Identification of medial coracoclavicular (Caldani's) ligament by magnetic resonance imaging

Original protocol and clinical applications

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Abstract

Introduction: The Caldani's or medial coracoclavicular ligament has been studied anatomically, but we have not found any reference to imaging identification. The aim of this study is to present a magnetic resonance imaging (MRI) original technique that we have developed to identify it, and describe the images we got this way.
Materials and Methods: We included seven volunteers with no shoulder condition we knew of. We used a Phillips Ingenia MRI scanner with magnetic field intensity of 1.5 T, 4.1 version, Gantry diameter of 70 cm and shoulder-specific 8-channel coil for high resolution-images. We carried out ligament search sequences on three planes.
Results: The medial coracoclavicular ligament was identified in all cases, spreading obliquely from the coracoid process to the clavicle, what coincides with the anatomy bibliography we consulted. It showed hypointense signal in all MRI sequences, what suggests scarce space between fibers and that it is made up of compact collagenous tissue. Average ligament length was 41.15 m (34-47 range, standard deviation= 4.40). Average ligament width was 2.11 mm (1.3-3.2 mm, standard deviation= 0.66).
Conclusions: The medial coracoclavicular ligament can be seen in MRI images using the original technique we describe. The possibility of locating it and visualizing it using this imaging study opens the doors to future research about the likely role it plays not only in neurovascular compression but also in acromioclavicular traumatic injuries, especially type V Rockwood acromioclavicular dislocation.

Key words: Medial coracoclavicular ligament; Caldani; magnetic resonance imaging; protocol; thoracic outlet; acromioclavicular dislocation.
Level of evidence: II

Conflict of interests: The authors have reported none.

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Identificación del ligamento coracoclavicular medial o de Caldani en imágenes de resonancia magnética. Original protocol and clinical applications

Resumen

Introducción: El ligamento de Caldani o coracoclavicular medial ha sido estudiado anatómicamente, pero no hemos hallado mención alguna sobre su identificación imagenológica. El objetivo de este trabajo es presentar una técnica original de resonancia magnética que hemos desarrollado para identificarlo, y describir las imágenes correspondientes.

Materiales y Métodos: Se incluyó a siete voluntarios sin patología de hombro conocida. Se utilizó un resonador magnético Philips Ingenia de una intensidad de campo magnético de 1.5 T, versión 4.1, diámetro de Gantry de 70 cm, bobina específica para hombro de 8 canales con imágenes de alta resolución. Se realizaron las secuencias de búsqueda del ligamento en tres planos.

Resultados: El ligamento coracoclavicular medial fue identificado en todos los casos, se extendía oblicuamente desde la apófisis coracoides hasta la clavícula, lo que coincide con las descripciones de la bibliografía anatómica consultada. Tuvo una señal hipointensa en todas las secuencias, lo que indica el poco espacio entre fibras y que corresponde a tejido colágeno compacto. Su longitud promedio fue de 41,15 mm (rango 34-47 mm, desviación estándar 4,40). El espesor promedio fue de 2,11 mm (rango 1,3-3,2 mm, desviación estándar 0,66).

Conclusiones: El ligamento coracoclavicular medial se puede observar en imágenes de resonancia magnética mediante la técnica original que describimos. La capacidad de localizarlo y observarlo con este estudio por imágenes abre las puertas a futuras investigaciones sobre su posible papel no solo en las compresiones neurovasculares, sino también en las lesiones traumáticas acromioclaviculares, especialmente en las de tipo V de Rockwood.

Palabras clave: Ligamento coracoclavicular medial; Caldani; resonancia magnética; protocolo; opérculo torácico; luxación acromioclavicular.

Nivel de Evidencia: II

Introduction

The medial coracoclavicular ligement (MCCL) was first called "bi-horn ligament" by Leopoldo Caldani in 1802.[1] This structure has been described as a band of pearl-yellow fibers located in the rib-clavicle space.[2,3] It originates in the medial border of the coracoids process by two separate fascicles, anterior and posterior, which further down get fused to form the body of the ligament.[4] It continues medially and cephalically towards the clavicle and gets divided into two fascicles:[5-7]

- superior, that ends up attached to the anterior border of the clavicle in front of the fascia of the subclavian muscle, with which it fuses,
- inferior, that gets attached to the sternum end of the first rib.

