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Radiological evaluation of acromion morphology: Based on 142 scapulae

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Abstract
The aim of this study is to determine the shape of the acromion according to age; to correlate the type of acromion with the acromial index and the critical shoulder angle.
Methods: This is a prospective study lasting two months, from 1 June 2019 to 31 July 2019. After obtaining informed consent, subjects aged 40 or under were included, while those with shoulder trauma or shoulder pain were excluded. Acromial morphology was analysed according to Bigliani and Morisson after calculating the subacromial distance, lateral overhang by the acromial index and critical shoulder angle.
Results: 142 shoulders in 85 subjects were selected, with a mean age of 51.14 years and a male predominance with a sex ratio of 1.74. There were 52.11% type I acromions; the mean acromial index was 0.62; the mean critical shoulder angle was 33.42°; there were no type I acromions in the elderly and very elderly. There was a significant association between acromion type, acromial index and critical shoulder angle on the one hand, and between acromial index and critical shoulder angle on the other.
Conclusion: Based on our radiological observations of standard shoulder X-rays, analysis of the acromion allows us to predict the future of the shoulder and, at a minimum, its exposure to the risk of rotator cuff rupture or, conversely, omarthrosis.

Keywords: Acromion, morphology, assessment

Introduction
The acromion is an apophysis that extends the spine of the scapula upwards, forwards and laterally. It is quadrangular in shape, flattened from top to bottom, and lies in a plane perpendicular to that of the spine of the scapula [1].
Its main role is to provide the space necessary for the insertion of the deltoid, an essential muscle of the shoulder. Its lateral protrusion relative to the humeral head is a key point for the forces exerted by the deltoid muscle on the humeral head: mainly ascending if the acromion protrudes significantly, and glenohumeral coaptation if the acromion protrudes only slightly. It is the extrinsic factor in subacromial impingement and has long been considered the obvious culprit in rotator cuff tears [2].
Conflict between the acromioclavicular arch and the rotator cuff has long been recognised as a cause of chronic shoulder pain.
In 1972, Neer [3] showed that subacromial impingement is located in the anterolateral part of the acromion, opposite the lesions located in the critical zone of the supraspinatus and biceps.
Since acromioplasty was first described, its frequency has been steadily increasing. Is this justified, or has this scapular apophysis been wrongly blamed? A recent analysis of the literature and studies conducted on the lateral part of the acromion sheds new light on the relationship between the acromion and rotator cuff tears, as well as the indications for acromioplasty [2]. Thus, the shape and, above all, the size of the acromion may be important factors in the dynamics of the deltoid muscle.
The objectives of our study are to determine the shape of the acromion according to age and to correlate the type of acromion with the acromial index and the critical shoulder angle.
This could be useful for orthopaedic surgeons, rheumatologists and radiologists in the management of shoulder pain.

Materials and Methods

This was a prospective, descriptive study conducted over a two-month period from 1 June 2019 to 31 July 2019. After informed consent, subjects aged 40 years or younger admitted to the surgical unit of the SAU at Idrissa Pouye Hospital were included; subjects with shoulder trauma, painful shoulders, and poor-quality X-rays were not included. A total of 142 shoulders in 85 subjects were selected. The average age of the series was 51.14 years, ranging from 40 to 80 years; adults over 60 years of age accounted for 80% of subjects; males accounted for 63.52% with a sex ratio of 1.74, and civil servants accounted for 31.76%.

Radiological data were collected from a standard full-size shoulder X-ray including Lamy's frontal and profile views. We took the various measurements using a goniometer and a black pencil.

This enabled us to determine:

-The type of acromion after measuring the subacromial distance (SAD), which is the distance between the lower cortex of the acromion and point C located in the middle of line AB.

