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SCIENTIFIC ARTICLE

A new method for measurement of subcoracoid outlet and its relationship to rotator cuff pathology at MR arthrography

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Abstract
Objective Orthopaedic surgical studies have shown that variations in the vertical distance between the tip of the coracoid process and the supra-glenoid tubercle alter the shape of the subcoracoid outlet. Our objective was to measure the vertical distance between the coracoid tip and the supra-glenoid tubercle (CTGT) on MR and to assess whether this showed better correlation with rotator cuff pathology compared with the axial coraco-humeral distance.
Materials and Methods A retrospective review was performed of 100 consecutive shoulder MR arthrograms. Vertical distance between the coracoid tip and the supraglenoid tubercle was measured in the sagittal oblique plane. Separate assessment was then made of tendon pathology of the subscapularis, supraspinatus and long head of biceps tendons. Axial coraco-humeral distance was then measured. Correlation between tendon abnormalities and the two measurements was then made.
Results Of the 100 cases, 42 had subscapularis tendon lesions, 21 had lesions of the long head of biceps and 53 had supraspinatus tendon lesions. Mean vertical distance from the coracoid tip to supraglenoid tubercle was greater in those with lesions of any of these tendons and was statistically significant for the supraspinatus group (P=0.005). Reduced axial coraco-humeral distance was also seen in patients with tendinopathy, although with less statistically significant difference (p=0.059).
Conclusion Our results support orthopaedic studies that have shown that the vertical distance between the coracoid tip and the supraglenoid tubercle increases the incidence and risk of rotator cuff disease by altering the shape of the subcoracoid outlet.

Keywords CTGT · Subcoracoid outlet · Coraco-humeral · MRI · Chevron

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Introduction

Subcoracoid outlet impingement is a recognised cause of anterior shoulder pain although often overlooked on clinical examination and on MR. It is often only appreciated when patients have persistent pain, possibly even after subacromial decompression for rotator cuff disease has been performed with no relief of symptoms. Orthopaedic surgical studies have demonstrated that the location of the coracoid tip affects the shape of the subcoracoid outlet [1]. Different shapes have been described but in particular a "chevron"-shaped outlet in which the coracoid tip lies inferior to the supraglenoid tubercle has been shown to correlate surgically with subcoracoid impingement and entrapment of the subscapularis tendon (Fig. 1) [2] Studies measuring subcoracoid outlet impingement on imaging however have used only axial MR sequences to assess features, particularly the axial coraco-humeral interval, which is the shortest distance from the tip of the coracoid to the humeral head [3]. Measurement of axial coraco-humeral distance on MR has however been shown to be a poor predictor of subcoracoid impingement. Correspondingly [4], surgical studies, suggest that it is actually the location of the tip of the coracoid with respect to the humeral head in the vertical plane that is of more importance [5]. This cannot be assessed on axial sequences and is best appreciated in the sagittal

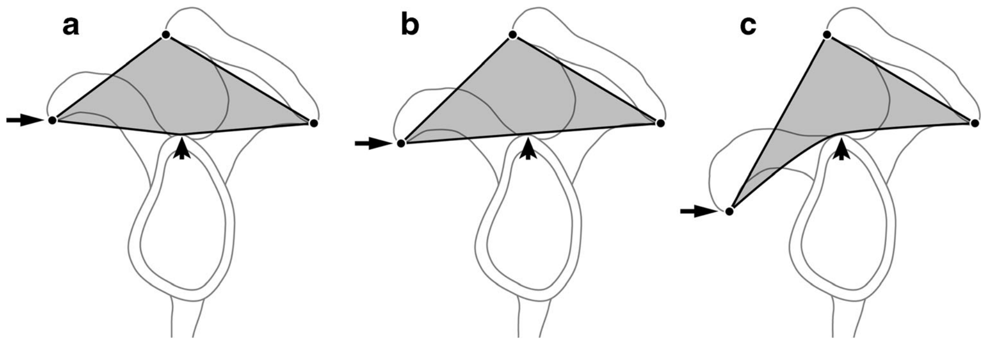

Fig. 1 Diagrams of the shoulder outlet in the sagittal oblique plane demonstrating how the distance that the coracoid tip (*arrows*) lies below the supraglenoid tubercle (*arrow heads*) can change the shape of the outlet (*shaded area*). When it lies above the supraglenoid tubercle (**a**) it is rhomboid shaped, it is triangular shaped when it is at the same level (**b**), and it is 'chevron' shaped when it lies below (**c**)

oblique plane. Furthermore, the coraco-humeral distance is affected by subluxation of the humeral head, which may lead to erroneous assessment of the coraco-humeral space when using this measurement alone.

