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LETTER TO THE EDITOR

A Response to: Letter to the Editor Regarding Ultrasound Features of Adhesive Capsulitis

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To the Editor:

We thank the colleagues for the interest shown in our work and the observations made in the Letter to the Editor of Rheumatology and Therapy [1]: it is a welcome invitation to better explain the concepts presented in our paper and the images shown with their correspondence with anatomy and pathology [2]. This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

Our scientific work is not only the result of a thorough research of the scientific literature but also of a constant daily ultrasound (US) practice (for some of us developed over the last 30 years) and intense US study of adhesive capsulitis over the past 18 years. First, our scientific work is mainly focused on the presented novel US features of adhesive capsulitis: the reduced sliding of the infraspinatus tendon that bends during a firm external rotation, the so-called bounce sign

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of the infraspinatus tendon and the more known thickening of the axillary pouch, which can be easily investigated by US both in transverse and longitudinal humeral scanning. The thickening of the coracohumeral ligament (CHL) is often present and may produce a "pseudo-double tendon" appearance in some subjects. However, we reckon that the search for the thickening of the CHL is not specific because it can also be seen in other conditions such as ligament injuries, overuse syndromes, or in patients who suffer from anterior glenohumeral instability [3, 4]: in these cases, the ligament is not shortened [5] as in frozen shoulder, but only thickened, and for this reason it is difficult to differentiate all these conditions. Regarding your specific comments, it is easy to recognize that an oblique transverse scan on the pulley can include the first part of the bicipital sulcus.

As described in anatomical literature [6–8], the greater tuberosity and the lesser tuberosity are bone protrusions that delimit the bicipital groove. However, the bicipital groove extends cranially to these protrusions, just below the surgical neck, where the long head biceps tendon (LHBT) leaves an impression on the bone (see Fig. 1). The proximal part of the bicipital groove is normally visible when the probe is placed at the level of the distal insertion of a heavily thickened CHL on the greater tuberosity.

Moreover, the CHL does not only insert on the upper edge of the great tuberosity but also transversely on the prominence of the great tuberosity and on the superior crest of the lesser tuberosity, as described in the classical anatomical literature, so that a transversal/oblique US section can also include the proximal portion of the bicipital groove.

Based on our experience, anatomical variations may occur so that the US scan can show a more marked sulcus, depending not only on the prominence and anatomical position of the greater and lesser tuberosities, but also on the physical activity and overuse of the patients. For all these reasons, therefore, the probe must be translated along the entire superior sulcus to obtain the best definition of all the anatomical structures.

Regarding your objection to our interpretation of the "pseudo-double tendon" image at the pulley level as a thickened CHL, we need to consider that the "pseudo-double tendon" cannot be the superficial aponeurosis of the supraspinatus-subscapularis for strictly anatomical reasons: the CHL is not independent of the joint capsule but it is instead fused to it for the most part, forming a unique anatomical structure at the level of the rotator interval; therefore, in the case of adhesive capsulitis, the capsular thickening is visible where the capsule is more easily studied in the rotator interval where it is mainly made up of CHL. The aponeurosis of the supraspinatus-subscapularis, on the other hand, is thinner and more superficial than the CHL-capsule and separated by connective tissue.

Therefore, the thick "pseudo-double tendon" shown in Fig. 6 of our paper [2] is not an aponeurotic expansion of the supraspinatus, which is instead extremely thin. When performing a transverse/oblique anatomical US scan section, it is consistent to include the bicipital groove, which is delimited by the greater tubercle laterally and the lesser tubercle medially. The "pseudo-double tendon" *a fortiori* cannot be a bifurcate biceps brachii tendon because this structure would have been easily recognized following the course of the tendons inside the bicipital groove. This anatomical variation is simple to diagnose because the distinction of the two tendons is demonstrable not only at the pulley level (where it appears as "pseudo-double tendon") but also when the probe is proximal and mainly distal to it.

Unfortunately, none of the 43 patients with the "pseudo-double tendon" underwent MRI because the diagnosis was confirmed by the presence of the axillary pouch thickening and by detecting a reduced sliding of the infraspinatus tendon during the passive external rotation. Although no description of the CHL or the superior glenohumeral ligament within the bicipital groove has been made so far, we can easily observe that CHL is inserted transversely to the proximal part of the great tuberosity and proximal scans can also include the sulcus as you can well realize by observing Fig. 1 of an anterior part of a humeral bone. In

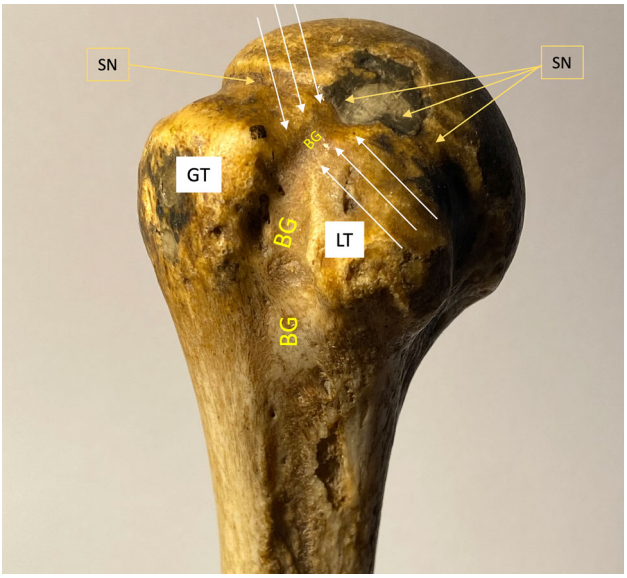

Fig.1 Right humeral head: the bicipital groove (BG and *white arrows*) begins just below the surgical neck (*yellow arrows*). *GT* great tuberosity; *LG* lesser tuberosity

conclusion, through a simple anatomical inspection of the humeral bone, it is evident that the biceps tendon makes a bone impression on the humeral head cranially, then caudally it is flanked by the 'body' of the two tubercles. Therefore, this depression is clearly visible on US scans even before the US scanning insonates the greater and lesser tuberosity. Additionally, the CHL, as described above and by anatomical literature, is not only inserted on the upper edge but also on the body of the greater tuberosity, which delimits the lateral portion of the bicipital sulcus and has a more cranial position than the lesser tuberosity. An oblique transverse scan of about 45 degrees is necessarily required to include both the thickened ligament and the LHBT, and of course this scan will also include the bicipital sulcus. The patient undergoing the US scan shown in Fig. 6 of our paper [2] was subsequently operated in mini-open surgery for a repair of a small lesion of the rotator cuff and the operative finding clearly confirmed thickening of the CHL and of the capsular superior gleno-humeral ligament with no LHBT abnormality. We hope that now the description of the indicted figure is clearer to the readers.

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Compliance with Ethics Guidelines. This article is based on previously conducted studies and does not contain any new studies with

human participants or animals performed by any of the authors.

Data Availability . Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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