The type of acromion is assessed on a Lamy profile X-ray; the acromion is classified into three types

- Type I or flat acromion: SAAD < 3 mm,
- Type II or curved acromion: FSA 3 to 5 mm
- Type III or hooked acromion, FSA > 5 mm

The acromial index (AI) according to Nyffeler is the ratio between the distance between the lateral edge of the acromion and the glenoid cavity on the one hand, and the distance between the external part of the greater tubercle and the glenoid cavity on the other. It is divided into three categories:

- AI ≤ 0.60: omarthrosis
- AI between 0.61 and 0.72: normal
- IA ≥ 0.73: rotator cuff tear

-The critical shoulder angle (CSA) according to MOOR This is the angle between the line running from the lower edge of the glenoid cavity to its upper edge on one side and the line running from the lower edge of the glenoid cavity to the lateral edge of the acromion on the other.

The CSA is classified into three categories:

- CSA< 30° risk of osteoarthritis
- CSA between 30° and 35° normal
- CSA >35° risk of rotator cuff tear

Statistical analysis: Data was entered using Word and Excel software. Statistical analysis of the data was performed using SPSS 20.0 software, with the Chi-square test used to correlate the means between qualitative and quantitative variables and a significance threshold of $p< 0.05$.

Results

Radiological data

Acromion type according to Bigliani

Type I accounted for 52.11% of cases, followed by type II and type III, accounting for 35.21% and 12.67% respectively.

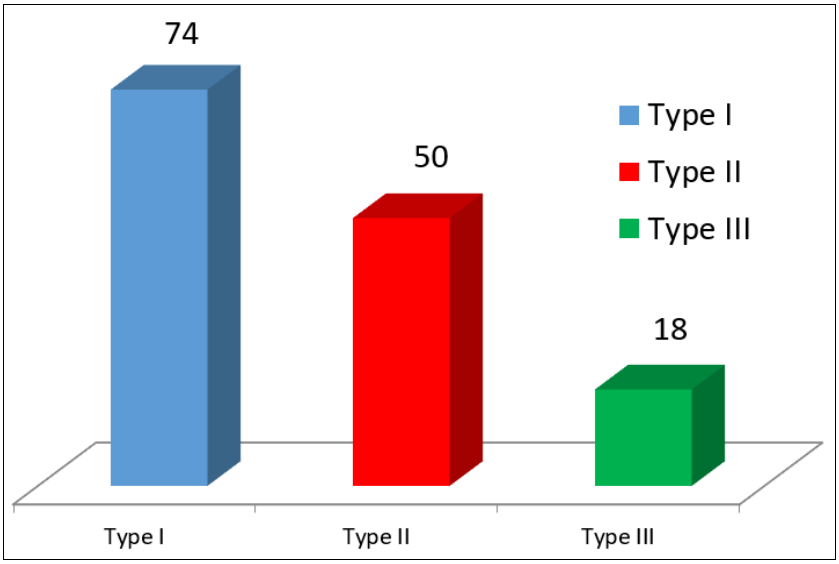

Fig 1: Distribution according to acromion type

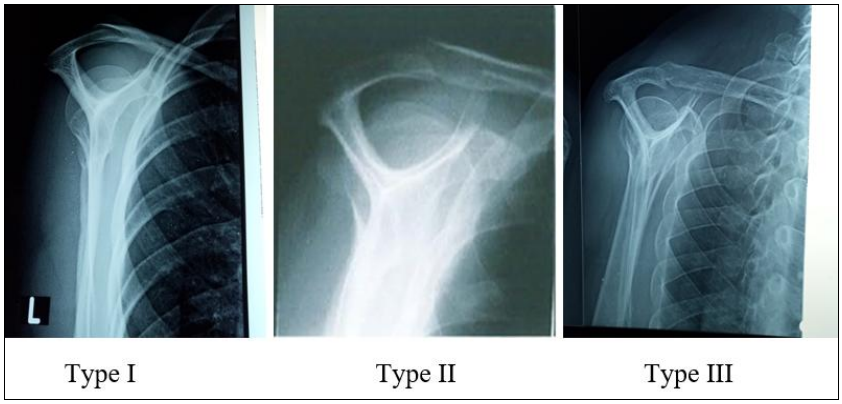

Fig 2: Acromion type

Acromion type according to age group

There were 74 type I acromions, 10 type II acromions and 2 type III acromions in adults; there were no type I acromions in geriatric patients and the elderly.

