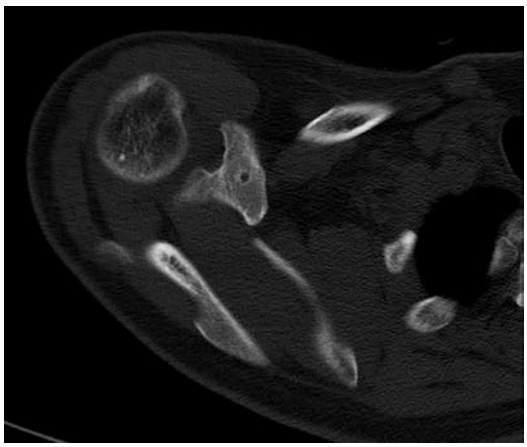

Fig. 6.12 Preoperative CT showing correct placement of the coracoid bone tunnel after recurrent ACJ instability. For this case, the coracoid bone tunnel was re-used during revision surgery

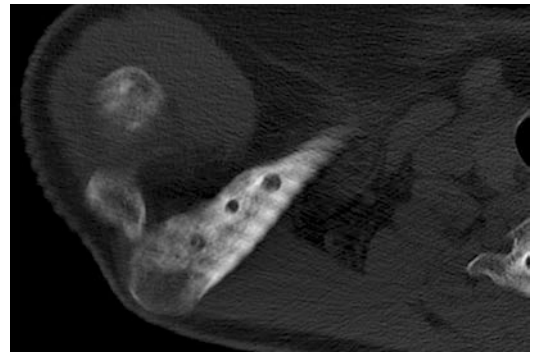

Fig. 6.13 Preoperative CT showing previous clavicular bone tunnel position and location after recurrent ACJ instability. Prior ACJ reconstruction consisted in a hybrid-technique using an allograft (similar to the ACCR technique) looped around the coracoid with an additional high-tensile suture/Endobutton reconstructing technique as an additional healing support

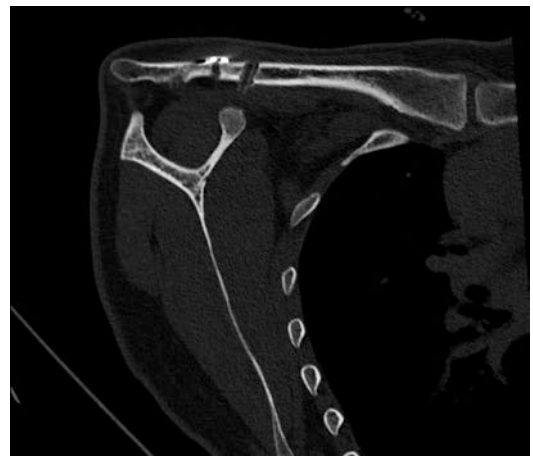

Fig. 6.14 Preoperative CT previous showing clavicular bone tunnel position, location, and tunnel width after recurrent ACJ instability

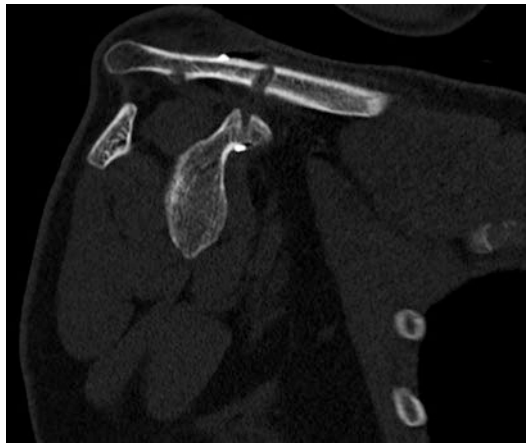

Fig. 6.15 Preoperative CT showing clavicular and coracoid bone tunnel position and tunnel width after recurrent ACJ instability

6.2 Sternoclavicular Joint

Injuries to the sternoclavicular (SC) joint account for as little as 3% of all shoulder injuries and often require high energy trauma to disrupt the SC ligaments [35, 36]. Additionally, close proximity to cardiopulmonary structures may put these structures at risk, especially when facing acute or chronic posterior SC joint dislocations. Unfortunately, injuries to the SC joint are frequently missed, as the pathomechanism of the injury repeatedly leads to more severe, dramatic injuries [37, 38].

