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Cuff tear arthropathy in the nineteenth century: 'chronic rheumatic arthritis' with 'partial luxation upwards' of the humeral head

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Abstract

Introduction Cuff tear arthropathy of the shoulder is a common indication for insertion of an increasing number of reverse shoulder arthroplasties. It is widely believed that this condition was unknown to medical practitioners and writers prior to the introduction of the term cuff tear arthropathy by Charles Neer in 1977.

Purpose To search nineteenth-century written sources for pathoanatomical and biomechanical descriptions of the typical changes found in cuff tear arthropathy.

Methods A historical review. Nineteenth-century medical textbooks, reviews, case series, autopsy reports and illustrations were systematically searched and retrieved for relevance. References were hand-searched. Illustrations were reproduced and interpreted.

Results A richly illustrated nineteenth-century literature was identified. The typical changes in cuff tear arthropathy were termed 'chronic rheumatic arthritis' of the shoulder with 'partial luxation upwards' of the humeral head and interpreted within a pathoanatomical and biomechanical framework. Detailed descriptions and illustrations of massive rotator cuff tears, biceps pathology and the osseous changes were identified and presented.

Conclusion The pathoanatomical and biomechanical changes later termed cuff tear arthropathy were well understood and nicely described in nineteenth-century medical literature.

Keywords Cuff tear arthropathy · Rotator cuff tear · Long head of biceps · Femoralization · Acetabularization · Neer · Nineteenth-century

Introduction

The term 'cuff tear arthropathy' (CTA) was introduced by Charles Neer (1917–2011) in 1977 [1] and further described as a clinical entity in a classical paper by Neer, Craig and Fukuda in 1983 [2]. It is a widely held belief that the condition was unknown prior to this description, and the authors state: *We could find no description of this lesion in the literature prior to brief reports by the senior one of us (C.S.N.,II) who introduced the term cuff-tear arthropathy in 1977* (p. 1232) [2].

In this paper, an illustrated historical review of nineteenth-century sources is given, and it is demonstrated how the pathoanatomical and biomechanical changes later known as CTA were nicely described and well understood in the early and mid-nineteenth century medical literature.

For example, a description of the upward migration of the humeral head, the massive rotator cuff tear, the rupture of the long head of biceps and the new articulation between the humeral head and the inferior part of the acromion can be found in this autopsy report from 1845 by Alfred Smee (1818–1877):

> *Upon a careful examination, we found that the upper part of the great tubercle of the humerus, instead of being used for the attachment of the muscles, was converted into an articular surface, around which the cellular tissue was a little thickened, to form a sort of feeble capsular ligament. This surface corresponded to another smooth surface formed on the acromion, partly on the under surface of the acromion itself, and partly by new*

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bony matter….the tendons of the supra-spinatus, infra-spinatus, together with the capsular ligament, were torn from the tubercle… the long head of the biceps…was found ruptured as well…the ruptured end had adhered firmly to the biceptal groove… (p. 323) [3].

A rich tradition for illustrating pathological autopsy findings in medical textbooks can be found in the nineteenth century allowing for comparison with the modern surgical pathology (Fig. 1) [4].

In this historical review, first, the typical pathoanatomical and biomechanical changes in CTA as described by Neer et al. in 1983 are summarized. Second, the hallmarks of CTA, including surface anatomy, clinical findings, changes of the long head of the biceps, superior migration of the humeral head and the typical osseous changes, are presented and compared with clinical reports, autopsy reports and illustrations from nineteenth-century written sources. Third, the role played by the changes in the tendon of the long head of the biceps in the superior migration of the humeral head is discussed and the current biomechanical understanding of the pathogenesis of CTA is compared with historical conceptions.

