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Medial coracoclavicular ligament revisited: an anatomic study and review of the literature

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Abstract The medial coracoclavicular ligament (MCCL), up to now rarely reported in the literature, was studied in a formol-fixed cadaver by means of dissection, morphometry, and light microscopy. This entity represents a true ligament within the coracoclavicular fascia. Although longer and narrower than its lateral counterpart, the medial coracoclavicular ligament follows the same morphological pattern, including the cartilage at the level of the coracoidal attachment. Its clinical significance and implications together with a review of the literature is presented.

Keywords Medial coracoclavicular ligament · Anatomy · Histology · Shoulder

Introduction

The coracoclavicular ligament (CCL) complex traditionally implies two components, the conoid and the trapezoid ligaments [8, 15, 17, 21]. Rare references mention beside them a medial coracoclavicular ligament (MCCL) [6, 14]. To our knowledge, data on morphometric and microscopic properties of this anatomical entity are lacking, in contrast to numerous studies of the lateral CCL [2, 7, 15, 18, 20].

This study was undertaken to define the anatomical characteristics of the medial CCL as well as its histological properties, in particular as compared to the lateral CCL.

Materials and methods

The study was conducted on a 92-year-old formol-fixed female cadaver, without previous medical history on injuries, deformities, or functional disabilities of the pectoral girdle. The body was bequeathed under the terms of local legal framework and under the directives of Swiss Academy of Medical Sciences. A dissection of the MCCL was performed and its relations to other anatomic structures noted. The dimensions (width and length) were determined with a Vernier caliper (Etalon, Roch, Switzerland).

After morphometry, the ligament was excised and underwent histological workup. It was divided into thirds (medial, middle, and lateral), embedded in paraffin, sectioned in the plane of its longitudinal axis and stained with hematoxylin-eosin, Masson's trichrome, and aldehyde fuchsin-modified Goldner's trichrome. The conoid ligament (CL) was used for control and underwent the same embedding and staining. Particular attention was drawn to preserve the ligaments in their natural position and avoid iatrogenic torque and deformities.

Results

The routine anatomical dissection of the shoulder and pectoral region revealed bilaterally in the infraclavicular

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area a slender ligamentous structure of pearly yellow appearance This ligament stretched from the medial knee of the coracoid, where the coracoidal undersurface changes direction from vertical to horizontal, to the anterior lip of the impression for costoclavicular ligament (Fig. 1). Its coracoid insertion was distal to the attachment sites of the conoid and trapezoid ligaments, and medial to the origin of the pectoralis minor muscle. According to the origin/insertion sites of this entity, we adopted the denomination medial coracoclavicular ligament (MCCL) [14]. In the reclined supine position, the ligament was tight; however, on protraction of the shoulder it became relaxed. The MCCL was completely enclosed within the clavipectoral fascia, ventral and caudal in relation to the subclavius muscle. As for vascular syntopy, the MCCL stretched out of the course of the cephalic vein and the thoracoacromial artery. The morphometry of MCCL revealed symmetricity—the length was 91 mm on the right and 86 mm on the left, and the width (for both sides) 2 mm, expanding into 3.5 mm at the level of the coracoid attachment.

On low-power light microscopy (Fig. 2), the MCCL displayed a dense core of tightly packed collagen bundles running parallel to each other, surrounded by a thin layer of irregular, often looser, well-vascularized connective tissue.

