Anatomical basics and variations of the scapula in Turkish adults

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ABSTRACT

Objective: To analyze the anatomical basis of the scapula, acromion, os acromiale, coracoid process, coraco-acromial arch, and glenoid cavity in Turkish adults.

Methods: We performed the study at the Faculty of Medicine, Akdeniz University, Turkey between January 2004 and December 2005. A total of 90 dry bones of the scapula from human cadavers were randomly selected. The length, width, and anterior thickness of the acromion and the acromial facet of the acromioclavicular joint were measured with an electronic caliber and was examined visually. For the radiological evaluation, the posterior–anterior and the lateral shoulder radiographs of 90 consecutive adult patients with normal findings were used. These films were evaluated and grouped according to the acromial arch morphology.

Results: The distribution of the acromial morphologic types according to slope was type I (flat) 10%, type II (curved) 73%, type III (hooked) 17%. Type I was seen in 11%, type II 66%, type III 23% of the specimens. The morphological shape of the tip of the acromion was 31% cobra shaped, 13% square shaped, and 56% intermediate type. The scapulas, coracoid process and the coraco-acromial arch were measured. In 72% of the specimen, the glenoid notch of the scapulas were absent and oval shaped, whereas in 28% the notch was well expressed and the glenoid cavity was pear-shaped. The mean vertical length of the glenoid cavity was 36.3 ± 3 mm, and the mean transverse length was 24.6 ± 2.5 mm. Os acromiale is a rare anatomical condition. Its incidence has been documented in radiographic and anatomical studies to be between 1-15%. The presence of os acromiale was 1% in shoulder radiographs (os pre-acromiale), and in dry bones (os meta-acromiale)

Conclusion: We reported the exact morphological measurements of the bone structures of the scapula in Turkish adult population. Our results present an instructive figures of anatomical preparations and radiological cases that can be used to make a more precise radiological and a differential diagnoses.

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The scapula plays several roles in facilitating optimal shoulder function when scapular anatomy and biomechanics interact to produce efficient movement.[1] The exact dimensions of the scapula and its geometry, however, are of fundamental importance in the pathomechanics of rotator cuff disease, total shoulder arthroplasty, and recurrent shoulder dislocation.[2] The shoulder joint demands close attention by orthopedic surgeons, physiologists and especially by radiologists.[1,3] The acromion process of the scapula contributes to the pathologic conditions of the shoulder. Early investigators noted the variability in the shape, slope, presence of os acromiale, and the size of the acromion.[4-8] Later investigations supports differing theories as to acromion function, its pathologic contribution to shoulder problems, and

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Table 1 - Different anatomical measurements taken on the scapula.

Measurements	Mean ± SD	Extremes
Length of the acromion	44.7 ± 5.1 mm	35.2 - 55.5 mm
Height of the acromion	3.2 ± 1.3 mm	0.4 - 6.5 mm
Coraco-acromial arch distance	17.8 ± 1.3 mm	11 - 25.4 mm
Height of coracoid process	14.6 ± 2.9 mm	9.5 - 21.2 mm
Slope of the acromion	23.1 ± 3.1^{o}	18 - 31^{o}
Slope of the coracoid process	13.4 ± 2.8^{o}	8 - 23^{o}
Scapular angle of root of coracoid process	124.8 ± 7^{o}	113 - 141^{o}
Scapular angle of base of acromial spine	124.4 ± 5.6^{o}	112 - 136^{o}
Length of coracoid process	19.4 ± 7.9 mm	10 -77.5 mm
Anatomical length of scapula	98.8 ± 7 mm	76 - 115 mm
Breadth of supraspinous fossa	43 ± 7.5 mm	24.6 - 58.4 mm
Breadth of infraspinous fossa	113.5 ± 10.3 mm	79.8 - 135.4 mm

appropriate treatment courses. Acromial morphology is well described and classified into 3 types based on the shape of the acromial tip. Type I acromions have a flat antero-inferior edge, type II acromions have a smooth curved under surface, and type III acromions have a hooked or sharp curved under surface.[9,10] In addition to this 3 types, some researchers reported a fourth type, which is rarely seen.[11-13] Acromial morphology is believed to play a key role in impingement syndrome and the pathogenesis of rotator cuff disease. The acromion is believed to be the primary causative factor in the pathogenesis of impingement syndrome, leading to possible rotator cuff disease.[9,14] The syndrome evolves mostly under acromion but also rarely under the coracoid process.