Consequently, with the unreliability of the axial coraco-humeral distance in predicting subcoracoid outlet impingement, it would be clinically useful if an alternative imaging measurement could be performed that would correlate more accurately with tendon pathology. In view of surgical studies demonstrating the position of the coracoid tip in the vertical plane having an influence on the shape of the outlet and hence the degree of subcoracoid impingement, it would appear likely that a similar vertical measurement on imaging should also correlate more accurately with imaging signs of subcoracoid outlet impingement. The aim of our study was to establish whether alternative measurements relating to the position of the coracoid tip could be performed on MR and whether these would enable better correlation with rotator cuff pathology. In addition we also wanted to establish whether this would correlate more accurately with pathology in the subscapularis and supraspinatus as compared with axial coraco-humeral distance.

Materials and methods

One hundred consecutive MR arthrograms of the shoulder were identified on our picture archiving and communication system (PACS). All were performed using a standard MR arthrogram technique. Using an anterior approach 10 to 15 ml of gadolinium 2 mmol/l was injected into the glenohumeral joint under fluoroscopic guidance. MR images were then obtained, including axial T1, axial T1 fat-saturated, coronal oblique T1 fat-saturated, coronal oblique T2 fat-saturated, sagittal oblique T1 and sagittal oblique T1 fat-saturated sequences, all with slice thickness of 3 mm. All scans were performed using a 3-T scanner (Siemens Magneton Skyra, Erlangen, Germany). All scans were reviewed independently by a senior musculoskeletal radiology fellow (5 years experience) and by a consultant musculoskeletal radiologist (12 years experience). Reviewers were blinded to each other's findings and to the scan reports. Cases of any discrepancies in tendon pathology interpretation between the two reviewers were also reviewed with the senior author (also a consultant musculoskeletal radiologist; 30 years experience). Measurements were also done by two authors on separate occasions. The observed measurement was averaged if a different value was read by the two authors. The study was approved by the local research and development review board.

There were two steps to the assessment. In step 1 each assessor commented on the degree of abnormality of the subscapularis, long head of biceps and supraspinatus tendons. For the subscapularis and supraspinatus tendons a grading system was used to quantify the degree of tendinopathy/tear using a modification of the technique described by Pfirrmann et al. [6]. Grade 0 was normal, grade I was tendinopathy (consisting of two of the following: signal change, morphological change of the fibro-fibrillar pattern with swelling) or MR arthrographic evidence of a partial tear less than 25 % of tendon diameter, grade II was a partial tear more than 25 % of diameter, and grade III was complete detachment of the tendon. Subluxation of the long head of biceps tendon from the bicipital groove was also documented. If subscapularis tendinopathy or tears were present then further assessment was made as to whether this predominantly affected the deeper portion, a feature that has been described as the roller-wringer effect [4]. This step was done blindly, without reference to measurements performed in step 2.

In step 2 measurements were then made to assess the position of the coracoid tip with respect to the supraglenoid tubercle (CTGT) for assessment of subcoracoid outlet impingement in the vertical orientation. This was done on a different occasion to step 1 in order to blind the assessors to the tendon pathology that had been documented. To perform this measurement the insertion site of the long head of biceps tendon on the supraglenoid tubercle was first identified on the coronal oblique T1 fat-saturated sequence (Fig. 2a). Imaging planes were cross-correlated to identify the location of the supraglenoid tubercle on the axial T1 fat-saturated sequence (Fig. 2b). Both of these

