Macroscopical anatomy of the so-called “rotator interval”.
A cadaver study on 19 shoulder joints

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Summary. The triangular capsular space between the insertion tendons of the Mm. supraspinatus and subscapularis – the “rotator interval”, can be divided into lateral, medio-superior and medio-inferior parts. The lateral part of the capsule is strengthened by the “Lig. semicirculare humeri” and the anterior fibres of the M. supraspinatus tendon. The Ligg. coracohumerale and “coracoglenoidale” are the macroscopical elements of the medio-superior part. The medio-inferior part of the “rotator interval” is reinforced by the Ligg. glenohumeralia superius et medium. The key ligament of the “rotator interval” is the “Lig. semicirculare humeri”. Laterally it ensures the insertion of the anterior fibres of the M. supraspinatus tendon above the Lig. transversum humeri and on the Tubercula major et minus. Medially it is the place of attachment of the Lig. coracohumerale and oblique fibres of the Lig. glenohumeralia superius. The “rotator interval” is not a weak capsular region but a complex network of macroscopically recognizable tendinous and ligamentous structures.

Key words: Shoulder joint – Articular capsule – Coracohumeral ligament – Glenohumeral ligaments – Rotator interval

Introduction

Under the clinical term “rotator interval” we understand the capsular gap between the Mm. supraspinatus and subscapularis tendons. As the term “rotator interval” is not officially recognized by the Terminologia Anatomica (1998), the anatomical composition of this region is not described in the text- and handbooks of anatomy (Fick 1904; Siegelbauer 1935; Testut and Latarjet 1948; Braus and Elze 1954; von Lanz and Wachsmuth 1959; Guyot 1981; Tillmann and Tendury 1987; Fenelon 1988; Flick et al. 1990; Agur 1991; Moore 1992; Platerz 1992; Somes 1995).

In the clinical literature the term “rotator interval” has two different meanings depending on the clinical findings. In association with ruptures of the rotator cuff it is the tenuous connection between the supraspinatus and the subscapularis muscles; in conjunction with glenohumeral instability it is defined as the triangular space of the glenohumeral joint capsule between the anterior portion of the M. supraspinatus and the superior border of the M. subscapularis tendons (Gartsman et al. 1999). The greatest width of this capsular space is located at the base of the Processus coracoideus and its apex at the Lig. transversum humeri (Harryman et al. 1992; Field et al. 1995). This capsular gap is described either as the weakest region without reinforcing structures (Steiner and Herman 1989), or as the thickest portion of the shoulder joint capsule (Jost et al. 2000). It is supposed to be reinforced superficially by the Lig. coracohumerale and in its deepest part by the Lig. glenohumeralia superius (Clark et al. 1990; Edelson et al. 1991; Clark and Harryman II 1992;
Field et al. 1995; Iannotti and Williams 1999; Jost et al. 2000). It has also been stated, that adjacent to the humeral attachments, the capsule, the Lig. coracohumerale and rotator cuff tendons all blend together (Harryman et al. 1992). In addition to the ligamentous structures the participation of the Mm. subscapulares and supraspinatus tendons in the composition of the “rotator interval” has been pointed out by several authors (Tillmann and Töndury 1987; Clark and Harryman II 1992; Harryman II et al. 1992; Kolts 1992; Tillmann and Gehrke 1995; Gartsman 1999; Jost et al. 2000).

Recent clinical and morphological investigations have improved the traditional understanding of the normal anatomy of the shoulder joint capsule. The description of capsular fibres running predominantly perpendicular to the cuff tendons (Clark et al. 1990; Clark and Harryman 1992) influenced additional investigations. The “transverse fibres” were identified as the shoulder’s “suspension bridge” for the Mm. subscapulas infraspinatus (Burkhart et al. 1993) and finally described as a new macroscopically recognizable capsular “Lig. semicirculaire humeri” (Kolts et al. 2000). In addition, the anatomy of the “classical” rotator interval structure, the Lig. coracohumerale and its relations to the “Lig. coracoglenoidale” has also been newly interpreted (Weinstabl et al. 1986; Ferrari 1999; Kolts et al. 2000).

The variety of differing opinions concerning the anatomical composition of the “rotator interval” indicate an urgent need for additional anatomical investigations of this clinically important capsular region. The obvious existence of the recently described anatomical structures and their relations within the “rotator interval” influenced the performance of the present investigation.

