The Scapula : Osseous Dimensions and Gender Dimorphism in Thais

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Abstract : **Anatomic and morphometric study of the scapula in Thais was aimed to provide fundamental information for surgical procedures such as fixation device selection, arthroscopic portal placement, prosthetic design and positioning. Thirty measurements were carried in 97 scapulas, 25 pairs from female and 23 pairs and one left side from male cadavers. The average age at the time of death was 69.82 years. The average length of scapula measured from the superior angle to the inferior angle was 13.93 ± 1.11 cm.(mean ± standard deviation). The thickness of the lateral border taken from the midpoint and 1 cm. from the edge was 0.82 ± 0.20 cm. thicker than the medial border taken in the same manner (0.12 ± 0.08 cm.). The inferior angle was more acute at 40.88 ± 5.29 degrees and thicker than the superior angle (84.29 ± 9.43 degrees). The superior border was thin and sharp; the suprascapular notch was presented on the border medial to the root of the coracoid process. The depth and shape of the suprascapular notch were variable. The length of the spine measured from the tip of the acromion process to its medial edge was 12.89 ± 0.94 cm. The anteroposterior width of the spine measured were 0.60 ± 0.15 and 1.78 ± 0.29 cm. taken from 1 and 4 cm. away from its medial edge, respectively, and 4.15 ± 0.43 cm. width measured in the plane of the spinoglenoid notch. The dimensions of the acromion process were 4.41 ± 0.47 cm. X 2.50 ± 0.37 cm. X 0.72 ± 0.51 cm. (L x W x T). The distance between the acromion and coracoid processes was 3.11 ± 0.41 cm. The coracoids measurements were 4.04 ± 0.41 cm. X 1.46 ± 0.19 cm. X 0.74 ± 0.12 cm. (L x W x T). The distance measured from the tip of the coracoid process to the bottom of the suprascapular notch was 4.84 ± 0.39 cm. The glenoid dimensions were 3.58 ± 0.35 (superoinferior) and 2.73 ± 0.31 cm. (anteroposterior). The thickness of the scapula neck was 1.91 ± 0.37 and 1.02 ± 0.27 cm. at 1 and 2 cm. away from the glenoid rims. Scapulas from male cadavers were significantly larger than those from female cadavers in 27 measurements.**

Key words : Morphometry, scapula, dimorphism, Thais

เรื่องย่อ : กระดูกสะบัก: มิติ ความแตกต่างทางเพศของกระดูกในคนไทย
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การศึกษากายวิภาคและการวัดโครงสร้างของกระดูกสะบักในคนไทย มีจุดมุ่งหมายเพื่อเป็นข้อมูลพื้นฐาน ในการทำหัตถการทางศัลยศาสตร์ เช่นการเลือกอุปกรณ์เพื่อยึดกระดูกที่หัก ตำแหน่งที่จะเจาะเปิดเพื่อทำการ