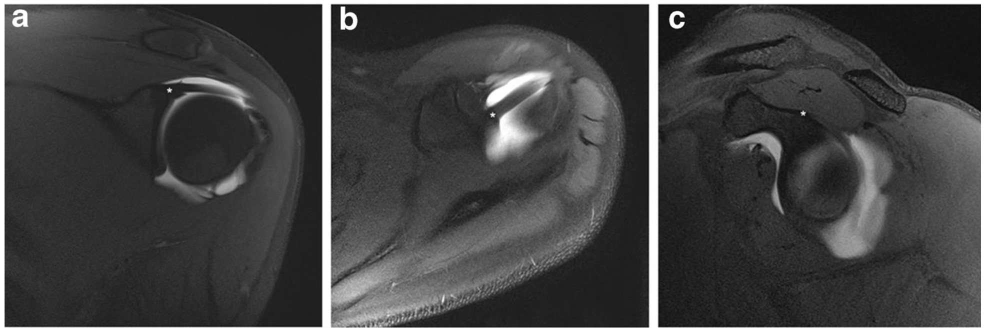

Fig. 2 T1 fat-saturated MR images demonstrating accurate identification of the supraglenoid tubercle (*asterisk*). The supraglenoid tubercle was initially identified on the coronal oblique sequence by identifying the insertion site of the long head of biceps tendon (Fig. 2a). This location was then correlated on the axial sequence (Fig. 2b). Both the coronal oblique and axial sequences were then correlated with the sagittal oblique sequence in order to accurately mark the supraglenoid tubercle position on the sagittal oblique sequence (Fig. 2c)

sequences were then correlated with the sagittal oblique sequence to accurately identify the position of the supraglenoid tubercle on the sagittal oblique sequence (Fig. 2c). Once the supraglenoid tubercle was accurately identified on the sagittal oblique sequence a line was drawn inferiorly from this point, bisecting the glenoid fossa (referred to as line a) (Fig. 3a). (On occasions when the glenoid rim was not optimally visualised on the same sagittal slice as the supraglenoid tubercle, adjacent images were used to identify the optimal slice that demonstrated the glenoid fossa to the best advantage in order to accurately draw line ‘a’). A second line was then drawn perpendicular to this line from the supraglenoid tubercle directed anteriorly (referred to as line b) (Fig. 3b). The sagittal oblique sequence was then scrolled through to identify the coracoid tip. The cursor