Methods

Search strategy

A search for nineteenth-century written sources was conducted using the search machines at The Royal Danish Library (https://rex.kb.dk), Welcome Library Catalogues (https://wellcomelibrary.org) and Pubmed (https://www.ncbi.nlm.nih.gov/pubmed). Potentially relevant sources were approached through WorldCat (https://www.worldcat.org) and provided by eBooks on Demand (https://books2ebooks.eu). Nineteenth-century clinical case series, autopsy reports, textbooks, dissertations, reviews, editorials, letters and illustrations were searched and retrieved for relevance. Historical descriptions, interpretations and illustrations were identified, presented and interpreted. Contemporary discussions of clinical and autopsy cases and in the scientific literature were identified. Reference lists and references in the text were retrieved for additional relevant sources. The search could not be restricted to chronic cases as several important specimens were initially interpreted as traumatic changes in the late eighteenth and early nineteenth century but reinterpreted in the mid-nineteenth century as changes attributed to 'chronic rheumatic arthritis' with 'partial upwards luxation' of the humeral head. Therefore, the initial search was conducted using the following terms:

((((((luxation OR dislocation) AND (shoulder OR (gleno* AND humer*)))) OR "Shoulder Dislocation"[Mesh]) OR (((chronic rheumatic arthritis OR partial luxation upwards) AND shoulder)))) AND "History, 19th Century"[Mesh].

Mesh-terms were used in Pubmed only.

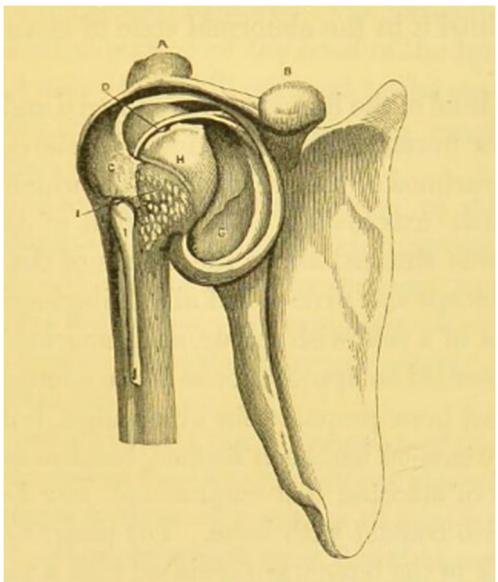

Fig. 1 Drawing from autopsy reprinted from Robert Adams illustrating the 'chronic rheumatic arthritis' with 'partial luxation upwards' of the humeral head. The capsule is enlarged and distended with excessive joint fluid. The long tendon of the biceps is ruptured and reinserted in the groove (Adams, 1857) [4]

Results

Pathoanatomical findings in CTA according to Charles Neer

Based on a clinical series of 26 patients, Neer et al. reported successive pathoanatomical changes seen in the development of CTA (Table 1). They divided the changes into a 'pre-collapse stage' and the end-stage termed 'cuff-tear arthropathy'. It was not explicitly stated whether all changes should be present to define the condition, but it was emphasized that [o]*nly after collapse of the subchondral bone of the head is the term cuff-tear arthropathy used.* (p. 1237) [2].

Pathoanatomical findings in 'chronic rheumatic arthritis' in nineteenth-century sources

Changes in the surface anatomy

According to Robert Adams (1791–1875), the typical appearance of the shoulder affected by 'chronic rheumatic arthritis'

Table 1 The pathoanatomical changes found in CTA (adapted from Neer) [2]

Massive rotator cuff tear
Leaking of synovial fluid
Instability of the humeral head
Rupture or dislocation of the long head of biceps
Atrophy of the glenohumeral articular cartilage
Osteoporosis of the subchondral humeral bone
Upward displacement of the humeral head
Subacromial impingement
Erosion of the anterior part of the acromion
Erosion of the AC-joint
Erosion of the glenoid
Erosion of the coracoids
Humeral head collapse

includes swelling, bony prominence and elevation of the humeral head. Illustrated descriptions of the surface anatomy of partial luxation upwards of the humerus above the level of the acromion and the coracoid process can be found in Robert Adams [4, 5] and Robert William Smith (1807–1873) [6](Figs. 2 and 3).