Acute dislocations treated non-operatively often result in painful degenerative osteoarthritis, as patients may consult an orthopaedic surgeon years after sustaining the injury [39–41]. Accurate diagnosis of acute SC joint dislocations or fractures is key, with acute posterior dislocations being classified as an emergency, as mediastinal compression, pneumothorax, or complete shock can occur [40, 42]. There have been several reconstruction techniques described in current literature, with biological (auto- or allografts) or suture augmentation may be noted as the current gold standard in treating acute or chronic SC joint dislocations [43–45].

6.2.1 Clinical Evaluation

In the acute setting, dysphagia, cough or hoarseness, venous congestion or a feeling of choking are the first symptoms of acute mediastinal compression [40]. Acute SC joint or clavicle pain and/or deformity or observable step-off deformity are often noted in patients with SC joint injuries. A detailed examination of the rib cage, clavicle, ACJ, and shoulder girdle is important to detect any concomitant injuries such as the "floating clavicle", ACJ instabilities, or fractures [40, 46, 47]. Severe anterior chest pain can be triggered by dynamic arm movement in patients with acute SC joint injuries. In contrast, patients with symptomatic SC joint osteoarthritis often complain about swelling, pain, and local crepitus especially during dynamic arm movement. In these patients, palpable osteophytic prominences may be present [40]. The physician can reproduce these symptoms by the cross-body test, the push-down test, resisted arm abduction, or by dynamic provocation tests. (Table 6.1, Fig. 6.16) [48].

In cases of mild sprains or subluxations, patients may complain about instability. In the case of severe instability, the involved shoulder may be protracted, or patients may hold the involved arm across the chest in an adducted position to support their injured arm. Spontaneous anterior subluxation may also been found in young patients with demonstrated ligamentous laxity.

Atraumatic conditions such as osteoarthritis or rheumatoid arthritis (RA) may also occur [49]. In contrast to traumatic events, RA commonly affects multiple joints or presents bilaterally at the SC joint. Osteophyte prominence, crepitus, and fixed subluxation may also occur [49]. If patients present with unilateral SC joint symptoms, seronegative spondyloarthropathies (e.g.