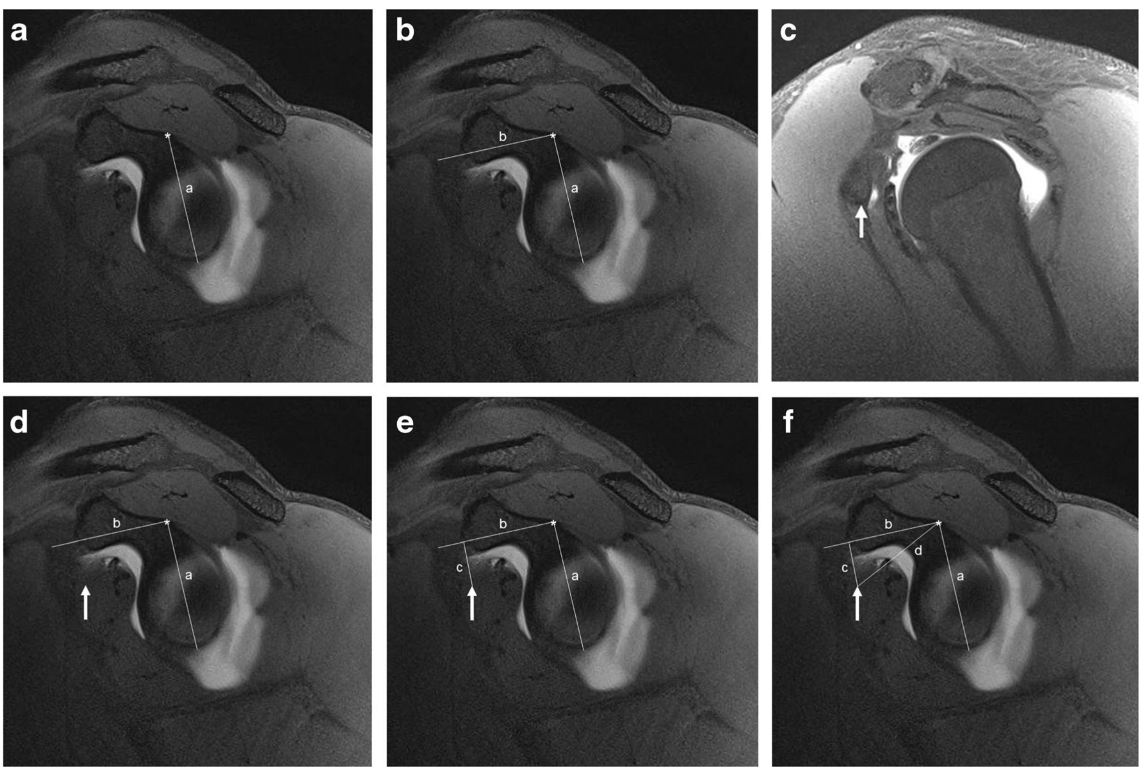

Fig. 3 T1 fat-saturated sagittal oblique MR images demonstrating measurement of the vertical and oblique distances relating to the positions of the coracoid tip and the supraglenoid tubercle. Having accurately identified and marked the supraglenoid tubercle (*asterisk*) on the sagittal oblique sequence in Fig. 2, a line was then drawn inferiorly from the supraglenoid tubercle bisecting the glenoid fossa (*line a*) (**a**). A second line (*line b*) was then drawn perpendicular to *line a*, intersecting it at the supraglenoid tubercle (**b**). The sequences were scrolled through to identify the coracoid tip and a cursor was placed over this point (*white arrow*) (**c**). Without moving the cursor on the screen, the images were then scrolled back to the slice with the above lines drawn on and the point of the coracoid tip was then marked on this image (*white arrow*) (**d**). A third line (*line c*) was then drawn from this *arrow* to *line b*, parallel to *line a* (**e**). This line (*line c*) represents the *vertical* distance that the coracoid tip lies below the supraglenoid tubercle. A fourth line (*line d*) was also drawn from the *arrow marker* to the supraglenoid tubercle in order to perform an alternative oblique measurement (**f**)

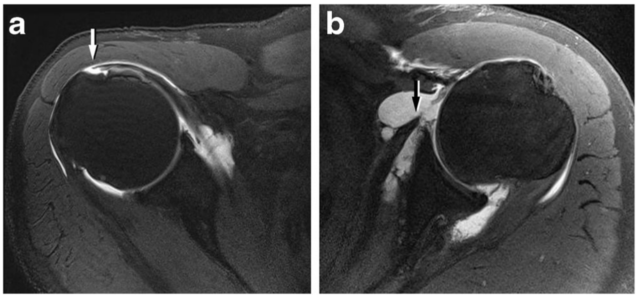

Fig. 4 Axial T1 fat-saturation MR images demonstrating subscapularis abnormalities in patients with a low-lying coracoid tip. **a** A grade II tear and **b** grade III tear

was then placed over the most infero-lateral aspect of the coracoid tip (Fig. 3c). Without moving the cursor position on the screen, the sequences were scrolled back to the image on which the above lines had been drawn relating to the supraglenoid tubercle. An arrow was then drawn on this image marking the position of the most infero-lateral aspect of the tip of the coracoid process as identified on the more lateral sagittal oblique images (Fig. 3d). The distance was then measured from this point to the nearest portion of line b, intersecting with it perpendicularly (referred to as line c) (Fig. 3e). This measurement was recorded as a negative number if the supraglenoid tubercle was inferiorly located to the tip of the coracoid process.

This measurement represents the vertical distance that the tip of the coracoid process lies above or below the supraglenoid tubercle and determines the shape of the subcoracoid outlet, which as mentioned above, surgical studies have correlated with the degree of subcoracoid impingement.

In order to establish whether any other alternative measurements could be performed that would provide better correlation with subcoracoid impingement, an oblique measurement was also performed. This was done by measuring the distance in the sagittal oblique plane from the arrow marking the position of the coracoid tip to the supraglenoid tubercle (referred to as line d) (Fig. 3f). Finally, the coraco-humeral distance was also measured in the axial plane to compare results with currently used measurements. Statistical difference regarding each of these measurements in patients with tendinopathy compared to those without tendinopathy was performed using Student's *T*-test.