Os acromiale is present when the anterior portion of the acromion has one or more separate ossicles. Macalister[15] provided a precise description of the formation of the acromial epiphysis. Several ossification points fuse to form 3 major elements. The anterior element is the preacromion, the middle one is the mesoacromion, and the posterior element, which forms the acromial angle, is the metaacromion. These 3 elements merge to form a triangular epiphyseal bone, which finally fuses with the basi-acromion. Reports of os acromiale associated with the subacromial pathology have been cited to imply that this entity is a cause of subacromial impingement.[16] Since the morphology of the acromion and the impingement syndrome has been shown to be related by some authors, the bony structures of the shoulder attract the attention of researchers.[3,9,11,12] So we aimed in this study to analyze the anatomical basis of the scapula, acromion, os acromiale, coracoid process, coraco-acromial arch, and glenoid cavity in Turkish adults.

Methods. The study was performed at the Faculty of Medicine, Akdeniz University, Turkey between January 2004 and December 2005. A total of dry 90 scapula bones were randomly selected at the anatomy laboratory of our faculty. Of the 90 scapulas, 44 were from the right side, and 46 were from the left. The bones belonged to mature specimens, but the exact ages and gender of the specimens were not known. The bones were isolated and inspected macroscopically. Scapulas were grouped according to the morphology of the acromial arch and the tip of the acromion. The scapulas, acromions, coracoid process and the coraco-acromial arch were measured with an electronic caliber. We measured the vertical and the transverse length, from the widest side of the glenoidal cavity, the supraglenoidal and the infraglenoidal tubercles as the reference points, with an electronic caliber.

For the radiological evaluation, the posterior-anterior and the lateral shoulder radiographs of 90 consecutive adult patients with normal findings were used. These films were evaluated and grouped according to the acromial arch morphology.

The Statistical Package for Social Science version 11.0 package (Chicago, Illinois, USA) for personal computer was used for the statistical analysis. There was no statistical significance between data of the radiological and bone specimens according to chi-square test.

Results. A summary of measurements regarding the scapula, acromion, coracoid process and the coraco-acromial arch was shown in **Table 1**. We classified the scapulas into 3 groups according to the morphological shape of the tip of the acromion. Twenty-eight of the specimens (31%) were cobra shaped (**Figure 1a**), 12

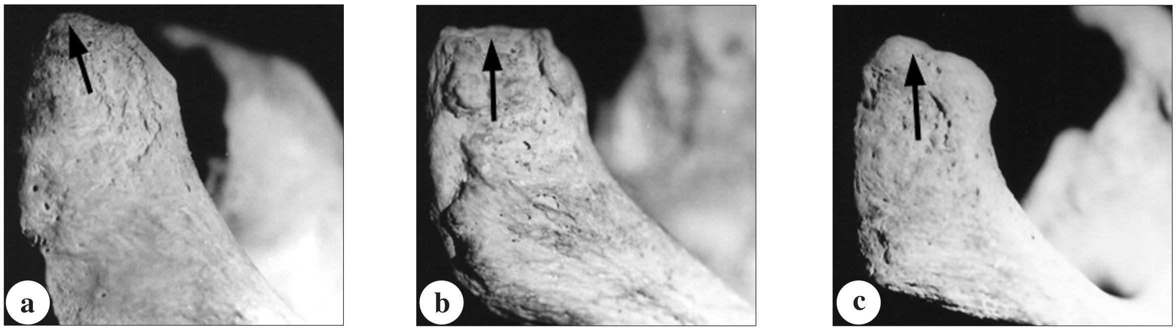

Figure 1 - Morphological shapes of the tip of the acromion. **a)** "cobra" shaped acromion, **b)** "square tip" acromion, and **c)** "intermediate-shaped" acromion.

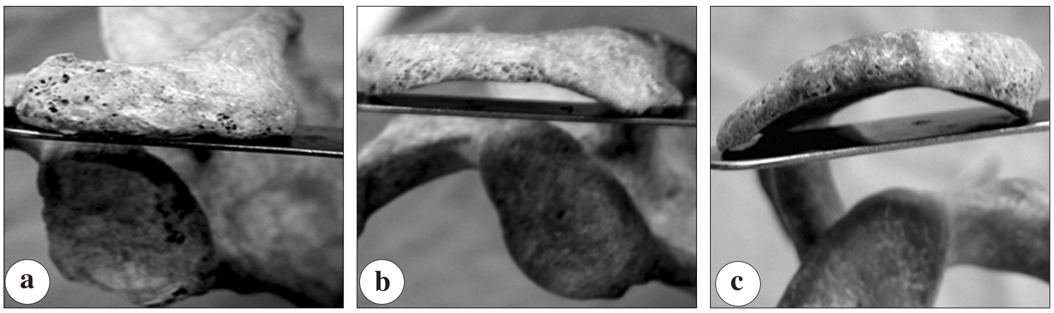

Figure 2A - Types of acromion according to its slope. **a)** A specimen of Bigliani type I acromion (flat), **b)** Bigliani type II acromion (curved), and **c)** Bigliani type III (hooked).