Neer describes the physical examination with the typical swelling from the presence of synovial fluid that communicated between the glenohumeral joint and the subacromial bursa, the 'fluid sign' with 'leaking' of the synovial fluid [2]. This abnormal communication has also been described in arthrography as the 'Geyser sign' (p. 1318) [7].

Robert Adams describes how he found the capsular ligaments thickened and hypertrophied and described the 'over-distension' of the capsule with more than a pint of synovial fluid (hydrops articuli). He describes a circular opening at its upper part and deposit of pieces of 'foreign bodies' in the capsular ligaments. The tendon of the biceps is without connection with the scapula but adherent to the highest part of the bicipital groove in the humerus (Fig. 4).

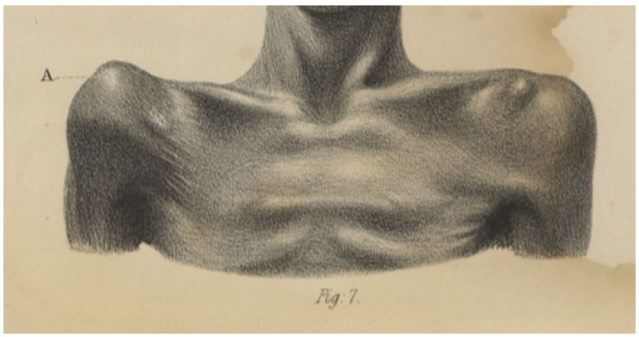

Fig. 2 Surface anatomy of a shoulder with 'partial luxation upwards' (right shoulder) of the humeral head (reprinted from Adams, 1857) [5]

Pathology of the long tendon of the biceps

Neer reported pathological changes of the long head of the biceps in all his 26 cases of CTA. The tendon was ruptured in 18, dislocated in three and 'frayed and subluxated' in five patients. He suggested that the loss of the stabilizing function of the long head of the biceps following rupture or displacement of the tendon contributed to the instability of the humeral head and the upward migration of the head against the acromion and the acromioclavicular joint (p. 1237) [2].

In the nineteenth century sources, three distinct pathologies of the long head of the biceps can be found as well as descriptions of the role of biceps insufficiency in the 'partial luxation upwards' of the humeral head. Three pathoanatomical patterns of degenerative changes of the long tendon of the biceps were described by Robert Adams as 'rupture', 'corrosion' or 'dislocation' (pp. 103–104) [4].

Rupture

In 1834, John Gregory Smith (d. 1886) reported a case with a complete rupture of all four muscles of the rotator cuff, communication between the subdeltoid bursa and the glenohumeral joint, and rupture of the tendon of the long head of the biceps:

> *…the tendinous insertion of the subscapularis muscle had been entirely torn away from the lesser tubercle; the supra spinatus, infra spinatus, and the teres minor muscles, had likewise been completely detached from the greater tubercle. The tendon of the long head of the biceps had been torn away from the upper part of the glenoid cavity, and entirely withdrawn from the joint: it was found to be firmly attached to the anterior margin of the bicipital groove.* (p. 281) [8].

A similar description is found in Robert Adams:

> *As to the tendon of the biceps…we usually observe that the whole of the intra-articular portion of it has been removed. The remains of the portion of this tendon of the biceps external to the capsule will be found to have contracted firm adhesions to the summit and edges of the bicipital groove.* (p. 103) [4](Fig. 5).

Corrosion

Robert Adams noted that

> *In some very rare cases this tendon has been flattened and spread out, though still preserving its ordinary position in the synovial cavity.* (p. 103) [4]