Materials and methods

Nineteen alcohol-formalin-glycerol fixed right shoulder joints (age range 45-78 years; 10 male and 9 female) were investigated. Muscles of the shoulder girdle, except the M. pectoralis minor and the M. deltoides were removed. Acromion was cut from the Spina scapulae and moved together with the Lig. acromioclavicularia anteriorly. Mm. supraspinatus, infraspinatus, subscapulares and teres minor tendons were cleaned of the remains of the Bursa subacromialis and separated from the joint capsule. The joint capsule, Lig. “semicirculaire humeri”, coracohumerale, “coracoglenoidale” and gelenohumeralia were dissected in detail. The Processus coracoides was cut at its base and moved together with the Lig. coracohumerale and “coracoglenoidale” posteriorly. The structures within the “rotator interval” were visualized and the analysis of their relations was done with the humerus in the neutral position.

Results

The “rotator interval” consisted of a complex of tendinous and capsulo-ligamentous structures. The Ligg. coraco-

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Fig. 1. Antero-superior view of a right shoulder joint. Muscles of the shoulder girdle except the M. pectoralis minor (PMI) are removed. Acromion (A) is separated (→) from the Spina scapulae. The “Lig. coracoclavicularis” (C) continues the course of fibres of the M. pectoralis minor tendon and separates the “inferior part” (→) of the Lig. coracohumerale from the base of the Processus coracoideus (PC). The “superior part” of the Lig. coracohumerale (→) begins below the posterior labrum (→) of the Lig. coracoacromiale (ICA; ∗) and runs in the medio-lateral direction under the M. supraspinatus tendon (SSP). The “rotator interval” (→: RI →) is triangular capsular space between the tendons of the Mm. supraspinatus and subscapularis (SSC) with its greatest width at the base of the Processus coracoideus and apex at the Lig. transversum humeri (∗). ISP = M. infraspinatus.

Fig. 2. Medio-superior view of the same right shoulder joint. Acromion (A) together with Lig. coracoacromiale (LCA; ∗) is drawn to the anterior side. The “superior part” of the Lig. coracohumerale (→) runs near parallel to the M. supraspinatus tendon into the “Lig. semitendinoseum” (→). The Lig. coracoglenohumerale (→) courses under the M. supraspinatus (SSP) towards the Tuberculum supraglenoidale. The “inferior part” of the Lig. coracohumerale (→) arises approximately one centimetre medial to the tip of Processus coracoideus (PC) and the Lig. coracoglenohumerale. The anterior part of the “inferior” Lig. coracohumerale (→) is without special macroscopical structure, whereas the posterior (→) part has a tendinous appearance. The two parts of the Lig. coracohumerale insert in the middle of the “rotator interval” into the “Lig. semitendinoseum humeri”. ISP = M. infraspinatus; SSC = M. subscapularis; ∗ = Lig. transversum humeri. The M. supraspinatus (SSP) is separated from the superior joint capsule and placed laterally. The Processus coracoideus (PC) has been cut (CUT → CUT) at its base. The medio-superior capsule (MSC) composed of the Ligg. coracoclavicularis and coracohumerale is separated from the medio-inferior capsule and moved backwards together with the Processus coracoideus. The “rotator interval” is laterally composed of the “Lig. semitendinoseum” (→) and the anterior M. supraspinatus tendon (SSP →) fibres. The medio-inferior capsular layer shows medio-lateral (M → L) and cranio-caudal (C → C) fibre arrangement arising from the Tuberculum supraglenoidale region (C). The medially oriented fibres insert at the “Lig. semitendinoseum humeri”; the cranio-caudally arranged bundle courses under the M. subscapularis (SSC) tendon into the joint capsule. TMA = Tuberculum majus; ∗ = Lig. transversum humeri.

Fig. 3. Antero-superior view of the same right shoulder joint. The Caput longum m. bicipitis brachii anteriorly and inserted on the Tuberculum minus. The oblique fibres of the Lig. glenohumerale superius fused with the overlying fibres of the Lig. coracohumerale, courses over the intraarticular portion of the Tendo capitis longi m. bicipitis brachii and inserted on the “Lig. semitendinoseum humeri” (Fig. 4).

The most medial part of the deep layer of the “rotator interval” was composed by the cranio-caudally oriented fibres of the Lig. glenohumerale medium. The ligament originated from the Tuberculum supraglenoidale region, anterior to the insertion of the Tendo capitis longi m. bicipitis brachii and courses under the M. subscapularis tendon into the joint capsule (Fig. 4).