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ผ่าตัด หรือการออกแบบและจัดตำแหน่งของข้อต่อเทียม เป็นการศึกษาโดยวัดส่วนต่างๆ 30 ตำแหน่งจากกระดูกสะบักทั้งหมด 97 ชิ้นจากอาจารย์ใหญ่เพศหญิง 25 คู่ และเพศชาย 23 คู่กับข้างซ้าย 1 ชิ้น อายุเฉลี่ยของอาจารย์ใหญ่ตอนเสียชีวิตคือ 69.82 ปี ความยาวของกระดูกสะบักที่วัดจากมุมบนไปยังมุมล่างเป็น 13.93 ± 1.11 ซม. (ค่าเฉลี่ย ± ค่าเบี่ยงเบนมาตรฐาน) ความหนาของขอบกระดูกด้านใกล้ริมโดยวัดจากกึ่งกลางของขอบและห่างจากขอบ 1 ซม. เป็น 0.82 ± 0.20 ซม. ซึ่งหนากว่าขอบด้านใกล้กลางที่วัดในทำนองเดียวกัน (0.12 ± 0.08 ซม.) มุมล่างของกระดูกมีลักษณะหนาและเป็นมุมแหลม (40.88 ± 5.29 องศา) มากกว่ามุมบน (84.29 ± 9.43 องศา) ขอบด้านบนของกระดูกมีลักษณะบาง พบรอยเว้าซูปราสแคปปูลา (suprascapular notch) อยู่ด้านใกล้กลางต่อฐานของปุ่มกระดูกโคราคอย (coracoid process) รูปร่างและความลึกของรอยเว้ากระดูกนี้มีความแปรผัน ความยาวของสันกระดูกสะบัก (spine of scapula) วัดจากปลายของปุ่มกระดูกอะโครเมี่ยน ไปยังขอบสันด้านใกล้กลางยาว 12.89 ± 0.94 ซม. ความกว้างของสันกระดูกในแนวหน้าไปหลัง วัดห่างจากขอบใกล้กลาง 1 และ 4 ซม. เป็น 0.60 ± 0.15 ซม. และ 1.78 ± 0.29 ซม. ตามลำดับ และความกว้างที่วัดในแนวของรอยเว้าสไปโนกรีนอย (spinoglenoid notch) เป็น 4.15 ± 0.43 ซม. มิติของปุ่มกระดูกอะโครเมี่ยนคือ 4.41 ± 0.47 ซม. X 2.50 ± 0.37 ซม. X 0.72 ± 0.51 ซม. (ยาว X กว้าง X หนา) ระยะระหว่างปุ่มกระดูกอะโครเมี่ยนและปุ่มกระดูกโคราคอยคือ 3.11 ± 0.41 ซม. ปุ่มกระดูกโคราคอย วัดได้ 4.04 ± 0.41 ซม. X 1.46 ± 0.19 ซม.X 0.74 ± 0.12 ซม. (ยาว X กว้าง X หนา) วัดระยะจากปลายของปุ่มกระดูกโคราคอยไปยังรอยเว้าซูปราสแคปปูลายาว 4.84 ± 0.39 ซม. มิติของกลีนอย (glenoid) คือ 3.58 ± 0.35 ซม. (วัดระยะจากบนลงล่าง) และ 2.73 ± 0.31 ซม. (วัดจากหน้าไปหลัง) ส่วนความหนาของคอของกระดูกสะบักวัดห่างจากขอบเข้าไป 1 และ 2 ซม. เป็น 1.91 ± 0.37 และ 1.02 ± 0.27 ซม. สะบักในเพศชายพบว่ามีขนาดใหญ่กว่าในเพศหญิงอย่างมีนัยสำคัญจากการวัดใน 27 ตำแหน่ง

INTRODUCTION

Scapula, a large flat triangular bone is situated on the back of the body and plays an important role as forming the articular surfaces for shoulder and acromioclavicular joints. The shoulder joint together with the acromioclavicular joint are held to the body by the sternoclavicular joint which are all called the shoulder girdle. The shoulder girdle can produce the widest range of motion; in doing so they have to sacrifice their stability, particularly of the shoulder joint. The articular surfaces of the shoulder joint are the glenoid cavity (or fossa) and head of the humerus. The glenoid fossa is a shallow ovoid depression on the lateral angle of the scapula. The bony contour of the glenoid cavity is insufficient to promote the stability of the shoulder joint itself; thus the surrounding muscles and ligaments, especially the rotator muscles, are the most important to provide joint stability. There are eighteen muscles attached to various part of the scapula:[1] pectoralis minor, coracobrachialis and biceps short head muscles attached to the coracoid process, subscapularis, supraspinatus, infraspinatus, teres minor, teres major, levator scapulae, rhomboid minor, rhomboid major, serratus anterior, omohyoid inferior belly and part of the latissimus dorsi muscles attached to the body. Deltoid and trapezius muscles are attached to the spine of the scapula and acromion process. The long head of both biceps brachii and triceps brachii muscles are attached to the parts of the glenoid[1]. These muscles bind the humerus to the scapula and the later to the trunk as well as produce movements of the shoulder girdle.

Although the scapula is well protected by several surrounding muscles and soft tissue, it may be subject to fracture, developmental abnormalies, tumor, arthritis and dislocation[2-7]. Anatomical considerations of the scapula are crucial for understanding its specific abnormalities such as glenohumeral instability and dislocation as well as impingement syndrome and rotator cuff injuries. Detailed morphometric knowledge of the scapula is essential for various surgical procedures such as glenohumeral arthroplasty, scapulectomy[4] and scapula replacement[6]. The morphometric data of the scapula have been reported and all of the studies were taken

from westerner cadavers and specimens[8,9]. Although the complete quantitative anatomic study of the scapula in Thais is still lacking, this study aims to fill that gap and is carried out in Thai cadavers from the Department of Anatomy, Faculty of Medicine Siriraj Hospital.