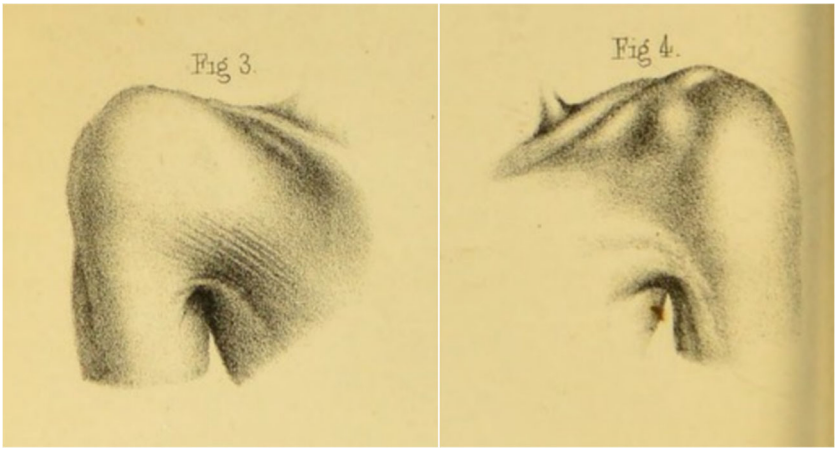

Fig. 3 Comparative surface anatomy of the shoulder with partial luxation upwards (right shoulder) of the humeral head (reprinted from Smith, 1853) [6]

Edwin Canton (1817–1885) reported a case with the tendon intact but with alterations in form and structure insufficient to prevent the superior escape of the humeral head (Fig. 6):

> *The long tendon of the biceps, as it passed through the joint, was considerably flattened, expanded, and divided into four or five slips, placed side by side. This condition of the tendon had permitted the head of the humerus to shift upwards, and thereby to articulate with the under part of the acromion process, in which situation was seen a broad surface, against which the former played…* (p. 958) [9]

Canton further describes the degenerative changes in the articular portion of the long tendon of the biceps:

> *…it sometimes, in retaining its proper place, is so spread out as to become eventually split up into many strips, which shall be, in process of time, altogether absorbed, or the unraveled portions, as I have seen, may lie loosely over different parts of the humeral head. Again, the under surface of the tendon is frequently shred...and this state is due to its playing over the articular cartilage beneath, which before its removal becomes split into fibres, like the pile of velvet.* (p. 20) [10]

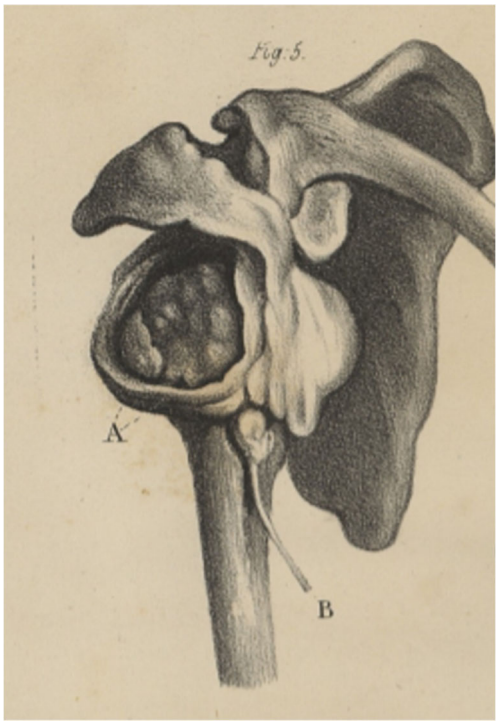

Fig. 4 Anterior view of a right shoulder-joint and acromioclavicular articulation (Adams, 1857) [5]