Other pieces of anatomy research recently done[4] describe this ligament as present in 100% of the subjects, with a coracoid process origin by two fascicles, a body, terminal attachment to the anterior border of the clavicle (overlapping with the fascial sheathe of the subclavian muscle) and three branches: superior, inferior and medial. The medial branch continues towards the first rib and passes as an arch over the suclavian vein. Out of these data, we believe that the most appropriate denomination for this ligament is MCCL, in opposition to the two lateral ligaments—the trapezoid and conoid ligaments.

There are numerous anatomical references to and descriptions of this ligament in medical literature. It was been suggested that it participates in rib-clavicle compression conditions [8-12] and has an influence on invasive therapeutic procedures performed in the infra-clavicular area.[7,13-16] However, we have not found any bibliographic reference to the visualization of the ligament first described by Caldani using some imaging diagnostic technique. [18-22]

The aims of this study are 1) to identify the MCCL in MRI studies using an especially designed diagnostic protocol and 2) to establish its prevalence in a group of persons that do not show symptoms.

Materials and methods

We used a cross-sectional, prospective, observational and descriptive design. The study subjects were recruited prospectively among patients that had attended the imaging diagnostic center to take MRI in the contralateral shoulder. We evaluated the shoulder that showed neither disorders nor diagnostic indications by the patient's doctor. We included only those persons that had neither history of pain in the shoulder to asses, nor history of surgical treatment or instability in that shoulder. We ruled out those persons with history of limitations in daily-life or sports activities caused by that shoulder. We explained to the patients the reason why their shoulders were being studied and the fact that studies would last more. We also informed them that the results would be confidential and they would only be used with research purposes, and that the study implied neither radiation nor risk for his or her body. Moreover, we made it clear that neither volunteers nor researchers would profit from this study. They joined voluntarily to the study, which was allowed by the imaging diagnostic center's authorities.

At this stage we studied seven individuals who met the inclusion criteria and accepted the conditions of the study by signing an informed consent; they joined the study.

We used a Phillips Ingenia MRI scanner with magnetic field intensity of 1.5 Tesla, 4.1 version, Gantry diameter (tunnel) of 70 cm and shoulder-specific 8-channel coil for high resolution-images, what allows for applying acceleration factors and reduces the time for acquisition of images (Figure 1).

MRI technique

To design the MRI technique, before conducting the study and with no intention of including results in the research, we analyzed 10 fresh corpses previously dissected in which we evaluated the shape of the ligament and its relationships with neighbor structures (Figures 2 and 3).

Patients were in supine position with his or her upper limbs extended and upward palms (Figure 4). Technical details are as follows: full axial three-planar quick locating sequence (Figure 5A), with visualization field of 550 mm and 12 sections. Axial locating sequence as anatomical reference for programming in different plane sections,

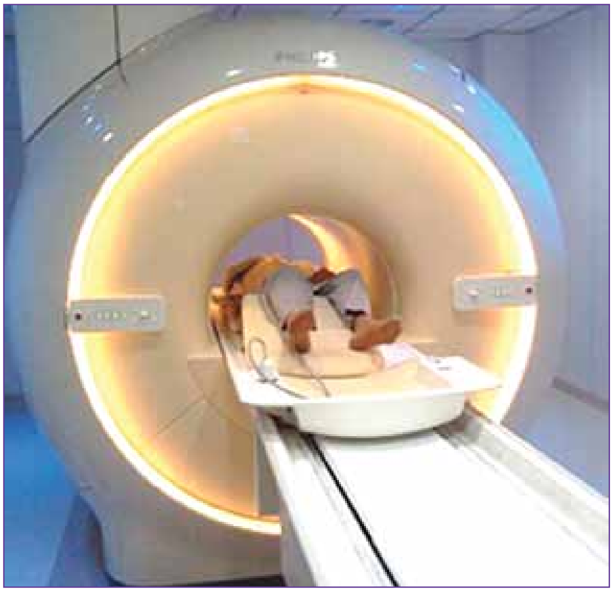

Figure 1. MRI scanner.