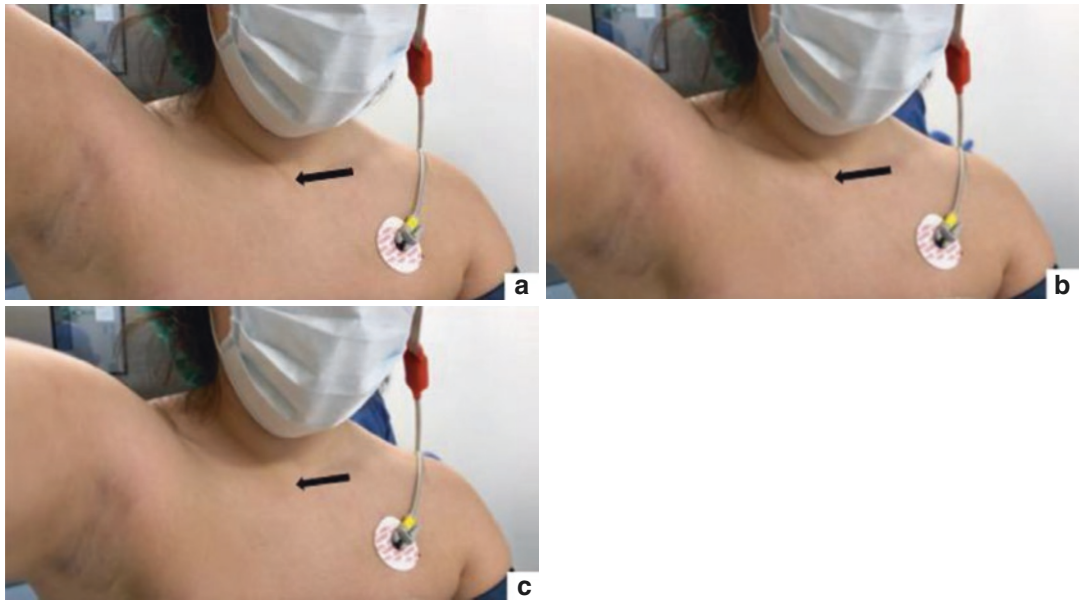

Fig. 6.16 Dynamic examination of a chronic posterior SC joint dislocation. (**a**) The examiner holds the arm in maximum abduction and high external rotation; (**b**) anterior translation of the chronic posterior dislocated SC joint (black arrow) through dynamic arm extension; (**c**) bringing the arm back to maximum abduction and flexion leads to the chronic posterior dislocation

psoriasis, Reiter's syndrome, and Bechterew's disease) have to be excluded.

Septic conditions may be surrounded with fever, chills, night sweating, pain, and swelling (around the SC joint) and may be more common in patients with chronic alcoholism, drug misuse, HIV, osteomyelitis, or immunocompromised patients [49]. Aseptic osteonecrosis such as the Friedrich's disease often include swelling, crepitus, infections, or loss of active shoulder motion [49]. In conclusion, laboratory studies may be helpful to rule out certain inflammatory or infectious diseases and should be considered.

Fig. 6.17 Preoperative a.p. view of the glenohumeral joint including the SC joint

6.3 Imaging of the Sternoclavicular Joint

6.3.1 Radiographic Imaging

Radiographic imaging of SC injuries includes standard AP radiographs (Figs. 6.17, 6.18, and 6.19). However, radiographic imaging of SC injuries remains demanding especially in clinical daily practice because overlapping structures such as ribs and vertebrae can hide the view on the SC joint. In 1990, Wirth and Rockwood described the "serendipity" view, an oblique view

Fig. 6.18 Preoperative bilateral panoramic view to evaluate the SC joint

Fig. 6.19 Postoperative bilateral panoramic view to evaluate the SC joint. Those radiographs are highly demanding in clinical practice because overlapping structures such as ribs and vertebrae can hide the view on the SC joint

of the SC joint to visualize both clavicles and help visualize dislocation and osteoarthritis changes to the SC joint [40, 50].

6.3.2 Magnetic Tomography Imaging

MRI plays a minor role in acute SC joint disruption as multiplanar CT scans are favoured in the acute trauma setting due to speed, availability, and ability to distinguish between soft-tissue and bony injuries (Fig. 6.20). However, if patients suffer from symptomatic posterior dislocation, MRI can help visualize concomitant injuries such as vascular lesions [37, 40, 48]. In patients with atraumatic SC joint injuries, MRI may be helpful as an adjunctive method for diagnosing sternoclavicular hyperostosis, avascular necrosis, infections, rheumatoid arthritis, or osteoarthritis [48].

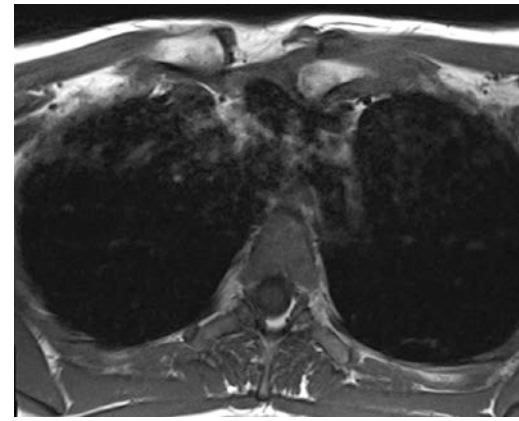

Fig. 6.20 Preoperative MRI of the SC joint showing chronic posterior dislocation. Note the proximity to (neuro) cardiovascular structures

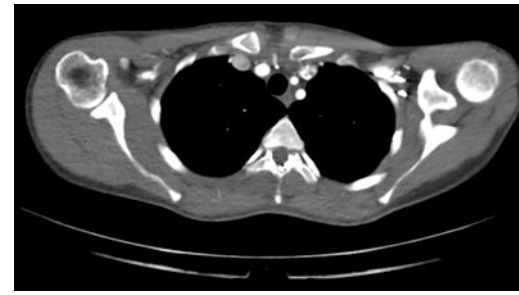

Fig. 6.21 Axial preoperative CT of the SC joint showing chronic posterior dislocation. Note the close proximity to (neuro) cardiovascular structures