Fig. 5 Sagittal oblique T1 fat-saturation MR image demonstrating long head of biceps tendinopathy (*arrow*) in a patient with a low-lying coracoid tip

Results

Of the 100 MR arthrograms, 42 cases had subscapularis tendinopathy/tear, of which the majority (34 patients) were grade I, 6 were grade II and 2 were grade III. Fifty-eight cases had no subscapularis tendinopathy. Of the cases demonstrating subscapularis pathology, in 20 (47.6 %) this involved predominantly the deep aspect of the tendon in keeping with the roller-wringer effect (Fig. 4). Twenty-one cases had tendinopathy of the long head of biceps and a further five cases had partial tears of the long head of biceps tendon (Fig. 5). In six cases there was subluxation of the long head of biceps tendon from the bicipital groove, of which all except one of these cases also had long head of biceps tendinopathy demonstrable on MR. A total of 53 cases demonstrated supraspinatus tendinopathy/tear, of which 29 were grade I, 11 were grade II and 13 were grade III (Fig. 6). Correlation between the two reviewers was very good, with only two cases requiring the further involvement of the senior author. Both of these were regarding the grading for subscapularis pathology (κ coefficient=0.98). There was also very good correlation between the two readers regarding the various measurements. For the vertical distance, 51 % had no difference in readings. Of the 49 % that had a difference, only 9 % had a difference of >1 mm. The maximum difference between assessors' readings was 2 mm (mean difference=1.18 mm). For coracoid tip to SGT measurement, 37 % had no difference in readings. Of the 63 % that had a difference, only 16 % had a difference of >1 mm. The maximum difference between assessors' readings was 2 mm (mean difference=1.25 mm). For axial CHD, 32 % had no difference in readings. Of the 68 % that had a difference, only 7 % had a difference of >1 mm. The maximum difference between assessors' readings was 2 mm (mean difference =1.10 mm). The mean age was 39 years; median age was 40 years. Age range was 13 to 76 years. Twenty-six patients were females; 74 were males. Thirty were of the left shoulder; 70 were of the right.

The mean vertical distance that the coracoid tip lay inferior to the level of the supraglenoid tubercle was greater in those with tendinopathy/tear of supraspinatus or subscapularis compared to cases with normal tendons. Results however were only statistically significant for the supraspinatus group (P= 0.005). Reduced axial coraco-humeral distance was also seen in patients with subscapularis and supraspinatus tendinopathy compared to those without, although with less statistically significant difference compared with measuring the vertical distance. The largest statistical difference using the axial

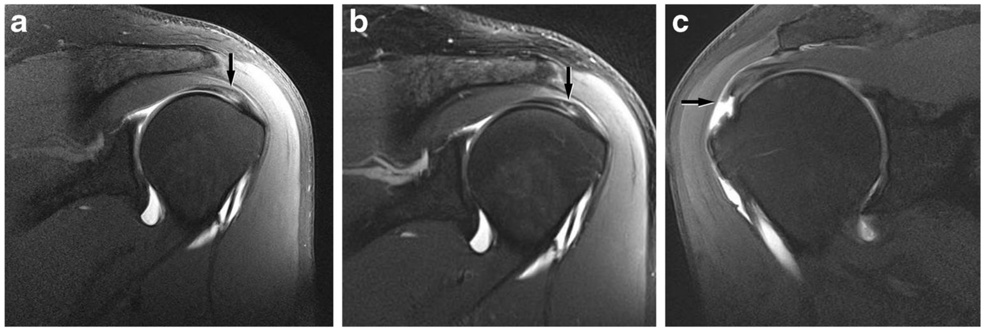

Fig. 6 Coronal oblique MR images demonstrating supraspinatus abnormalities (*arrow*) in patients with a low-lying coracoid tip. **a** (T1 fat saturation) and **b** (T2 fat saturation) demonstrate a grade I tear and **c** (T1 fat saturation) demonstrates a grade II tear

measurement was also seen with regards to supraspinatus (P=0.059). The oblique distance between the arrow marking the position of the tip of the coracoid process and the supraglenoid tubercle correlated poorly with tendinopathy in all of the tendons, with no statically significant difference between those with and without tendinopathy.