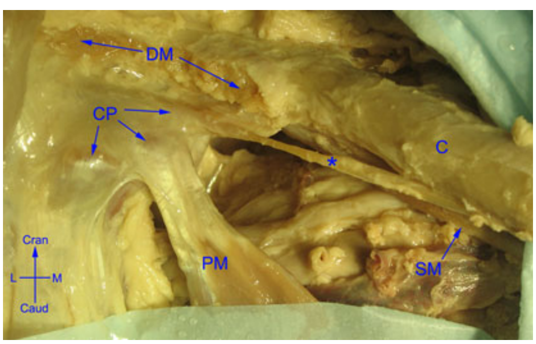

Fig. 1 Medial coracoclavicular ligament (MCCL—*asterisk*) in a right shoulder region. View from in front. *C* clavicle, *CP* coracoid process (*horizontal portion*), *DM* deltoid muscle (*resected*), *PM* pectoralis minor, *SM* subclavius muscle

At the lateral—coracoid—attachment site (Fig. 2a) the surrounding connective tissue was significantly enlarged, with abundant collagen fibers, adipose tissue, blood vessels and nerves. Although of significantly reduced size, the medial—clavicular—attachment site displayed the same type of structures. Near this medial attachment site, the MCCL's collagen fibers start to twist with fibers crossing in multiple directions (Fig. 2c). Although bone and cartilage were macroscopically dissected out to allow direct histological processing without any prerequisite demineralization, some smaller zones of partially calcified cartilage were still present in the close vicinity of both attachment sites; some focal, possibly ageing-related microcalcifications were occasionally observed within the connective tissues.

At higher magnification (Fig. 3), hematoxylin-eosin staining of the MCCL (Fig. 3b) confirmed typical features of ligaments, i.e., dense, closely apposed collagen fibers forming aligned bundles of thick diameter, with more or less evenly distributed fibrocytes in between; this microscopic organization was closely similar to that of the control CL (Fig. 3a). MCCL's collagen bundles were specifically stained in blue (Masson's trichrome, Fig. 3c) or green (aldehyde fuchsin-modified Goldner's trichrome (AF), Fig. 3d). This collagen staining was homogenous at the periphery and at the ligament endings but, surprisingly, the central core of both the MCCL and the CL (not shown) displayed more irregular staining. These modified staining properties of collagen could possibly result from some of the ageing-related changes. Finally, the AF staining—which allows the concomitant staining of thick collagen bundles (in green) and thin elastic fibers (in violet)—showed similar content and distribution of these fibers in both MCCL (Fig. 3d) and CL, elastic fibers distribution in these ligaments being sparse and less abundant than in the surrounding fascia.

Taken together, the microscopic observation of the MCCL confirms its ligamentary nature. The histological structure and overall composition of the MCCL is also very close to those of the CL.

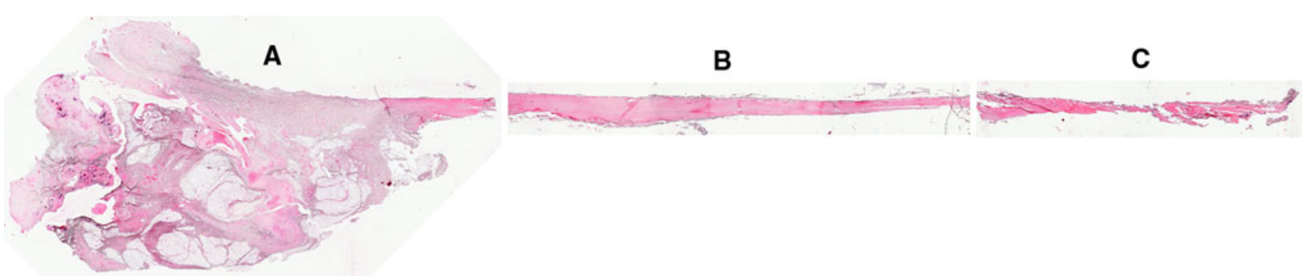

Fig. 2 Low-power, microscopic reconstruction of the MCCL thirds (**a**, lateral; **b**, middle; **c**, medial) from paraffin sections stained with hematoxylin-eosin. Note abundant surrounding connective tissue at the lateral attachment site and torque of the MCCL's collagen fibers start to twist at the medial attachment site