6.3.3 Computer Tomography

In acute SC joint dislocations, CT is needed to exclude life-threatening injuries. Further, CT can identify fractures of the clavicle and associated joints, determine the degree of dislocation in comparison to the contralateral, non-injured side (Figs. 6.21 and 6.22) [48, 51]. In case of acute or chronic ST joint infections, CT scans will reveal bony erosions and retrosternal gas or abscess formation [48]. A CT angiogram is

Fig. 6.22 Coronary preoperative CT of the SC joint showing chronic posterior dislocation

indicated before any surgical intervention to evaluate the proximity of vascular and nerval structures.

Additionally, modern 3D-reconstructions may help better visualizing complex dislocations or may help in the preoperative setting (Figs. 6.23 and 6.24).

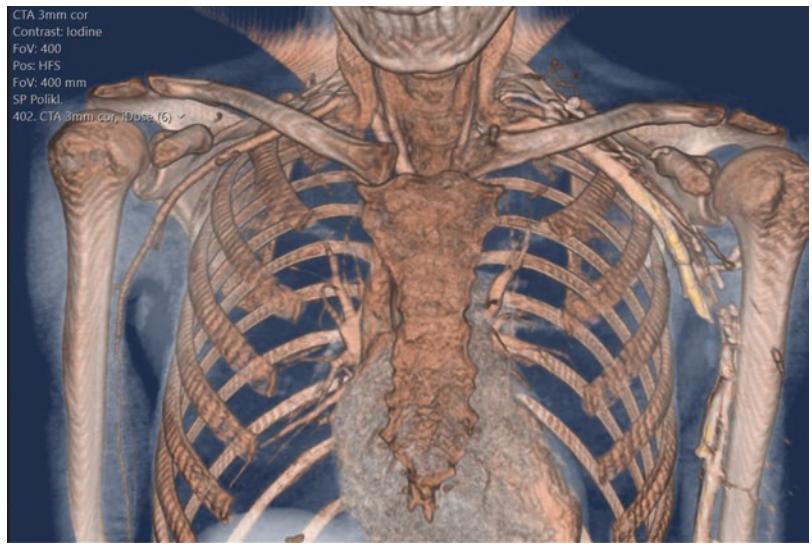

Fig. 6.23 Preoperative 3D-Reconstruction of the thoracic cage and the shoulder girdle to visualize any dislocation of the SC Joint (in this case: posterior dislocation)

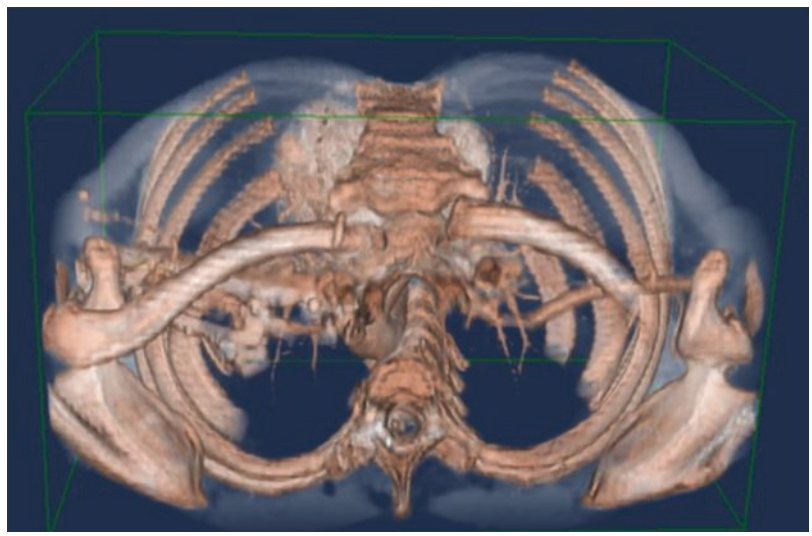

Fig. 6.24 Preoperative axial 3D-Reconstruction of the thoracic cage and the shoulder girdle to visualize the posterior dislocation of the SC Joint

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