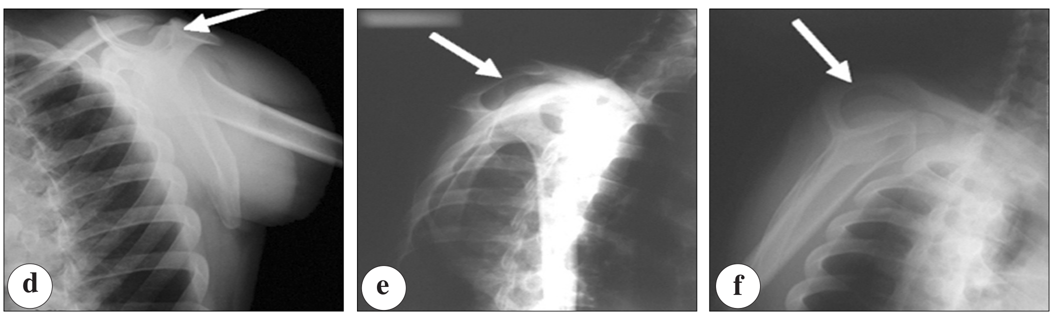

Figure 2B - Radiological typed of acromion according to its slope. **d)** Radiograph of a specimens with a type I acromion (flat), **e)** Type II acromion (curved), and **f)** Type III (hooked).

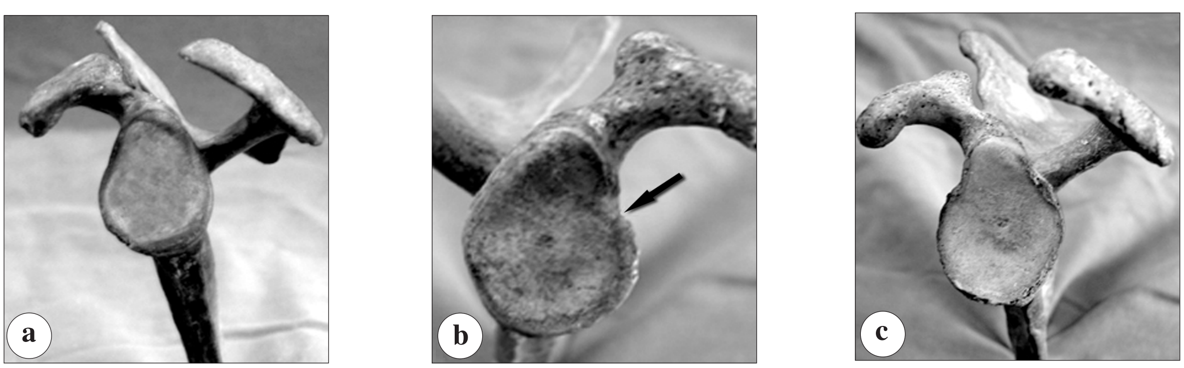

Figure 3 - Types of glenoid notch. **a)** Glenoid cavity without glenoid notch. **b)** Glenoid cavity presenting a pronounced glenoid notch (arrow), and **c)** Glenoid cavity presenting double glenoid notch.