In two cases the mean coracoid tip actually lay slightly above the supraglenoid tubercle and in four cases both landmarks were located at exactly the same level. In the other 94 cases the coracoid tip lay below the supraglenoid tubercle. The overall mean distance that the coracoid tip was below the level of the supraglenoid tubercle was 6.6 mm. The overall mean oblique distance between the arrow marking the position of the coracoid tip and the supraglenoid tubercle was 30.9 mm. The overall mean axial coraco-humeral distance was 12.2 mm.

For cases with supraspinatus tendinopathy/tear the mean distance that the tip of the coracoid was below the level of the supraglenoid tubercle was 7.3 mm compared with 5.8 mm in those without tendinopathy (P=0.005). Although there was a highly statistically significant difference in this distance between those with supraspinatus tendinopathy/tear and those without, no trend was shown relating to the grade of tendinopathy (7.1 mm for grade I, 8.5 for grade II, 6.8 for grade III) (Fig. 7). The mean axial coraco-humeral distance was 11.8 mm in those with supraspinatus tendinopathy compared

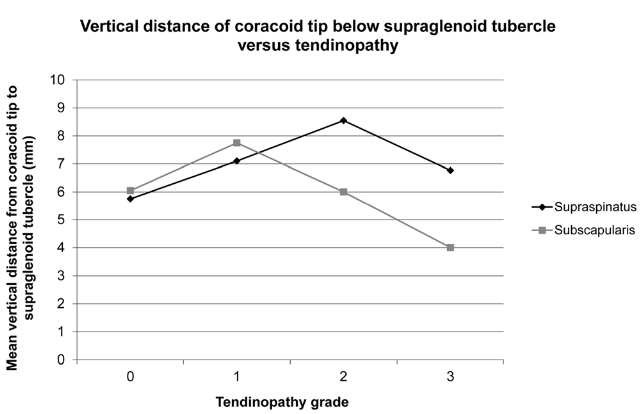

Fig. 7 Graph depicting mean vertical distance that the coracoid tip lies below the glenoid tubercle (CTGT) compared with grade of tendinopathy for supraspinatus and subscapularis tendons

with 12.6 mm in those without (P=0.059). Also, there was no trend in this measurement relating to the grade of supraspinatus tendinopathy (12.2 for grade I, 12.4 for grade II, 10.7 for grade III). Using the oblique measurement between the arrow marking the position of the coracoid tip and the supraglenoid tubercle showed a mean distance of 31.2 mm for those with supraspinatus tendinopathy compared with 30.6 mm in those without (P=0.118). Once again, no trend was shown relating to the grade of supraspinatus tendinopathy with this measurement (31.6 for grade I, 31.9 for grade II, 29.6 for grade III).

The mean vertical distance that the tip of the coracoid process lay below the supraglenoid tubercle in cases with subscapularis tendinopathy/tear was 7.3 mm compared to 6.1 mm in cases without subscapularis tendinopathy (P=0.109). Similar to supraspinatus, there was no trend demonstrated between this distance and the grade of subscapularis tendinopathy (7.8 mm for grade I, 6.0 mm for grade II and 4.0 mm for grade III). The degree of correlation with subscapularis tendinopathy was also more statistically significant for the vertical distance measurement compared with either the axial measurement of coraco-humeral distance (P=0.331) or the oblique distance from the arrow marking the position of the coracoid tip to the supraglenoid tubercle (P=0.324). The mean axial coraco-humeral distance measurement in cases with subscapularis tendinopathy was 11.8 mm compared with 12.5 mm in those without. Although the overall presence of subscapularis tendinopathy was associated with a smaller axial coracohumeral distance, as with the vertical measurement of the coracoid tip below the supraglenoid tubercle there was no trend demonstrated between this distance and the grade of tendinopathy (11.7 mm for grade I, 12.6 mm for grade II, 10.5 mm for grade III). Using the oblique measurement from the arrow marking the position of the coracoid tip to the supraglenoid tubercle only showed a very slight mean difference between the cases with and without subscapularis tendinopathy, measuring 31.3 mm in cases with tendinopathy compared with 30.6 mm in those without. There was also no trend demonstrated relating to the grade of subscapularis tendinopathy and oblique distance (31.8 mm for grade I, 29.3 mm for grade II, 30.3 mm for grade III).