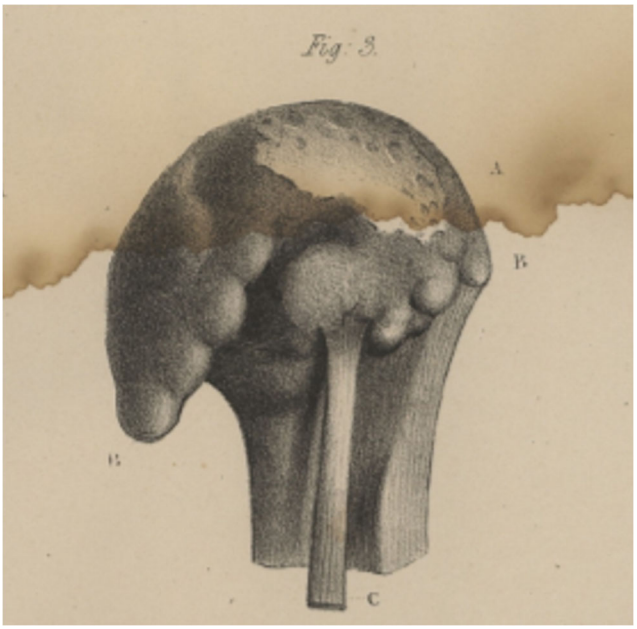

Fig. 5 In this specimen with a degenerated humeral head, the intra-articular portion of the biceps has disappeared and it is demonstrated how the extra-articular portion has contracted a firm adhesion to the summit of the bicipital groove (Adams, 1857) [5]

Fig. 6 Corrosion of the biceps tendon (Canton, 1855) [10]

A similar specimen can be found in R.W. Smith:

> *At first it becomes flattened and increased in breadth, but at a later period the fibres are separated from one another, and its under surface acquires a corroded appearance.* (p. 351) [6] (Fig. 7)

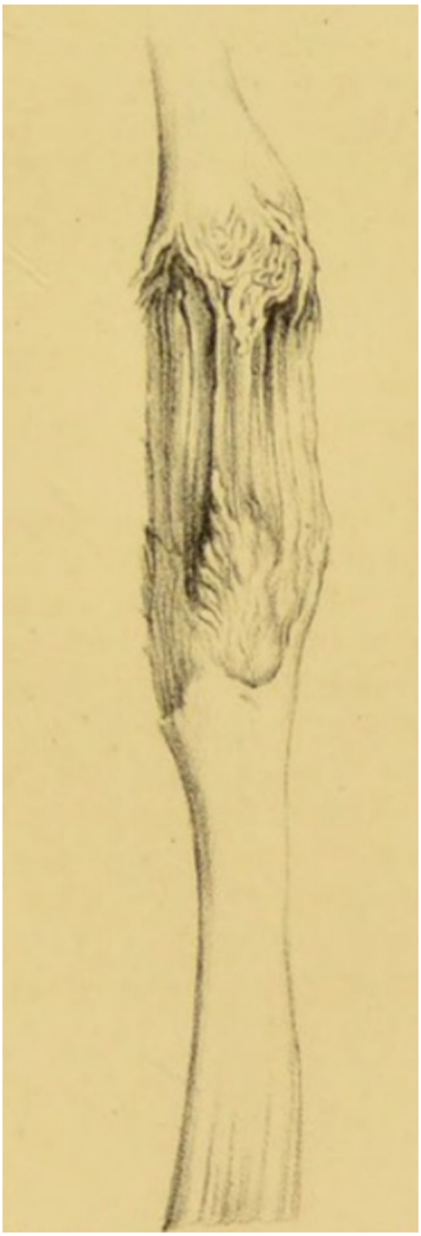

Fig. 7 Corrosion of the biceps tendon (Smith, 1853) [6]

Biomechanics

The biomechanical forces acting upon the long tendon of the biceps are nicely described by Robert Smith:

> *From the moment when the shoulders…begin to be elevated, the tendon of the biceps is put upon the stretch, and pressed against by the head of the humerus, which unceasingly tends to pass still further upwards. When the latter has come into contact with the under surfaces of the acromion, and coraco-acromial arch, the effects of compression, as far as the tendon is concerned, have then reached their utmost limits.* (p. 351) [6]

He further underlines the biomechanical importance of the long head of the biceps on

> *The remarkable elevation of the head of the humerus, to which the name "partial luxation upwards" has been given, has invariably been ascribed to the destruction or*

Fig. 8 Displacement of the biceps tendon from its groove (reprinted from Soden, 1841) [11]

> *displacement of the long head of the biceps, not only by those who look upon it as a result of external injury, but also by those who, in my opinion correctly, refer it to the effects of chronic rheumatic arthritis.* (p. 350) [6]