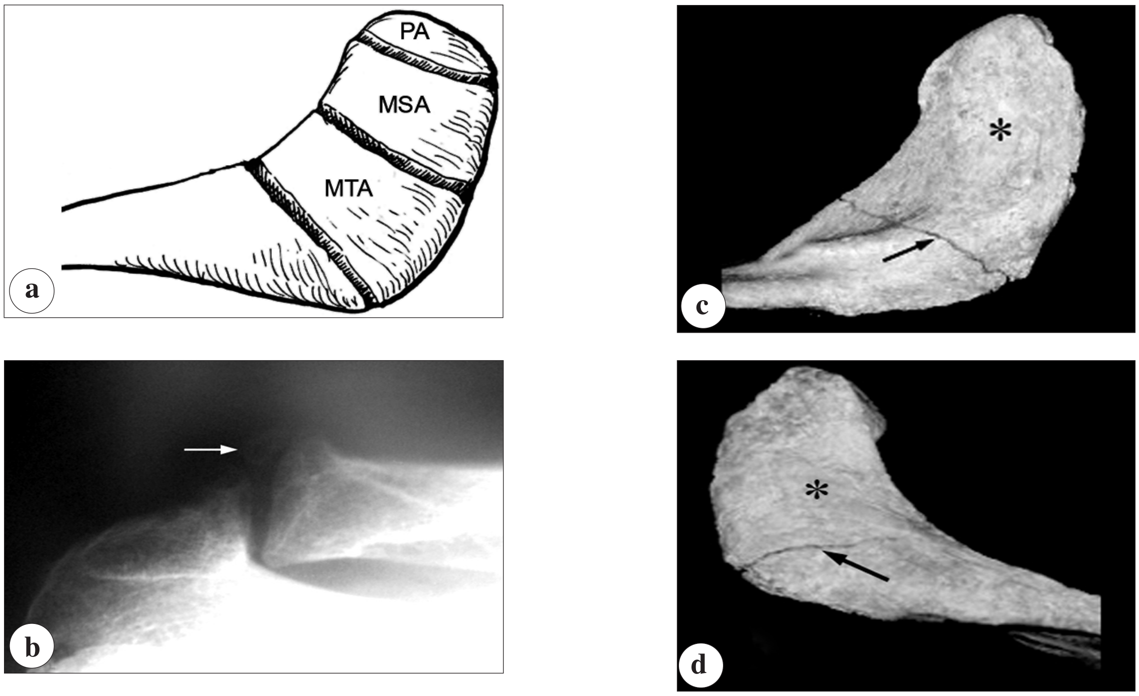

Figure 4 - Types of os acromiale. **a)** Schematic illustration showing the 3 ossification centers of the acromion that determine os acromiale. PA: pre-acromion, MSA: mesoacromion, and MTA: meta-acromion. **b)** Radiograph of a specimens with an os acromiale (os pre-acromion). **c)** ventral view, os acromiale (*) and line of meta-acromion (arrow), and **d)** dorsal view, os acromiale (*) and line of meta-acromion (arrow).

(13%) were square shaped (**Figure 1b**), and 50 (56%) were intermediate shape (**Figure 1c**).

We examined the types of acromion according to its slope. Type I flat was seen in 9 (10%) acromions, type II curved in 66 (73%) and type III hooked in 15 of 90 (17%) (**Figure 2a**). According to the slope of acromion we examined 3 types of acromions radiologically. Type I was seen in 10 (11%), type II was seen in 59 (66%) and type III was seen in 21 (23%) of the specimens (**Figure 2b**). In 64 (72%) of the scapulas, the glenoid notch was absent or it was a shallow oval shaped (**Figure 3a**). In 26 (28%), the notch was well expressed and the glenoid cavity was pear-shaped (**Figures 3b & 3c**). The mean vertical length of the glenoid cavity was 36.3 ± 3 mm, and the mean transverse length was 24.6 ± 2.5 mm.

In the shoulder radiographs, the os acromiale was observed in one patient aged 37 years. Location of the os acromiale was pre-acromion (**Figure 4b**). Os acromiale was observed only in one dry bone, which was located as meta-acromion (**Figures 4c & 4d**).

Discussion. Four structures of the scapula, the acromion; the glenoid cavity; the superior margin, and the ligamenta propriae scapulae, are of special clinical interest.[3] In this study, some of the bone structures of the scapula, which has a special clinical interest, were investigated morphologically in Turkish adult population.

The morphology of the acromion has been studied extensively since first described by Bigliani et al.[9] Especially when the undersurface of the anterior third of the acromion is under the influence of coraco-acromial ligament resulting in the formation of different acromion types.[17-19] It was reported that the increased length of the acromion limits the overhead activities. Acromion types were classified as flat, curved and hooked according to the anterior surface length. Studies have noted an association between type III acromions, and the presence of rotator cuff tears.[20] The acromial shape also has been shown to have correlation with the severity of symptoms in impingement syndrome and to influence the outcome of conservative therapy.[14,21] The rotator cuff compression was seen mostly in hooked types, often seen in curved types and rarely seen in flat types of acromions. This classification is useful for clinical diagnosis and helpful for understanding the reasons of the rotator cuff compression and its treatment.