Results for the cases with tendinopathy or partial tears of the long head of biceps tendon showed no statistically significant difference in any of the measurements compared with cases with no long head of biceps tendinopathy or tears. The mean axial coraco-humeral distance showed the greatest statistical difference between the two groups, with a measurement of 11.6 mm in those with long head of biceps tendinopathy or tears compared with 12.4 mm in those without (P=0.282). In those with long head of biceps tendinopathy/tears the vertical distance that the coracoid tip was below the supraglenoid tubercle measured 6.5 mm compared with 6.6 mm in those without (P=0.945). For the oblique measurement these distances were 30.6 mm in those with tendinopathy/tears compared with 31.0 mm in those without (P=0.631). Results for cases of subluxation of the long head of biceps tendon also showed no statistically significant difference compared to cases without subluxation when using any of the measurements, although as in the tendinopathy/tear group the most statistically significant difference was when using the axial coraco-humeral distance (P=0.145). The number of patients with long head of biceps subluxation was very small; however for those with subluxation the mean axial coraco-humeral distance measured 11.3 mm compared with 12.2 mm in those with no subluxation. The mean vertical distance of the tip of the coracoid below the supraglenoid tubercle was 5.4 mm in those with long head of biceps subluxation compared with 6.7 mm in those without (P=0.450). The mean oblique distance from the arrow marking the position of the tip of the coracoid to the supraglenoid tubercle was 30.4 mm in those with long head of biceps subluxation compared with 30.9 mm in those without (P=0.324).

A comparison of the three measurements was also made between MR scans that showed no rotator cuff abnormality (31) and those with an abnormality (69) (either supraspinatus or subscapularis or long head of biceps tendon or any combination). The average distances are included in the table below (Table 1). There was also a statistically significant difference for the vertical distance in this group (P=0.007), but not the oblique distance (P=0.103) or axial coraco-humeral distance (P=0.076).

Discussion

Since Neer's [7] first description of subacromial impingement of the rotator cuff, most of the focus in the literature has centred on the acromial factors causing rotator cuff abnormalities. The most common method of classifying the acromion is based on the shape of its undersurface as described by Bigliani et al. [8] in 1986: type I (flat), type II (curved) or type III (hooked) as viewed in the sagittal plane. Tuite et al. [9] described an acromial angle as the measure of the anterior acromial shape. Nyffeler et al. [10] described a new acromial measurement to assess the amount of lateral acromial extension (acromial index). Some attention has also been directed towards the role of the coracoid in rotator cuff disease, in particular the axial coraco-humeral distance. Cine magnetic resonance imaging (MRI) was used to define the normal space between the humeral head and coracoid process by Friedman et al. [11]. Giaroli et al. [4] found that the axial coracohumeral distance had a poorly predictive value for a diagnosis of subcoracoid impingement when acquired via routinely performed MRI. However, there has been no image-based study assessing the location of the coracoid tip to the shape of the subcoracoid outlet, resultant impingement and pathology within the rotator cuff and the tendon of the long head of biceps.

We believe this to be the first imaging-based study to assess the relationship between the vertical distance of the coracoid tip below the supraglenoid tubercle, which we are designating as the coracoid tip - glenoid tubercle (CTGT) distance, with rotator cuff markers of subcoracoid impingement. Our results show a highly statistically significant difference in the vertical distance that the coracoid tip lies below the supraglenoid tubercle with regards to the presence of tendinopathy within the supraspinatus. An increased vertical distance of the coracoid tip below the level of the supraglenoid tubercle was also seen in cases with subscapularis tendinopathy, although not as statistically significant. No correlation was demonstrated between the vertical distance of the coracoid tip below the supraglenoid tubercle and long head of biceps pathology, although this may be in part due

Table 1 Average distances in relation to the rotator cuff abnormalities detected on the MRI scans