Dislocation

Several authors reported that the tendon of the long head of the biceps was occasionally intact but dislocated from the bicipital groove to the anterior part of the humeral head:

> *In other examples this tendon may be seen to be thrown off the summit of the humerus, and to lie internal to it…* (pp. 103–104) [4]

Table 2 The osseous changes found in CTA (adapted from Neer, pp. 1234–1235) [2]

Reduced acromiohumeral distance
Skeletal changes resulting from subacromial impingement
Erosion of the undersurface of the anterior part of the acromion and the AC-joint
The collapse of the proximal aspect of the humeral articular surface
Rounding off of the greater tuberosity
Loss of the sulcus
Anterior or posterior dislocation or subluxation
Erosion of the distal part of the clavicle
The collapsed articular surface eburnated, sclerotic and denuded of cartilage
Small marginal osteophytes

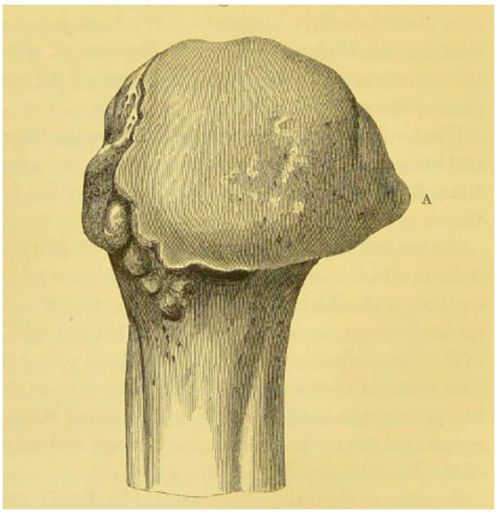

Fig. 9 'Femoralization' of the humeral head (Adams, 1857) [4]

> *The intra-articular portion of the tendon of the biceps… was now seen to lie entirely to the inside of the head of the humerus; indeed such was its position, that it might be rather been that the humerus was displaced outwardly and elevated above the level of the course of the tendon of the biceps, than the latter was dislocated inwards…* (p. 155) [4]

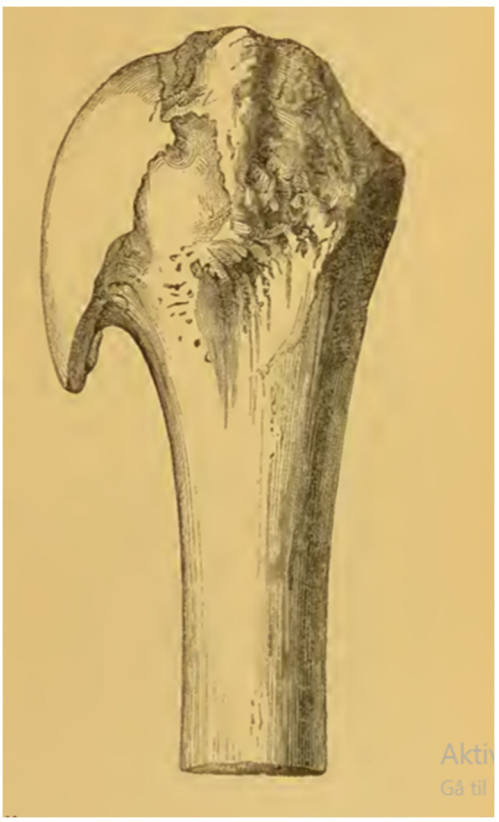

Fig. 10 'Femoralization' of the humeral head (Canton, 1855) [10]