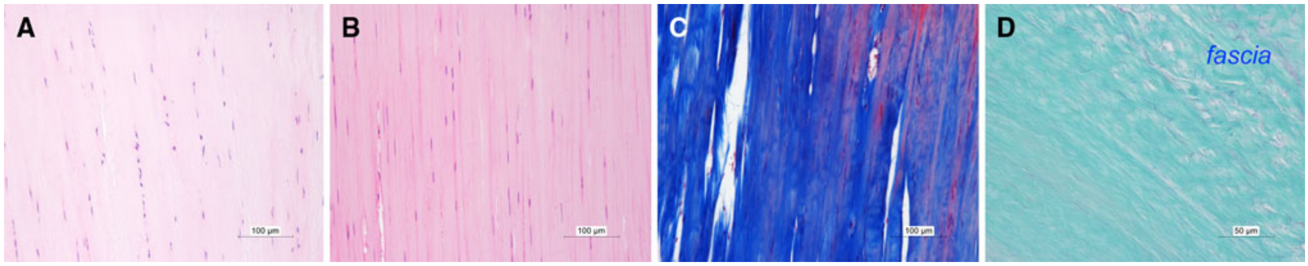

Fig. 3 Histological characteristics of the conoid ligament (**a**) as compared to the medial coracoclavicular ligament (**b**, **c**, **d**). **a**, **b** Hematoxylin-eosin, **c** Masson's trichrome (collagen: *blue*), **d** aldehyde fuchsin-modified Goldner's trichrome (collagen: *green*, elastic fibers: *violet*). The MCCL exhibits microscopic organization, content, and distribution of fibers typical for ligaments

Discussion

The herewith-described MCCL can be interpreted as a cordlike thickening of the clavipectoral fascia [14]. Its gross appearance and microscopic structure resemble a true ligament. In the latest edition of Gray's Anatomy, however, the only ligamental entity related to the clavipectoral fascia is the costocoracoid ligament, a dense whitish band extending between the first rib and the coracoid process [8]. The clavipectoral fascia, also called costocoracoid membrane or coracoclavicular fascia, is assumed to protect the axillary neurovascular bundle, stretched between the pectoralis minor and subclavius muscles. In the concept of supporting soft tissue planes of the glenohumeral joint, the clavipectoral fascia occupies the second layer, together with the conjoined biceps/coracobrachial tendon, coracoacromial ligament, posterior scapular fascia, and superficial bursae tissue [3]. The clavipectoral fascia, being in continuity with the suspensory fascia of the axilla below the pectoralis minor, provides dynamic anchoring of posteromedial arm subcutaneous tissue. Age, weight fluctuations, and loosening of the complex fascial system may lead to arm skin laxity [10]. It thus stands to reason that MCCL contributes to the supportive action of clavipectoral fascia.

It has been noted that the variability of soft tissue around the shoulder joints mainly concerns the coracohumeral ligament and capsular defects [3, 16]. According to Harris et al. [7], the variations of the CCL complex include confluence of conoid ligament and superior transverse scapular ligament, and additional superolateral fascicles, but the MCCL has not been mentioned. If analogy is made with the congenitally short costocoracoid ligament [1], we can assume that the MCCL could also imply an autosomal dominant mode of inheritance with variable expression, but with the very limited number of reports available on MCCL up to now, it is difficult to predict its exact incidence in the general population.

The biomechanical role of MCCL is also uncertain. As for the lateral counterparts, they are considered as constraints: for superior and anterior translation of the clavicle (conoid ligament), and for the axial compressive loading of the acromioclavicular joint (trapezoid ligament) [2, 18, 20]. Taking into account its origin, anatomical position and insertion, one can argue that the MCCL restrains the retraction of the scapula in the horizontal plane. However, its true significance in stabilization of shoulder girdle is debatable in view of its width, particularly if compared to lateral CCL. Several studies have addressed the dimensions of conoid and trapezoid with different methodological approaches. A detailed study presented the following mean length/width of 1.61/1.58 and 1.22/0.74 cm for the trapezoid and conoid ligaments, respectively [17]. With one exception, the values did not significantly differ between men and women. The trapezoid ligament expanded to 2.15 cm at the clavicular level, a similar feature that we found at the level of MCCL attachment to coracoid process. The CCL geometry in another study gave somewhat smaller dimensions and, interestingly, no significant differences could be demonstrated between conoid and trapezoid ligament [4]. On the other hand, Ockert et al. found the ligaments to be larger than in the previous two studies, precisely distinguishing the 3D components—length, width, and depth [15].