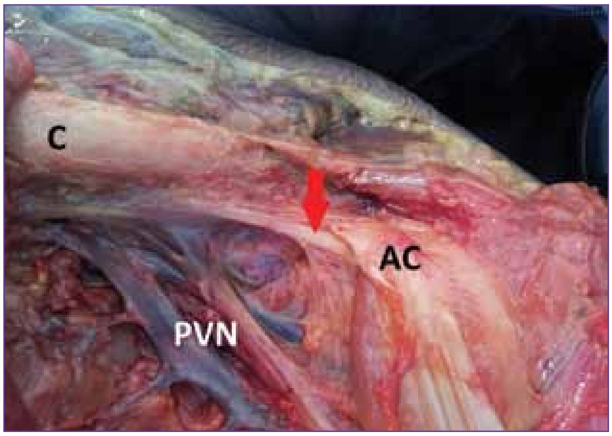

Figure 2. Frontal view, left shoulder, corpse study. The medial coracoclavicular ligament (red arrow) can be seen spreading between the coracoids process (CP) and the clavicle (C). We can see the brachial plexus and the axillary vases underneath the clavicle and the medial coracoclavicular ligament. NVB= Neurovascular bundle.

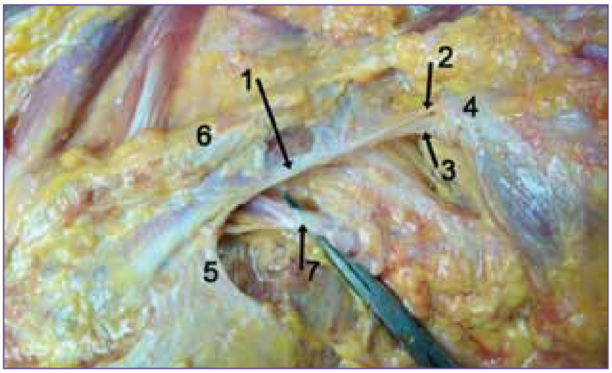

Figure 3. Frontal view, left shoulder, corpse study. 1. Medial coracoclavicular ligament. 2. Anterior bundle of origin. 2. Posterior bundle of origin. 4. Coracoid process. 5. Lower fascia. 6. Clavicle 7. Subclavian vein.

Figure 4. Patient in supine position.

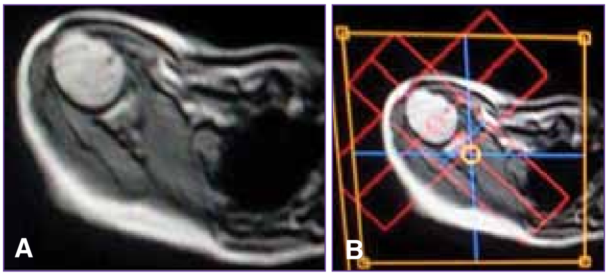

Figure 5. **A.** Quick locating sequence. **B.** Three-planar locator planning.

repetition time=6.4 ms, eco time= 3.2 m, deflection angle= 40º, section width= 10 mm, acquisition number= 1, pixels matrix= 264 x 288, visualization field= 530 mm, scanning time= 2.6 s.

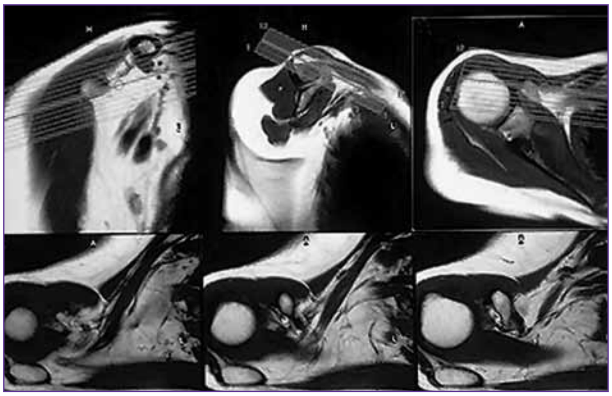

Figure 6. Locating sequence of the three spatial planes.