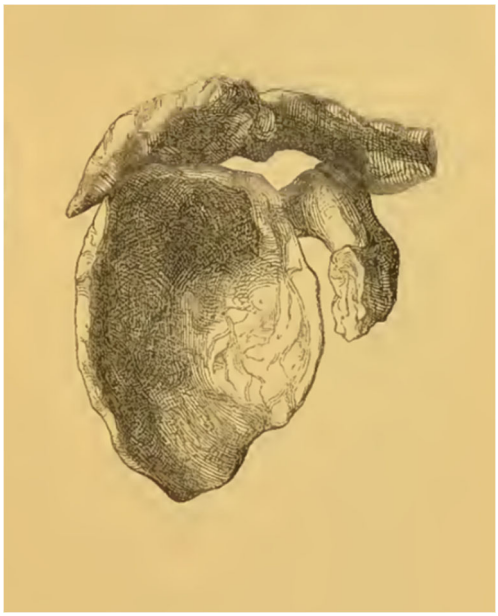

Fig. 11 'Acetabularization' of the socket. The glenohumeral joint is opened and the humeral head has been removed to allow an anterior view into the socket (Canton, 1855) [10]

In Fig. 8, the head of the humerus is consequently drawn upwards and forwards, in contact with the acromion and coraco-acromial ligament.

Osseous changes in cuff tear arthropathy

The osseous changes seen in CTA can be summarized from Neer based on radiological and surgical findings (Table 2).

The hip joint analogy

In modern textbooks, the osseous changes in advanced CTA are often described in analogy with the hip joint. This analogy can also be found in nineteenth-century sources:

> *…all these gave to the general appearance of the shoulder-joint some resemblance to a hip-joint which had been long affected by chronic rheumatic arthritis.* (p. 4) [5]

The degenerative changes of the superiorly migrated humeral head with rounding off the greater tuberosity, enlargement, eburnation, subchondral collapse and overhang of the remaining articular surface have been termed 'femoralization' of the humeral head and are described by Neer:

> *When the erosion of the glenoid was deep enough to involve the coracoid…the proximal part of the humerus was usually rounded off and almost completely devoid of rotator cuff, resembling a femoral head and making it difficult for the surgeon to determine where the articular cartilage of the head began and ended.* (p. 1235) [2]

The osseous changes of the humeral head were nicely illustrated and described in several nineteenth-century sources (Figs. 9 and 10).

Similarly, the new enlarged socket formed by the concave wearing and remodeling of the anterior part of the acromion, the acromioclavicular joint, the coraco-acromial arch and eventually the distal part of the clavicle has been referred to as 'acetabularization'. The radiographic occurrence of 'acetabularization' was used in Hamada's classification from 1990 [11] to distinguish between the presence and absence of 'subacromial arthritis' in 'massive rotator cuff tears'. It is also

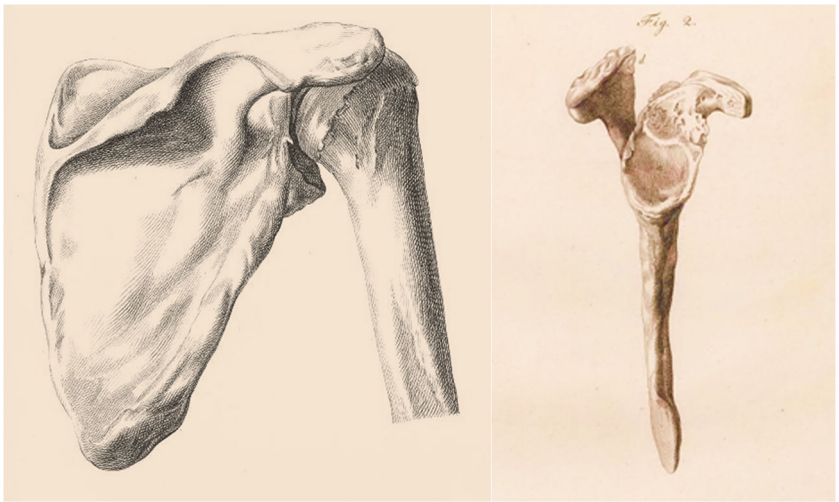

Fig. 12 Superior migration of the humerus (Sandifort, 1793) [13]

Table 3 Summary of pathoanatomical findings reported in nineteenth-century sources