	Vertical distance (CTGT) (mm)	Oblique distance from tip to SGT (mm)	Axial coraco-humeral distance (mm)
Any abnormality in SST, LHB, subscapularis	7.3	31.3	11.8
Normal SST, LHB, subscapularis	5.0	30.0	13.1
SST abnormality	7.3	31.2	11.8
No SST abnormality	5.8	30.6	12.6
Subscapularis abnormality	7.3	31.3	11.8
No subscapularis abnormality	6.1	30.6	12.5
Long head of biceps abnormality	6.5	30.6	11.6
No long head of biceps abnormality	6.6	31.0	12.4

to smaller numbers of patients with long head of biceps pathology in our study. The lack of trend demonstrated with regards to grading of tendinopathy may be due to the smaller numbers with higher grade tendinopathy, particularly in the case of the subscapularis. The traditional measurement of axial coraco-humeral distance was decreased in patients with tendinopathy of any of these tendons, although with regards to supraspinatus and subscapularis tendinopathy the differences were less statistically significant than using the vertical distance method.

The oblique measurement from the supraglenoid tubercle to the arrow marking the position of the coracoid tip was not statistically significant in any of the areas assessed and poorly correlated with pathology. It is worth mentioning that, as described above, in order to be able to perform the measurement in a simple non-time consuming manner, the oblique measurement was done in the sagittal oblique plane on the same slice as that showing the supraglenoid tubercle. This measurement was performed from the supraglenoid tubercle to the level of the coracoid tip projected onto this slice rather than from the true three-dimensional location of the coracoid tip. If a more accurate oblique measurement were performed from the exact position of the tip of the coracoid process to the supraglenoid tubercle then it is possible the results would be different; however such a measurement would be more time consuming to perform, requiring either image reconstruction or use of mathematical vector equations and therefore limiting the clinical value.

Overall, our findings support surgical studies suggesting that the vertical distance relating to coracoid tip position is more important in predicting anterior rotator cuff pathology compared to axial coraco-humeral distance. Interestingly however, our results showed the greatest statistical significance of coracoid tip position with regards to supraspinatus pathology, rather than subscapularis pathology, which might have been expected. This suggests that rather than only influencing the shape of the subcoracoid outlet, the vertical position of the coracoid tip has a bearing on the shape of the whole rotator cuff outlet (Fig. 1), hence also influencing the development of supraspinatus pathology. A low-lying coracoid tip alters the morphology of the anterosuperior aspect of the rotator cuff outlet with reduction in the distance between the coracoacromial arch and glenoid rim, thereby impinging on the anterior aspect of the supraspinatus tendon. Indeed, this close anatomical relationship between the anterior margin of the supraspinatus and the coracoid is well demonstrated on routine ultrasound examination with the humerus in internal rotation. The osseous variation will also have a bearing on the location of soft tissue structures, which are known to play a role in impingement and rotator cuff pathology such as the coracoacromial ligament. Alteration in the shape of the supraspinatus outlet for a variety of reasons will increase the risk of pathology within the anterior aspect of the rotator cuff as demonstrated in our study. We propose that in addition to these already well-known acromial factors that contribute to supraspinatus outlet variation and the risk of rotator cuff pathology, there is an important contribution from the position of the coracoid, which also changes the shape of the supraspinatus outlet. It maybe that the combined presence of acromial and coracoid pathology increases the risk of rotator cuff tear. It is not known if this also has an effect on infraspinatus tendon pathology as this was not part of the study. We would therefore advise that attention should be paid to observing the vertical distance of the coracoid tip below the supraglenoid tubercle when reporting shoulder MR examinations, particularly where there is tendinopathy in any of the rotator cuff tendons. In the same way that acromion morphology is important in the causation and treatment plan for rotator cuff pathology, the level of the tip of the coracoid process should be taken into consideration. In these cases a diagnosis of rotator cuff outlet impingement, including subcoracoid impingement, should be considered, which may greatly influence patient management and surgical outcomes.

Conclusions

Our results support orthopaedic studies that have shown that measurement of the vertical distance between the coracoid tip and supraglenoid tubercle (CTGT) provides better correlation with rotator cuff pathology compared with the axial coraco-humeral distance. Results however were most significant for demonstrating a link between vertical distance and supraspinatus pathology suggesting that the position of the coracoid tip affects the whole shape of the rotator cuff outlet rather than just causing isolated narrowing of the subcoracoid outlet affecting only the subscapularis tendon.

Conflict of interest The authors declare that they have no conflict of interest.

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