On a central section of the humeral head we designed a three-planar locator (Figure 5B) on the joint axis with a visualization field of 220 mm in transverse, oblique coronal and oblique sagittal sections. The aim of this step is to orientate the sections by the plane of the Caldani's ligament ant the planes normal to it.

We carried out a three-planar locating sequence as anatomical reference: repetition time= 7.5 ms, eco time= 3.7 ms, deflection angle= 45º, section width= 10 mm, acquisition number= 1, pixels matrix= 216 x 224, visualization field= 220 mm, and scanning time= 12.6 s.

The subclavian muscle and the coracoid process are the anatomical references to program T1 sequences by an oblique transverse plane (Figures 6 and 7). Once we got the Caldani's image on the transverse plane, we planned coronal images (Figures 8 and 9). T1 TSE sequence for MCCL, repetition time= 500 ms, eco time= 15 ms, section width= 2 mm, gap= 0.2 mm, acquisition number= 4, pixels matrix= 344 x 259, visualization field= 130 mm, and scanning time= 2.32 m.

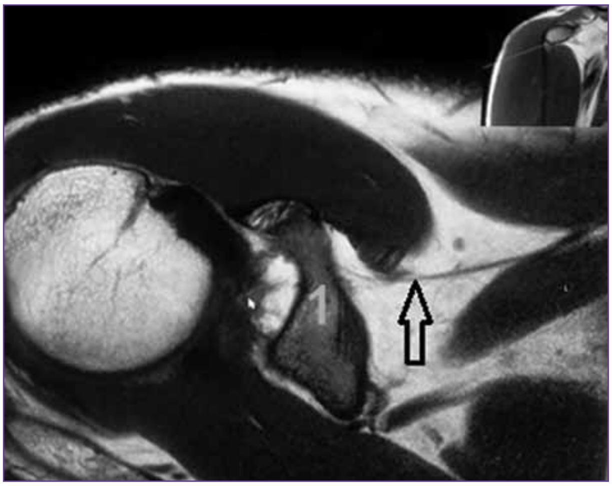

Figure 7. T1-sequence Caldani's ligament in MRI, oblique transverse plane.

Figure 9. Medial coracoclavicular ligament in coronal plane image. 1. Coracoid process. 2. Clavicle.

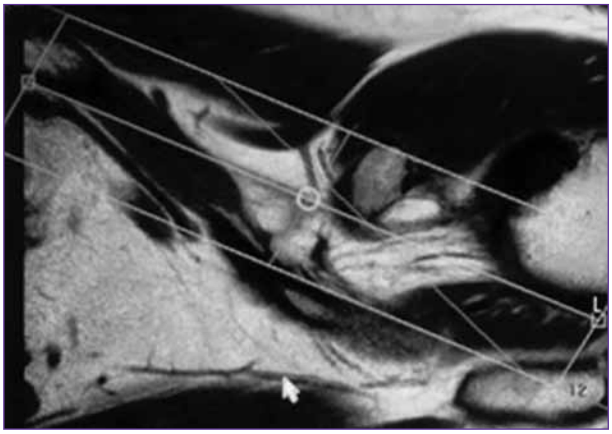

Figure 8. Coronal image planning.

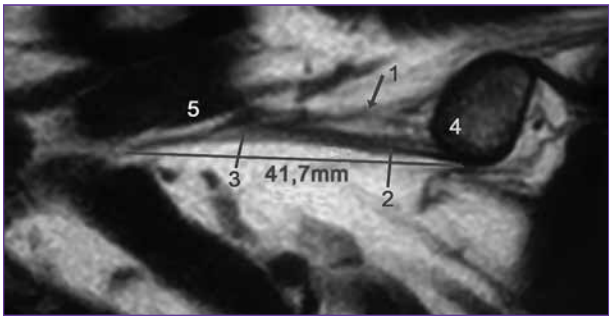

Figure 10. Medial coracoclavicular ligament in coronal section. Ligament length. 1. Anterior bundle of origin. 2. Posterior bundle of origin. 3. Medial coracoclavicular ligament. 4. Coracoid process. 5. Subclavian muscle.