Discussion

The present results support the previous statements that the “rotator interval” is not a weak capsular gap without reinforcing elements, but a complex of tendineous and ligamentous structures. In addition to the Ligg. coracohumerale and glenohumerale superius, that are supposed to be the main macroscopical structures of this region, the “Lig. semitendinoseum humeri” (Clark et al. 1990; Clark and Harryman II 1992; Burkhart et al. 1993; Kolits et al. 2000),
Fig. 4. Antero-superior view of the same right shoulder joint. M. supraspinatus (SSP) is separated from the superior joint capsule and moved laterally. Processus coracoideus (PC) has been cut (CUT → CUT) at its base. The Lig. "coracoeglenoidale" and coracohumerale that compose the medio-superior joint capsule (MSC), have been separated from the medio-inferior capsule and moved backwards together with the Processus coracoideus. The fibre arrangement of the medio-inferior part of the "rotator interval" is visualized after removing a thin capsular sheet (CS) of connective tissue to the lateral side. The direct (D →) and oblique (O →) fibres of the Lig. glenohumeralis superius originate from the Tuberculum supraglenoidale region (SSC). The direct fibres course medio-laterally towards the Tuberculum minus parallel to the intra-articular portion of the Caput longum m. biceps brachi (B). The oblique fibres course over the intra-articular portion of the Tendo capitii longi m. biceps brachi and insert into the "Lig. semicirculare humeri" (→ →). The Lig. glenohumeralis medium (LGHM →) arises together with the Lig. glenohumeralis superius from the Tuberculum supraglenoidale region and courses cranio-caudally under the M. subscapularis (SSC) into the joint capsule, occupying the most medial position within the medio-inferior part of the "rotator interval": GHM → Lig. transversum humeri.

the anterior portion of the M. supraspinatus tendon (Kolts 1992; Tillmann and Gehre 1995; Jost et al. 2000), the "Lig. coracoeglenoidale" (Weinstabl et al. 1989; Kolts et al. 2000) and the Lig. glenohumeralis medium are the structural elements of this region. The M. subscapularis tendon fibres play the minimal role within the "rotator interval" composing in some cases the superior part of the Lig. transversum humeri (Tillmann and Tondury 1987; Steiner and Herrmann 1990; Kolts 1993), that is the apex of the "rotator interval". The existence of the Lig. transversum humeri as a separate anatomical structure has recently been officially accepted (Terminologia Anatomica 1998). As there is still not enough anatomical information concerning the composition and variations of this new ligament, the anatomical description of the tip of the "rotator interval" is a separate work, and will therefore not be discussed in the present study.

According to the anatomical position of structures, the "rotator interval" may be divided into lateral, medio-superior and medio-inferior parts. All the three parts are composed of different macroscopical structures and the lateral and medial segments occupy approximately equal halves of the "rotator interval". The division is in correlation with the previous studies that divide the "rotator interval" into lateral and medial parts and find the medial part to be composed of two layers (Jost et al. 2000).

The main structures within the lateral part are the so-called "Lig. semicirculare humeri" and the M. supraspinatus tendon. The "Lig. semicirculare humeri" was at first recognised on histological sections as transverse fibres of the superior shoulder joint capsule, that were also identified as posterior prolongation of the Lig. coracohumerale (Clark et al. 1990; Clark and Harryman II 1992). During the intra-articular arthroscopic investigations and additional cadaver dissections the fibres were described as "suspension bridge" for the rotator cuff tendons (Birkhart et al. 1993). Recently the transverse fibres have been identified as a separate semi-circular capsular ligament of the superior shoulder joint capsule that is spread between the Tubercula major et minus. The name "Lig. semicirculare humeri" has been proposed (Kolts et al. 2000). The capsule reinforcing area of the "transverse fibres" was anteriorly and posteriorly made and the ligament filled the lateral part of the "rotator interval". The existence of the anterior portion of the M. supraspinatus tendon with additional insertion on the Tuberculum minus has been reported in approximately 30% of investigated shoulder joints (Kolts 1992). Several works confirm the finding, describing the existence of the tendinous connection between the M. supraspinatus and the M. subscapularis (Clark et al. 1990; Clark and Harryman 1992; Tillmann and Gehre 1995; Jost et al. 2000). According to the present results the macroscopically visible tendinous connection between the Mm. supraspinatus and subscapularis was made up of anterior fibres of the M. supraspinatus tendon in nine cases of nineteen. As the anterior part of the M. supraspinatus tendon fuses with the Lig. semicirculare humeri and follows the course of the ligament, the existence of the M. supraspinatus tendon fibres within the "Lig. semicirculare humeri" is obvious even then, when the anterior portion of the M. supraspinatus tendon is not macroscopically recognizable. It means that the fusion of the anterior portion of the M. supraspinatus tendon with the "Lig. semicirculare humeri" ensures the direct as well as indirect insertion of the M. supraspinatus tendon fibres above the Lig. transversum humeri and on the Tubercula major et minus. The fixation of the intra-articular portion of the Tendo capitii longi m. biceps brachi within the joint cavity is one of the main functional properties of the complex construction.

