An analysis of acromioclavicular joint morphology as a factor for shoulder impingement syndrome

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Abstract

Background: The present study aimed to determine whether acromioclavicular (AC) joint morphology was a factor in the development of symptomatic impingement necessitating AC joint excision.

Methods: We performed a prospective cohort study on all patients undergoing AC joint excision for symptomatic joint pain unresponsive to conservative treatment between 2009 and 2011. This involved 106 consecutive patients (57 women, 49 men, average age 54 years, age range 33 to 76 years). Prior to surgery, radiographic classification of the AC joint was performed producing three main groups: oblique, flat or curved. Pre- and postoperative assessment was performed using the Oxford Shoulder Score and the Disabilities of the Arm, Shoulder and Hand questionnaire.

Results: A significantly ($p < 0.05$) higher frequency of oblique AC joint morphology was seen in the AC joint excision study population compared to the normal population. Postoperative outcome demonstrated no significant difference ($P > 0.05$) between any of the three AC joint morphologies.

Conclusions: The present study demonstrates a significant association between the oblique AC joint morphology and those patients who develop AC joint pain requiring surgery. Outcomes of surgery were independent of joint morphology, gender or age, with all patient subgroups demonstrating significant improvement by the end of the study.

Keywords

Acromioclavicular joint, excision, impingement, morphology

Date received: 15th August 2013; accepted: 30th January 2014

Introduction

Acromioclavicular (AC) joint pain secondary to degenerative change or associated rotator cuff impingement often requires surgical intervention. AC joint arthrosis is one of the commonest causes for painful shoulders, accounting for approximately 31% of patients with painful shoulder.¹ It can cause localized pain and high arc dysfunction. The incidence of primary arthritis of the AC joint in the general population is reportedly as high as 82% in asymptomatic subjects² and degenerative arthritis has been shown to increase significantly with each decade of age.³

The AC joint provides a structural connection between the scapula and clavicle that facilitates support of the shoulder complex on the thorax. Previous studies have classified AC joint morphology, determining three main three-dimensional groups: flat, oblique or curved.⁴ The morphology of a normal AC joint is of

clinical relevance with regard to its loading biomechanics. The areas of articulation within the joint are small, whereas the load transmitted is high. This arrangement produces high stresses through the joint. Load transmitted across a flat or curved joint may be more uniform, whereas a more oblique joint may provide higher stresses at specific articular points, which in turn could promote evolution of degenerative change.

Since Hamilton in 1875 first proposed that variation of the morphology of the acromion to be a potential

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cause of shoulder pain this concept has gained support⁵⁻⁸. Neer⁷ and Bigliani both⁸ described morphological variations of the acromion to be associated with rotator cuff impingement and tears. This established a precedent suggesting that regional variations of normal anatomical morphology can be the cause of localized pathology in particular leading to extrinsic impingement. The concept of a relationship between variation in acromion morphology⁸ and associated localized rotator cuff pathology provides an allied model for considering the impact of different AC joint morphologies on localized cuff and joint disease. As yet, there is no known association between the different AC joint morphologies and related localized pathology.

The present study aimed to determine whether a specific AC joint morphology was more frequently seen in those undergoing surgery for related impingement or degenerative symptoms compared to the others. The null hypothesis assumed was that there was no difference in the frequency of AC joint morphologies in those that require AC joint excision and the normal population.

Materials and methods

The present study comprised a prospective cohort study on all patients undergoing AC joint excision for symptomatic joint pain unresponsive to conservative treatment between 2009 and 2011. This involved 106 consecutive patients (57 women, 49 men, average age 54 years, age range 33 to 76 years) (Table 1). The procedure was performed on the right side in 56% ($n = 59$) of the cases and 4% ($n = 4$) had sequential bilateral procedures.

Inclusion criteria for the study were any patients who presented with a history of a painful AC joint and with related AC joint impingement. The patients must have failed conservative treatment in the form of basic analgesics and local steroid injection and now required surgical excision because of isolated joint pain or localized impingement. Clinical examination of the AC joint was performed to confirm the diagnosis. Exclusion criteria for the study were patients with AC joint pathology that was radiologically unclassifiable as a result of severe degenerative change or patients with

previous shoulder surgery or additional pathology such as cervical spine disease.