We assessed the length of the ligament (in oblique coronal sections) and its width (in oblique transverse sections) (Figure 10).

We tabulated and processed the figures using the Microsoft Excel statistical package and the VCC Stat 2.0 program. We evaluated averages, standard deviations and confidence intervals in every individual.

Results

We identified the MCCL in the seven patients that we studied. Its shape varied depending on its width and signal, but the ligament was always present (Figures 11-14).

The MRI signal of the ligament body is that of compact collagenous tissue, i.e. hypointense in all the sequences in all the cases, what suggests that there is little space between the ligament fibers. Its edges are distinct and its direction is linear, with no evidence of other areas of neither attachment nor isolated fibers joining it to adjacent ligaments or structures. It is surrounded by (hyperintense) fatty tissue, what facilitates contrast in sequences that do not suppress fat.

With respect to the coracoid process origin, it is wide, many times fan-shaped, with fibers of collagen interwoven with fatty tissue as evidenced by the images (hyperintense in T1, hypointense in T2-fat suppression).

The ligament average length was 41.15 mm (ranging from 34 to 47; standard deviation= 4.40). The ligament average width was 2.11 mm (ranging from 1.3 to 3.2; standard deviation= 0.66) (Table).

Discussion

According to Vallois and Thomas,[5] it was Caldani who first described the medial coracoclavicular ligament. Although this author called it "bi-horn" in his 1881's de-

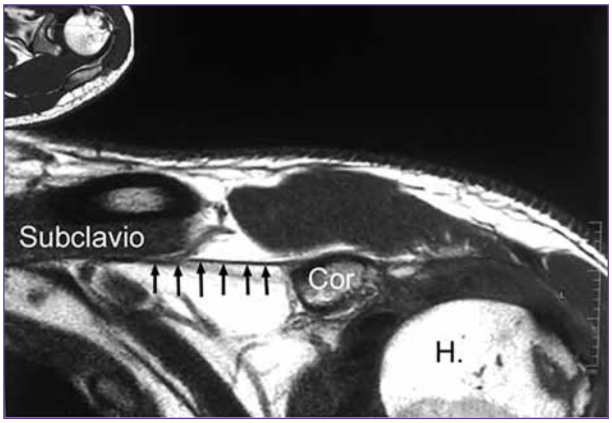

Figure 11. Left side, coronal section, MRI. Arrows point at the medial coracoclavicular ligament. Cor= coracoid process, H= humeral head.

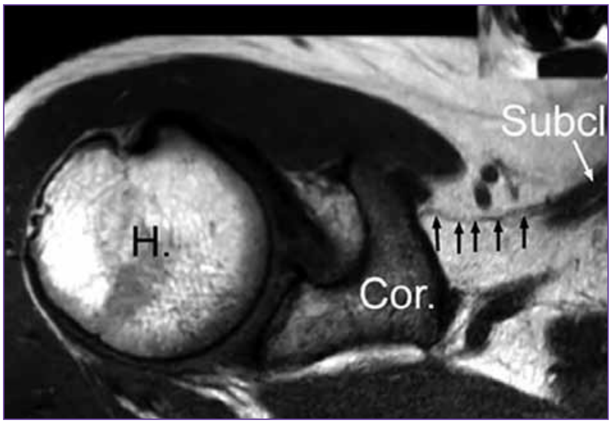

Figure 12. Right side, transverse section, MRI. Cor= coracoid process, H= humeral head.

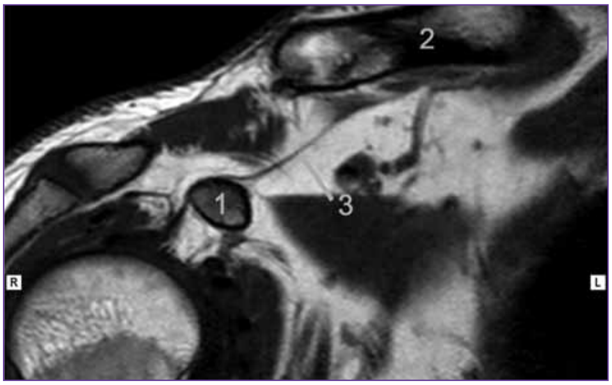

Figure 13. Right side, coronal section, MRI. 1. Coracoid process. 2. Clavicle. 3. Medial coracoclavicular ligament.