The medio-superior part of the "rotator interval" was built up between the joint capsule, the posterior margin of the Processus coracoideus and the "Lig. coracoeglenoidale". The structural elements of this part were the Lig. coracohumerale and "coracoeglenoidale". It is a common belief that the Lig. coracohumerale is the main reinforcing element of the rotator interval. It is usually described as a thickening of the joint capsule that originates from
the base of the Processus coracoideus and inserts on the Tubercula minus et majus (von Lanz and Wachsmuth 1959; Tillmann and Tendyru 1987; Ferrari 1990; Edelson et al. 1991; Clark et al. 1990; Clark and Harryman II 1992; Soames 1955; Thiel 1999; Iannotti and Williams 1999). Recent investigations have improved the classical understanding about the origin and insertion of the Lig. coracohumerale (Weinstabl et al. 1986; Kolts et al. 2000). The Lig. coracohumerale has been reported to be composed of two separate parts originating from the medioposterior margin of the Processus coracoideus and the Lig. coracoglenoidale. Both parts course into the "rotator interval" and under the M. supraspinatus tendon. The fibers of the ligament fuse approximately in the middle of the medial part of the "rotator interval" with the underlying Lig. glenohumerale superius and insert at the "Lig. semicircularis humeri" (Kolts et al. 2000). The text-and-handbooks-of-anatomy, Terminologia Anatomica and the clinical literature do not recognize the "Lig. coracoglenoidale" as a separate macroscopic structure (Weinstabl et al. 1986). Recently it has been reported to be a stable macroscopic structure composed of dense-like connective tissue that separates the Lig. coracohumerale from the base of the Processus coracoideus (Kolts et al. 2000). The tight structural connection between the Lig. coracohumerale and "coracoglenoidale" and the teninous appearance of the posterior fibres of the inferior part of the Lig. coracohumerale makes it obvious that the Lig. coracohumerale is a rather prolongation of the M. pectoralis minor tendon remnant, than a thickening of the shoulder joint capsule (Agur 1999; Kolts et al. 2000). The connection of the two ligaments and the M. pectoralis minor tendon has been previously reported (Agur 1999; Weinstabl et al. 1986), but it is not always accepted as a normal anatomical finding. Therefore, participation of the "Lig. coracoglenoidale" in the composition of the "rotator interval" has been described as an anomalous, constant extension of the pectoralis minor tendon (Clark et al. 1990) or as an aberrant pectoralis minor tendon inserted into the "rotator interval" (Dumontier et al. 1999).

The medio-inferior part of the "rotator interval" is strengthened by the Lig. glenohumerale superius et medium. The Lig. glenohumerale superius is classically described as the second main structural component of the "rotator interval". The direct fibers of the ligament begin from the Tuberculum supraglenoidale region, bordered anteriorly by the Caput longum m. bicipitis brachii and courses towards the Tuberculum minus. In addition, the oblique fibers course over the Tendo capitatis longi m. bicipitis brachii and insert into the "Lig. semicircularis humeri" strengthening the "rotator interval" above the intra-articular portion of the Tendo capitatis longi m. bicipitis brachii. The present results support the previous statements, that structures of the rotator interval make up a stabilizing network for the intra-articular portion of the long head of the biceps tendon (Werner et al. 2000). The insertion of the oblique fibers of the Lig. glenohumerale superius together with the Lig. coracohumerale into the "Lig. semicircularis humeri" explains the reason for the tight connection between the two ligaments before the attachment (Ferrari 1990; Kolts et al. 2001).

The Lig. glenohumerale medium occupy the most medial part of the "rotator interval". The ligament arises from the Tuberculum supraglenoidale anterior to the insertion of the Tendo capitatis longi m. bicipitis brachii and courses in the cranio-caudal direction under the M. subscapularis muscle into the joint capsule. One possible explanation as to why the Lig. glenohumerale medium has not been previously described within the most medial part of "rotator interval", might lie in the fact, that the ligament was absent in the investigated joints or it was not recognized as the Lig. glenohumerale medium. Anatomists are of the opinion, that the Lig. glenohumerale are weak and variable thickenings of the shoulder joint capsule without clear macroscopical form and appearance. Therefore, there has not been enough detailed anatomical information about the Lig. glenohumerale superius, medium et inferius until nowadays. In the Terminologia Anatomica (1998) they are represented together under the term Lig. glenohumerale.

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