Despite the smaller diameter, the tensile properties of the MCCL should be regarded in the light of its fibers twisting in its medial third, what should result in a significant increase in the ultimate tensile strength and resilience to strain.

Therefore, histological processing of this ligament has been performed to compare it to the conoid portion of the same-sided lateral CCL. This comparative morphological analysis confirmed the ligamentary nature and structure of the MCCL. It is peculiar that the microscopic anatomy of the coracoclavicular ligament has not attracted much attention. In the report of Satler et al. [17] the histological sections included the plenitude of the acromioclavicular joint with the surrounding ligaments, in order to study better the anatomical relationships of the structures in question. Based on tensile testing and not on histology, no statistically significant differences could be demonstrated for all structural properties between the conoid and trapezoid ligament [4]. A comprehensive immunochemistry study, carried out on CCL complex, revealed fibrocartilage at the level of both clavicular and coracoid entheses, considering it a consequence of adaptation to compression and shear forces [15]. A similar finding was seen in our case of MCCL. Being of relatively small quantity and surrounded by abundant fat tissue with blood vessels, it could hardly pose as a weak point in cases of injury.

The presence of calcifications in our case of MCCL was also intriguing, despite its modest extent. The interpretation of such calcifications on plain X-rays was attributed to displaced ossification centers, clavicular cleft, or ossification in the trapezoid ligament, due to repair or damage after trauma [19]. The ossifications of the costocoracoid ligament may be seen in cleidocranial dysostosis or, rarely, they are spontaneous [1]. In the absence of congenital defects or history on shoulder trauma, the calcifications in the present case of MCCL can be related to the person's advanced age.

The medial coracoclavicular ligament could have impact on placing pacemaker leads and central venous catheters through the subclavian vein. Entrapment by intervening soft tissue (subclavius muscle, costocoracoid ligament) can impose stress on leads and catheters, particularly during movements of ipsilateral arm [12]. Therefore, one would appreciate knowledge of the presence and position of MCCL in order to avoid such a complication.

Being in the junctional region between the hypobranchial and the pectoral regions of the body trunk, the MCCL could contribute to the thoracic outlet syndrome, analogous to the congenital anatomical anomaly of subclavius posticus muscle [13]. Indeed, one of the variations of supernumerary muscles (scapuloclavicular) fits well to the attachment sites and the position of MCCL, but our histology revealed no muscle fibers in this entity. However, the MCCL could be formed by metaplasia of the scapuloclavicular muscle as a response to stress during development, as it has already been described in other body structures [11].

Knowledge of MCCL is also relevant for several operations. The subcoracoid transfer of sutures or graft during coracoclavicular cerclage for acromioclavicular joint reconstruction [9] could be more challenging in presence of MCCL. Soft tissue insertions on the coracoid process allows surgeons to correlate the location of the coracoid osteotomy during Latarjet procedure [5]. Confusion of the MCCL with posterior band of the pectoralis minor insertion could lead to a too posterior coracoid osteotomy, lateral CCL desinsertion and possibly acromioclavicular instability. Moreover, medial soft tissue release for coracoid transfer during Latarjet procedure could be more tedious.

This study is limited by inherent limitation of a single (although bilateral) case in an older subject. However, it is the first one, to our knowledge, that presents detailed macro- and micromorphology of the MCCL.

We hope that this case presentation will ignite surgeons' and anatomist's awareness and interest in searching for this very rare form of connective tissue variation, enabling determination of its incidence rate and comparison of different individuals.

Conflict of interest None.

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