Bigliani et al[20] reported 33% rotator cuff tears in 140 cadavers. They characterized acromions as type I flat (3%), type II curved (24%), and type III hooked (73%). Edelson and Taitz[22] study classified 200 dry scapulas as type I (17%), type II (43%) and type III (40%); our comparable figures in 90 dry bones were 10% as type I, 73% as type II and 17% as type III and in radiological cases 11% as type I, 66% as type II and 23% as type III. In a study by Ekin et al[11] identified the types of the acromion as type I (18%), type II (61%), type III (13%), type IV (8%) in 102 scapulas and 20%, 60%, 17%, 3% among 40 radiographs. They also reported that subacromial spurs and sclerotic changes were seen significantly and mostly in type III acromions. Cezayir et al[12] reported the types of the acromion as type I (24%), type II (45%), type III (30%) and only in one case as type IV (0.86%) in 115 scapulas. In a study by Yazici et al,[13] type I was reported in 22.5%, type II in 70%, type III in 5%, and type IV (convex hooked) in 2.5% in 40 neonatal cadavers. Furthermore, Yazici et al[13] reported type III acromions seen in adults increased with the degenerative changes due to the lowest incidence of type III acromion in neonatal cadavers. In our study, type IV was found neither in dry bones nor radiological cases.

The exact dimensions of the scapula and its geometry take importance in some clinical aspects[2] so that we measured scapulas morphologically. One of this measurement is the length of the acromion and our results (**Table 1**) reveals similarities with some studies[2,23,24] in the literature. Anetzberger and Putz[23] observed acromial length as 4.7 cm, Lack et al[24] as 4.4 cm. Mallon et al[2] took his measurements from x-rays films, recorded a length of 4.2 cm. Anetzberger and Putz[23] reported that the distance between its tip and the upper edge of the glenoid cavity also influenced the acromial length; it is an important factor in the diagnosis of the impingement syndrome. They further reported the anatomical length of the scapula as 10.5 cm, the breadth of the supraspinous fossa of as 3.9 cm, and of the infraspinous fossa as 11.5 cm. Our results were similar to these studies.[13]

Glenoid orientation, or version, has been implicated as a contributing factor in glenohumeral instability in multiple studies.[3,23,25,26] The precise size and orientation of the glenoid fossa are not well defined although several authors have attempted to determine glenoid version. This has been performed in a variety of ways, including direct measurement of dry scapula, radiographic (x-ray), measurement, and more recently CT.[26] The shape of the glenoid cavity is as egg-shaped, oval, teardrop or pear-shaped, round, tear with a notch, shape without a notch and elongated oval variously described in the literature.[3,23,27,28] The dissimilarity results in a variety of different anthropometric parameters to describe the glenoid cavity. Anetzberger and Putz[23] reported, a tear with a ventral notch (59%), a similar shape without a notch (29%) and an elongated oval (12%). Huber,[28] distinguished 2 types and observed that a cavity with a notch (87.5%) and an oval articular surface (12.5%). As these different shapes may express individual's stresses, acting on the articular surface or, as in the case of the elbow joint,[29] the different forms of the joint can affect on the contact surfaces and therefore, on the stress acting on those surfaces. Therefore, in our opinion, it is reasonable to establish a precise description of these types. In our study, there was no notch in the glenoid cavity in 72% of the specimens whereas the other 28%, had a notch. Nevertheless, there is an agreement on the function of the glenoid cavity, that it exists as an osseous base providing stability of the glenohumeral joint both sagittally and vertically. Cezayir et al[12] reported the transverse width of the glenoid cavity as 27 mm, the vertical width as 37 mm and the angle between the glenoid cavity and the coracoid process as 12.23^{O}. In this study, we observed the transverse width of the glenoid cavity as 24.6 mm, the vertical width as 36.3 mm and the angle between the glenoid cavity and the coracoid process as 13.4^{O}. Furthermore, the scapula-spinal angle was measured as 140^{O} by Mallon et al,[2] 126^{O} by Anetzberger[23] and was 124^{O} according to our results.

A typical variation (1-15%) is the os acromiale, which forms the triangular epiphysis of the scapular spine.[3,19,30,31] Os acromiale results from a failure of fusion at any of 3 separate acromial ossification centers. As ossification of the acromion is completed approximately at the age of 20 years (range 20-25),[3,32,33] the os acromiale should be diagnosed only after these ages.[3] Its frequency has been documented, in radiographic and anatomical studies. Sammarco[16] reported its incidence as 8%, Edelson et al[31] 8.2% and Boehm et al[33] 6.2%. The literature mainly describes os meso-acromiale, and os pre-acromiale[30,34-41] Warner et al[40] reported the treatment of 3 symptomatic os meta-acromiale. In our study, radiologically we observed one pre-acromion and one meta-acromion, which is reported rarely in the literature, in 90 of the dry bones.

This paper summarizes the acromion, os acromiale, coraco-acromial arch distance, glenoid cavity, the anatomical measurements of the scapula, classified according to the morphologies and variations of these structures. We reported the exact morphological measurements of the bone structures of the scapula, which has a special clinical interest, in Turkish adult population and also presents instructive figures of anatomical preparations and radiological cases that can be used to make more precise radiological and differential diagnose.

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