Radiographic assessment

All patients underwent standard pre-operative antero-posterior radiographs of the AC joint that were used to assess joint morphology. The radiographs were taken in a standardized manner, with the arms by the patient's side and the horizontal beam centred over the acromioclavicular joint. The morphology of the joint was subsequently assessed in the coronal plane. The AC joint was classified as flat, oblique, curved or unclassifiable (Figure 1). This method was identical that used in the previous radiographic assessment of the morphology of the ACJ in the normal population.⁴ The reported frequency of AC joint morphology in the normal population was used as a reference point for comparison with the AC morphology frequency in this study population. The study of the normal population also included assessment of the AC joint using reformatted computed tomography scans in both the true coronal and transverse planes. This was used to confirm the validity of the plain radiographic assessment method. This method has previously been discussed in the radiological assessment of AC joint morphology.⁴

Figure 1. Diagrams and radiographs of the three main three-dimensional shapes of the acromioclavicular joint.

Table 1. Breakdown of demographics of the present study against the normal population.

	Number in population of the present study (n)	Average age (years)	Age range (years)	Male:Female
Study population demographics	106	54	33 to 76	46%:54% ($n = 49$):($n = 57$)
Normal population demographics	82	41	21 to 83	72%:28% ($n = 59$):($n = 23$)

Surgery performed

All patients underwent the senior surgeon's default technique of arthroscopic AC joint excision. Arthroscopic subacromial decompression was concomitantly performed along with arthroscopic AC joint excision in all cases.

Scoring systems

Use of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and the Oxford Shoulder Score (OSS) for follow-up of shoulder surgery has been previously validated and shown to be an effective scoring tool.⁹ The patients were assessed pre-operatively, at 6 months, 12 months, 18 months and 24 months post-operatively using the DASH questionnaire and the OSS. The DASH has a value between 0 and 100, where 0 represents a normal shoulder and 100 represents a shoulder with the maximum disability. The OSS ranges between 0 and 48, where 48 would be the score obtained with a normal shoulder.

Statistical analysis

Two observers independently analyzed the radiographs. Chi-squared testing at the 5% level was employed to compare individually the frequency of each of the specific morphologies (flat, oblique and curved) determined on the radiographic analysis and their frequency within the normal population. Statistical differences were identified for each morphology between the study population and the normal population.

Unpaired Student's *t*-tests at the 5% level were used to individually compare the scores obtained by the scoring tools at the pre- and postoperative time intervals for each AC joint morphology. Unpaired Student's *t*-tests at the 5% level were also used to compare the scores of each respective AC morphology with the other morphologies at each individual time interval assessed. Analysis of the data was performed using SPSS statistical software (SPSS Inc., Chicago, IL, USA).

Results

AC morphology frequency

There was a significant difference ($p < 0.05$) between the frequency of AC joint morphologies in the study population and those in the normal population (Table 2). The chi-squared test demonstrated a significantly higher frequency of oblique AC joint morphology in the AC joint excision study population compared to the normal population.

Outcomes of surgery: AC joint morphology as assessed by DASH and OSS

Pre-operatively, there was no significant difference ($p > 0.05$) between the DASH or OSS scores for any of the three AC joint morphologies studied when compared with each other. There was significant improvement ($p < 0.05$) of the both the DASH and OSS when assessing the entire population on comparing pre-operative and end-of-study scores at 24 months (Figures 2 and 3 and Table 3). Similarly, there was a significant improvement ($P < 0.05$) for each of the three AC joint morphologies studied when assessed over the course of the study (Figures 2 and 3 and Table 3). Postoperatively, there was no significant difference ($p > 0.05$) in the DASH or OSS between any of the three AC joint morphologies when compared with each other (Table 4).

Outcome of surgery: assessed by patient gender

Pre-operatively, there was no significant difference in the frequency of AC joint morphologies seen in either the male or female subgroups. There was also no significant difference in the pre-operative OSS or the DASH scores between the male and female subgroups. Both outcome measures indicate a continued improvement in the scores over the duration of the study irrespective of gender, with significantly improved outcomes by 24 months compared to the pre-operative scores.