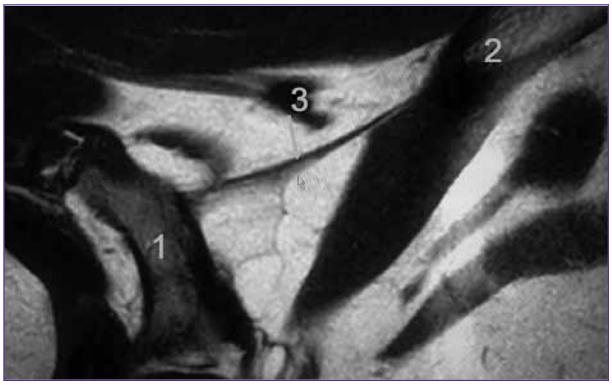

Figure 14. Righ side, transverse section, MRI. 1. Coracoid process. 2. Clavicle. 3. Medial coracoclavicular ligament.

Table. Length and width of the medial coracoclavicular ligament in our study population

Patient	Length	Width
1	39	2.4
2	42	1.7
3	34	2
4	39.9	1.3
5	40.2	2.6
6	46	1.6
7	47	3.2
Average	41.15	2.11
SD	4.41	0.66
95%CI	37.1-45.19	1.51-2.70

SD= standard deviation, 95%CI = 95% confidence interval.

scription, we believe it is most appropriate to call this ligament MCCL, in opposition to the two lateral ones (trapezoid and conoid ligaments).

Although there are diverse descriptions of this ligament in anatomy classic treatises, [2,3] we have not found in either national or foreign consulted bibliography references to the visualization of the Caldani's ligament with an imaging technique. [18-22]

For this reason it has been necessary to develop an original protocol of MRI to detect the Caldani's ligament. The idea that we came up to is painstaking, it is almost a handicraft, and consists of three stages:

1) Location of the ligament on three oblique transverse planes. Since this ligament is difficult to locate, it is necessary to take several packs of images.

2) Upon the partial visualization on this plane, it is necessary to program new sequences on the oblique coronal plane.

3) On the oblique coronal plane, now, the oblique transverse plane is programmed again for full visualization of the ligament.

By means of this protocol it has been possible to identify the ligament in all coronal and transverse sections, and this way we were able to assess its shape clearly.

The characteristics of the signal of the MCCL body, which is that of compact collagenous tissue, coincides with what was described following the histological analysis of one subject, which found microscopic ligament characteristics.

The presence of fatty tissue surrounding the ligament makes it possible to visualize it, in spite of its variable width.

The fan-like shape of the coracoid origin of the ligament, with fatty tissue interwoven, coincides with the previous anatomic findings of two fascicles or origin surrounding the tendon of the pectoralis minor muscle.[4]

In the bibliography that we consulted, we have not found references to the likely functions of this ligament. We did find some papers that highlight a possible MCCL role in dynamic compression of vases and nerves at rib-clavicle level.[8-12]

On the other hand, although this ligament is not likely to play any significant role in acromioclavicular joint stability, we believe it is possible that its rupture does play a role in of type V Rockwood acromioclavicular dislocation pathogeny.[15]

We believe that this protocol will make it possible to evaluate the likely role the MCCL plays in neurovascular compressive processes in the root of the upper limb. Likewise, we think that, in the future, its visualization and assessment in traumatic injuries of the acromioclavicular joint will evidence the possible role this ligament plays in the stabilization of such joint and, perhaps, it will become important at the time of classifying acromioclavicular dislocations.

This is the reason why, as following step in our research, we are set out to use this protocol for the imaging study of patients who show cervicobrachialgia or traumatic acromioclavicular injuries.

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