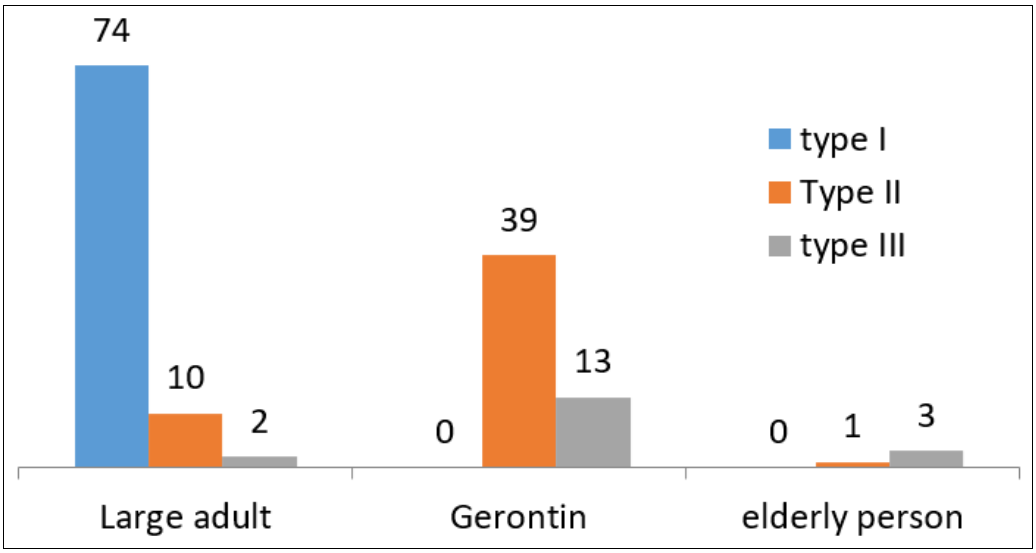

Fig 3: Distribution of acromion type according to age group

Acromial index (AI)

The average AI was 0.62, ranging from 0.57 to 0.74.

AI between 0.61 and 0.72 represented 75.35% of shoulders, with a mean value of 0.63 and a standard deviation of 0.02.

Table 1: Distribution according to acromial index

AI	n	Mean	Standard deviation
≤ 0.60	33	0.59	0.01
0.61-0.72	107	0.63	0.02
≥ 0.73	02	0.73	0.007

Critical shoulder angle (CSA)

The average CSA was 33.42° with extremes ranging from 28° to 41°.

The 30°-35° range accounted for 80.98% of CSAs, with a mean value of 33.22° and a standard deviation of 1.27.

Table 2: Distribution according to CSA

CSA	n	Average	Standard deviation
<30	06	28.71	0.48
30-35	115	33.22	1.27
>35	21	37	1.48

Correlation between the acromial index and the type of acromion

Type I had a mean acromial index of 0.61 with a standard deviation of 0.02, and types II and III had mean acromial indices of 0.63 and 0.65, respectively, with a significant p-value of 0.001.

Table 3: Correlation between the acromial index and the type of acromion

Acromion type	N	Average IA	Standard deviation	P
Type I	74	0.61	0.02	0.001
Type II	50	0.63	0.03	
Type III	18	0.65	0.02	

3. Correlation between critical shoulder angle and acromion type

Type I had a mean CSA of 32.30° with a standard deviation of 1.81; types II and III had mean CSAs of 34.33° and 35.15°, respectively, with a significant p value of 0.0001.

Table 4: Correlation between CSA and acromion type

Acromion type	N	Average CSA	Standard deviation	P
Type I	74	32.30	1.81	0.0001
Type II	50	34.33	1.84	
Type III	18	35.15	1.34	

4. Correlation between the acromial index and the critical shoulder angle

The mean acromial index in our series was 0.62 and the mean critical shoulder angle was 33.42° with a significant p value of 0.001.