Capsule
Capsular ligament thickened and hypertrophied
A large circular opening at its upper part
Freely communication between the subdeltoid bursa and the shoulder-joint
Deposit of pieces of bone 'foreign bodies' in the capsular ligament
Over-distension of capsule
Tendons
Disintegration or detachment of the tendons of the capsular muscles from the tubercles
Rupture, dislocation or corrosion of the long tendon of the biceps
The intra-articular portion absorbed
The extra-articular portion adherent to the edges of the bicipital groove
Bones
Eburnation and osseous growth of the humeral head
Humeral head ovoid, enlarged and smoothened by use and attrition
The tubercles have become articular
The acromion much reduced in thickness, detached in some cases or separated into two portions
The new and abnormal socket at the under the surface of the acromion and the coracoid
The coracoid becomes articular with a broad glenoid-shape surface
The glenoid cavity is enlarged and preternaturally excavated
Soft parts
The head of the humerus in contact with the deltoid or cut through
Deltoid muscle pale and its fibres occupied by 'unhealthy-looking fat'

part of the Seebauer classification from 2004 together with the term 'femoralization' (Seebauer type IA) [12]. Adams describes these changes in 1857:

> *The proper glenoid cavity, although enlarged, formed but a small portion of the socket or receptacle for the enlarged head of the humerus. This new abnormal socket presented the appearance, as it were, of a large and deep hemispherical cup, or acetabulum….* (p. 131) [4]

The new and abnormal socket at the undersurface of the acromion and the coracoid is demonstrated in a specimen from Canton (Fig. 11).

Superior migration of the humerus 'partial luxation upwards'

An early specimen from Eduard Sandifort (1742–1814) in *Museum Anatomicum* (1793) [13] (Fig. 12) was eagerly discussed in the mid-nineteenth century sources. It was initially interpreted as post-traumatic changes. In the nineteenth century, the osseous changes of the humeral head, the new joint cavity, and the superior migration of the humeral head *subluxatio in superiora ergo hic locum habuit* were described and reinterpreted within the frame of 'chronic rheumatic arthritis'.

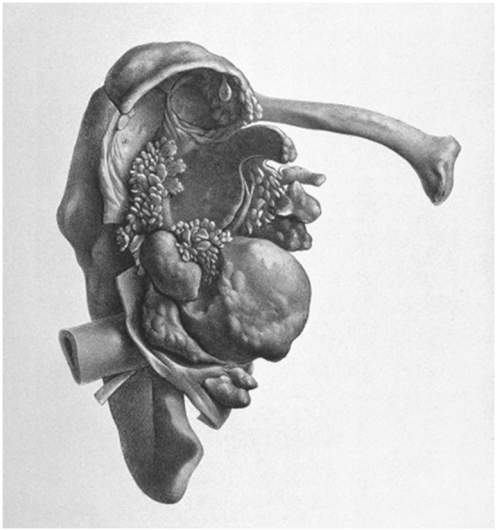

Fig. 13 Right shoulder-joint opened. Anterior view. The humerus has been luxated downwards to illustrate the typical changes in 'chronic rheumatic arthritis' (Adams, 1857) [5]

Thus, Robert Adams mentioned that there was no history of trauma and added that

> *The head of the humerus having been "driven upwards" between the coracoid process and the acromion, a new articular surface was produced partly on the upper narrow part of the glenoid cavity, and partly on the root of the coracoid process. This new articular surface was in parts porous, and in other parts much polished, and ivory-like…and had been in habitual contact with the head of the humerus. The latter was much enlarged, and the measure of its circumference round the corona of the head was much increased by the addition of a hard, everted margin…* (p. 131) [4]

Conclusion

The pathoanatomical findings in 'chronic rheumatic arthritis' with 'partial luxation upwards' of the humeral head as reported in nineteenth-century sources have been summarized in Table 3.

Most of these pathoanatomical changes can be found in a detailed engraving from Robert Adams (Fig. 13).

By conclusion, based on nineteenth-century written sources, it has been shown how the pathoanatomical and biomechanical changes later known as CTA were well understood in the nineteenth century although medical practitioners at that time were unable to provide effective treatment for this painful condition.

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