Table 2. Frequency of acromioclavicular (AC) joint morphology in the AC excision study group compared to the normal population.

AC joint morphology	Joint frequency in the excision study population	Joint frequency in the normal AC joint population	Chi-squared testing <i>p</i> -value of study population against normal population morphology frequencies
Oblique	64%* ($n = 68/106$)	37% ($n = 30/82$)	0.017*
Flat	31% ($n = 33/106$)	43% ($n = 35/82$)	0.426
Curved	5% ($n = 5/106$)	12% ($n = 10/82$)	0.633

*Significant difference at the 5% level.

Impact of patient chronological age

There was a relative increase of the oblique AC joint morphologies seen in the subgroups as the chronological age increased. However, this increase was not significant ($p > 0.05$) when comparing the frequency of oblique AC joint morphologies in the different age subgroups with each other. A similar but less

pronounced rise in the flat AC joint morphology (but not the curved morphology) was noted as the age of the subgroups increased. Again, however, this was not significant ($p > 0.05$). There was no significant difference in the pre-operative OSS or the DASH scores ($p > 0.05$) between any of the subgroups stratified by the patient's chronological age when tested against each other. Both outcome measures indicate a continued improvement in the scores over the duration of the study. All subgroups had significantly improved ($p < 0.05$) OSS and DASH

Figure 2. Postoperative Disabilities of the Arm, Shoulder and Hand (DASH) scores by specific acromioclavicular joint morphologies (mean values and 95% confidence interval error bars).

Figure 3. Postoperative Oxford Shoulder Scores by specific acromioclavicular joint morphologies (mean values and 95% confidence interval error bars).

Table 3. p -values returned from t -testing between the pre-operative and postoperative Disabilities of the Arm, Shoulder and Hand (DASH) score and Oxford Shoulder Score (OSS) for each individual acromioclavicular joint morphology.

	Pre-operative versus 6 months		Pre-operative versus 12 months		Pre-operative versus 18 months		Pre-operative versus 24 months	
	DASH	OSS	DASH	OSS	DASH	OSS	DASH	OSS
Oblique	0.533	0.799	0.251	0.227	0.029*	0.035*	0.017*	0.011*
Flat	0.222	0.043*	0.354	0.044*	0.298	0.182	0.020*	0.005*
Curved	0.815	0.699	0.131	0.582	0.206	0.205	0.025*	0.034*

*Significant difference at the 5% level.

Table 4. P -values returned from t -testing between the different acromioclavicular joint morphologies at each time point using the Disabilities of the Arm, Shoulder and Hand (DASH) score and Oxford Shoulder Score (OSS).

	Pre-operative		6 months		12 months		18 months		24 months	
	DASH	OSS	DASH	OSS	DASH	OSS	DASH	OSS	DASH	OSS
Oblique versus Flat	0.751	0.326	0.417	0.373	0.303	0.471	0.421	0.587	0.793	0.629
Oblique versus Curved	0.311	0.344	0.316	0.401	0.417	0.377	0.468	0.755	0.811	0.801

*Significant difference at the 5% level.

scores by 24 months compared to their pre-operative scores.

Discussion

Studies looking at the association between AC joint morphology and shoulder pain have been limited to date. Previous studies have largely looked at the effects of AC joint degeneration and the secondary impact on the rotator cuff. To date, there are no studies that have linked variation in AC joint morphology with the likelihood of developing AC joint symptoms at a later date.

A previous study of the AC joint has described three main morphologies of the AC joint (flat, oblique and curved).⁴ There is historical support for the presence of variation of the AC joint. De Palma described varying inclinations at the articulating ends of the clavicle and acromion.^{10,11} This observational study assessed cadaveric AC joints with respect to their inclination in the coronal plane and classified AC joints into three groups with respect to the inferomedially angulated plane of the joint.

The present study demonstrates that patients with an oblique AC joint morphology appear to have a higher risk of developing localized impingement symptoms requiring surgery compared to the other AC joint morphologies. This result was significant on statistical testing ($p < 0.05$) against the frequency of oblique AC joints seen in the normal population.