Table 5: Correlation between the acromial index and the critical shoulder angle

Measurement	Mean	Standard deviation	P
IA	0.62	0.03	0.001
CSA	33.42	2.10	

Discussion

Radiological analysis

Acromion type

Bigliani described three types of acromion in 1986 based on cadaver dissection

- Type I or flat acromion
- Type II or curved acromion
- Type III or hooked acromion

However, this classification is not very reproducible and is disrupted when there is ossification of the acromioclavicular ligament. Park *et al* [4] described a more reliable classification based on the same incidence.

In our series, we found 52.11% of type I, 35.21% of type II and 12.67% of type III.

These results are comparable to those found by Moor *et al* [5, 6], who found 31.4% of type I, 66.7% of type II and 1.9% of type III in 51 patients.

Le Reun *et al* [7] also found 35.2% type I, 40.8% type II and 18.3% type III in 67 scapulae from an anatomical collection of Caucasian bones.

Table 6: Summary of acromion types according to authors

Acromion type	Moor *et al* [26, 27] n=51	Le Reun *et al* [24] n=67	Our series n=142
Type I	31.4	35.2	52.11%
Type II	66.7	40.8	35.21%
Type III	1.9	18.3	12.67

Acromion type according to age group

In our series, we found a predominance of type I in tall adults, i.e. 74 acromions, whereas no type I acromions were found in geriatric patients and the elderly.

Nicholson *et al* [8] found an acromial spur in 30% of anatomical specimens from patients over 50 years of age after examining 420 scapulae.

Edelson [9], for example, found no hooked acromions before the age of 30, although impingement may occur in young athletes [10]. Primary damage to the rotator cuff muscles could be responsible for secondary subacromial impingement [11]. Muscular imbalance causes an increase in traction forces on the acromioclavicular ligament and its acromial insertion [12, 13, 14]. The morphology of the acromion is altered by the creation of traction enthesophytes, giving the arch an aggressive appearance.

Acromial index (AI)

On the frontal image, Nyffeler *et al* [15] in particular described methods for assessing acromial morphology by measuring the lateral overhang of the acromion. To do this, they described the acromial index (AI) on a frontal X-ray of the shoulder, perfectly aligning the glenohumeral joint space and the subacromial space, with the arm in neutral rotation.

In a population of 70 volunteers without osteoarthritis or rotator cuff tears, Nyffeler *et al* [15] reported a mean acromial index of 0.64.

Moor *et al* [5] also found an average acromial index of 0.66 for 51 shoulders.

These results are comparable to those found in our series, with an average acromial index of 0.62.

Table 7: Summary of the mean acromial index according to the authors

AI	Nyffeler *et al* [15] n=70	Moor *et al* [26, 5] n=51	Our series n=142
Mean AI	0.64	0.66	0.62

Critical shoulder angle (CSA)

More recent studies indicate that certain characteristics of the anatomy of the scapula, particularly a large lateral projection of the acromion and an upwardly inclined glenoid cavity, are associated with the presence of a rotator cuff tear [16, 15, 17]. An angle combining these two parameters, called the critical shoulder angle (CSA), has recently been defined.

In our series, based on the results obtained from the analysis of standard shoulder X-rays, we found that the mean CSA was 33.42°; the average CSA between 30-35 was 33.22°; the average CSA < 30 was 28.71° and the average CSA > 35 was 37°.

These results are similar to those found by Moor *et al* [5], who also found an average CSA of 32.9° in 51 shoulders.

Cherchi *et al* [18] reported an average CSA value of 33.3° in 27 patients.

Several other authors have shown that a high CSA is an important predictor of rotator cuff rupture; they found an average CSA value of 33.1° and 32.7° in control populations without shoulder pathology [4, 19, 20].

The mean CSA angle value in our series (33.42°) is comparable to that of controls without shoulder pathology in these authors (33.1° and 32.7°) [5, 6, 21] and higher than that of their arthritic controls (27.7◦, 28.1◦ and 28.7◦) [5, 17, 21]. This can probably be explained by the fact that our control population is not an arthritic population, but rather comparable to the general population.

An oblique glenoid is accompanied by an increase in the shear component of the force exerted by the deltoid muscle [19]. The humeral head tends to rise further [15]. A large acromial overhang increases the vertical component of the deltoid force [5, 6]. Thus, there are vertical forces that can cause the humeral head to rise. This could promote the development of lesions on the deep surface of the rotator cuff and subacromial impingement [5, 22]. The reproducibility of the measurement and the significance of the critical shoulder angle with rotator cuff rupture has been described by Neer [16] and Armstrong [23].

Correlation between acromion type and acromial index

We found that type I acromion had a mean acromial index of 0.61; types II and III had mean acromial indices of 0.63 and 0.65, respectively, with a p-value of 0.001.

In our series, there was a correlation between acromion type and AI; Naja [24] found that AI is more significant in patients with stage III acromion, and these figures show greater lateral acromial overhang in patients with aggressive acromion.

Thus, based on simple biomechanical and radiological observation of standard images, analysis of the lateral acromion allows us to predict the future of the shoulder and, at a minimum, its exposure to the risk of rupture or, conversely, osteoarthritis.

Correlation between acromion type and critical shoulder angle

We found that type I acromion had an average CSA of 32.30; types II and III had average CSAs of 34.33 and 35.15 respectively, with a p-value of 0.001.

In our series, there was a correlation between acromion type and CSA.

As part of their study, Moor *et al* [5] measured numerous other indices and statistical analysis enabled them to conclude that the CSA was the most powerful predictor of rotator cuff tears. No correlation was found between this angle and the classic Bigliani and Morrison classification.

It was initially shown that the percentage of rotator cuff tears was significantly higher when the acromion was type III [25] than when it was type I.

However, the hooked appearance and ossification of the acromioclavicular ligament are known to be most often acquired and may be secondary to the tear, rendering Bigliani and Morrison's interpretation obsolete. Furthermore, the reproducibility of this classification is poor [26]. Conversely, the CSA appears to be a constitutional element; it is strongly correlated with the presence of a rotator cuff tear when it exceeds 35°, indicating significant lateral protrusion. It is also strongly correlated with the presence of glenohumeral osteoarthritis when it is less than 30° [27].

The hypothesis that can be put forward is as follows: the supposed constitutional part of the problem is the lateral acromion protrusion. It gives the deltoid a predominant upward force. The rotator cuff suffers, the humeral head tends to rise and the arch承受s greater stress, causing morphological changes and, in particular, traction enthesophytes. Thus, with age, but also due to occupational

stress, the acromion lengthens and curves. This is the acquired part of the problem. The contact between the arch and the rotator cuff, which is normally physiological, then becomes symptomatic and the acromion may be responsible for damaging the rotator cuff. A study of the evolution of the acromion in humans compared with great apes and early humans was carried out by Voisin *et al* [27].

Correlation between the acromial index and the critical shoulder angle

We found a mean CSA of 33.42º and a mean acromial index of 0.62 with a significant p-value; there was a correlation between the acromial index and the critical shoulder angle.

Conclusion

In light of our study, we observe a dynamic evolution of the acromion, which tends to transform into Bigliani type III as a person ages. Type III often has the highest CSA and is particularly prone to rotator cuff tears. We recommend increased monitoring of people over the age of 50 and, in the event of shoulder symptoms, a complete radiological assessment with measurement of the AI and CSA. This will enable the detection of at-risk individuals (CSA greater than 35°) and prevent rotator cuff tears by protecting their shoulders.

Another benefit of measuring AI and CSA is that it allows the effectiveness of acromioplasty to be assessed, as this procedure involves transforming a type III acromion into a type I acromion and also reducing the CSA to below 35°.

Conflict of Interest

Not available.

Financial Support

Not available.

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