Assessment of outcomes as measured by both the DASH and OSS in the present study demonstrated a significant improvement in the patient's function and symptoms at the end of the study compared to their pre-operative status. This effect was independent of the AC joint morphology. The shoulder scores post AC joint excision improved continuously over time up to 2 years after surgery. Although the oblique AC joint morphology had a significantly higher association with surgical intervention, there was no significant difference in postoperative outcome measures between the three morphologies.

Gender had no effect on the distribution of morphologies observed. Gender also had no effect on the rate of recovery or outcome. This finding supports previous results indicating that gender was not a significant aetiological factor in the development of arthrosis within the shoulder.¹² Other potential aetiological factors influencing the development of shoulder arthrosis include chronological age.¹² There is some support for this concept from the results obtained in the present study. Our results showed that there was a relatively higher frequency of oblique-shaped AC joints in older patients; however, this did not reach statistical significance. In the present study, age did not impact upon the outcome of surgery in that there was no significant

difference in either the DASH or OSS between any of the age subgroups assessed by 24 months.

Neer⁷, Rockwood and Matesen¹³ and Bigilani et al.⁸ have established that there are changes to the distal acromion as the body ages. It has been shown that degenerative changes may even be evident as early as the fourth decade of life.¹³ This may be of relevance to the present study because the average age in the study was 60 years. Degenerative changes may in turn lead to a change in the apparent AC joint morphology. In the present study, we excluded AC joints in which there were advanced radiographic signs of arthrosis and, as such, were radiologically unclassifiable. However, we accept that small osteophytes and other early radiolucent signs of arthrosis would not have been evident on plain radiography. Also, there may have been some joints in which osteophytic changes were present without other radiographic signs of arthrosis. In turn, this could have masked their true morphology. This would have meant that some degenerative AC joints might have been assessed as oblique joints as a result of inferior distal clavicular osteophytes. However, it is accepted that there are variations in the morphology of not only the acromion,⁸ but also the AC joint.^{4,14} These true anatomical variations can be assessed on plain radiographs and age does not prevent identification of these various morphologies.⁴ Acromial morphology is a known aetiological factor in the development of subacromial impingement and rotator cuff tears. Variation in the acromion index has also been suggested as an extrinsic anatomical cause for impingement.¹⁵ Therefore, the concept that variation of the AC joint morphology is a potential extrinsic factor in the development of similar conditions is a reasonable theoretical extrapolation from this principle. The present study indicates that this is particularly true for oblique AC joints because there were significantly more patients presenting with this morphology and associated pathology in whom excision was required.

Another potential weaknesses of the present study include the index surgery that the patients underwent not solely comprising AC joint excision. However, the entire study population underwent arthroscopic AC joint excision combined with subacromial decompression. This provided homogeneity to the study group. Even though rotator cuff tears can be associated pathologies with AC joint arthrosis,^{11,16} such patients were excluded because their outcomes would have produced excess heterogeneity to the study population. This variation could have resulted in any conclusion being of less merit. The number of curved AC joints was relatively small compared to the numbers reported in the other morphological subgroups. In turn, this may have had an affect on the statistical analysis and overall trends in outcomes. The curved group had marginally

worse postoperative DASH and OSS scores and slower rates of recovery. However, by the end of the study, there was no significant difference in outcomes compared to the other groups. These slower early recovery results could have been a result of outliers, although the overall pattern of recovery is similar to the other morphologies. Other potential weaknesses include the study design itself. The study was not blinded to either patients or clinicians, potentially allowing for observer bias. The sizes of the groups were not matched, potentially allowing for a bias in the statistical assessment of their postoperative outcomes. The patients themselves were not matched for race, nor associated comorbidities.

The present study indicates that AC joint morphology can be considered as a potential factor with respect to causing AC joint-related impingement symptoms and localized pathology that in turn may require surgical excision. In particular, a significantly higher incidence of oblique AC joint morphology was noted in those patients requiring an AC joint excision. The study also demonstrates that, independent of joint morphology, patients continue to have a beneficial effect from AC joint excision up to 2 years after surgery. The outcomes of surgery were independent of joint morphology, gender or age, with all patient subgroups demonstrating significant improvement by the end of the study. We advise particular consideration of those patients with painful oblique AC joint morphology alongside subacromial impingement or rotator cuff disease for surgical excision of the AC joint.

Declaration of conflicting interests

None declared.

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