MATERIALS AND METHODS

Ninety-seven scapulas from adult Thais cadavers were studied by second year medical students at the Department of Anatomy, consisting of 25 pairs taken from female cadavers as well as 23 pairs and one left scapula from male cadavers. The average age at death was 69.82 years old and ranged between 39-88 years. All the attached muscles and soft tissues were dissected out except labrum glenoidal, suprascapular and spinoglenoid ligaments. The general anatomic feature of the scapula was investigated and photographs were taken. Linear measurements were carried out with a vernier (Figure 1B) (Mitutoyo Corporation with the manufacture certificate), having a precision of 1/100 cm. The thickness measurement of the rough area such as the neck of the scapula or AP width of the spine could not be determined by using the ordinary vernier; the measurements were obtained by using the caliper vernier (Figure 1A). The angular measurements were made by using a goniometer (Figure 1C). The

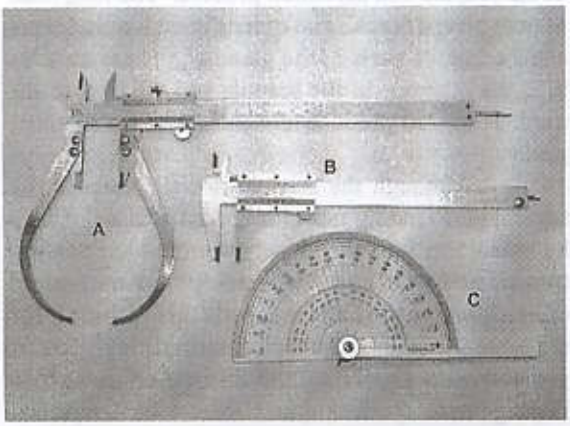

Figure 1. Instruments used for measurements. A. Caliper vernier for measuring the rough irregular area B. Vernier for smooth contour measurement C. Goniometer for angular measurement

measurements were carried out by only one investigator, using the same instruments througout the study. All the measurements were made twice and averaged out. The mean, standard deviation and range were determined on thirty measurements that are schemed below. Descriptive statistical analysis was worked out by using the Statistics program SPSS version 11.5. The continuous variables were compared between gender and side using the Student's t-test (SPSS) significance at $\alpha = <0.05$.

Measurement of the body

Seven general measurements were made on the body of the scapula (Figure 2) as follows: 1) The maximum length of the scapula was taken from the tip of the superior angle to the tip of the inferior angle. 2) The anterior width of the scapula was taken from the medial edge of the scapula where the spine of the scapula joined its medial border to the anterior rim of the glenoid. 3) The posterior width of the scapula was measured between the medial edge and posterior rim of the scapula. 4) The anteroposterior (AP) thickness of the medial border of the body of the scapula was measured half way and 1 cm. inwards by using the caliper vernier. 5) The AP thickness of the lateral border was taken in the same manner as the medial border thickness. 6) The inferior angle and 7) superior angle were measured by goniometer. The inferior angle was measured between the medial and lateral borders and avoided the rough bony projection of teres major muscle at the lower part of the lateral border. The succession numbers of the measurements are used consistently throughout the context of and illustration in this paper. The linear measurement is presented in centimeter while the angular measurement is in degree.

Measurement of the spine

Seven measurements were made for the spine of the scapula (Figure 3, 4). These measurements included length of the spine taken from the medial edge of the spine 8) to mid point of the lateral border of the acromion process and 9) to the tip of the acromion process. 10) The distance from the medial edge of the spine to the bottom of the spinoglenoid notch was measured. The AP width of the spine was measured at 11)1 cm. and 12) 4 cm. lateral to the medial edge of the spine and also 13) through the

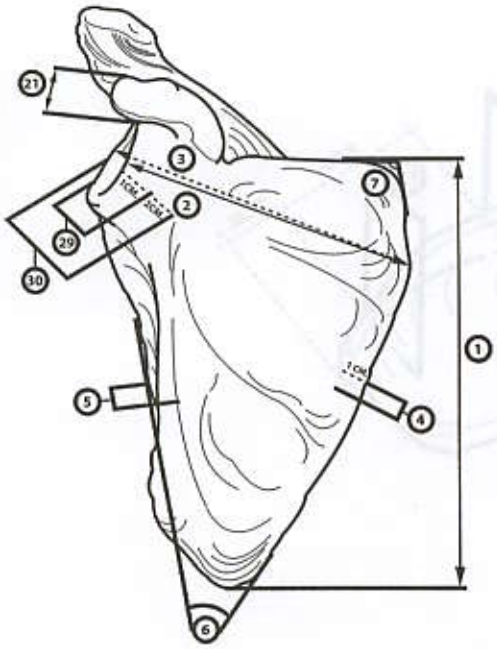

Figure 2. Anterior view of the right scapula illustrated the measurements taken (1) the maximum length of the scapula; (2) the anterior width of the body of the scapula measured from the medial edge of the spine to the anterior rim of the glenoid; (3) the posterior width of the body measured to the posterior rim of the glenoid (also shown in Figure 3); (4) the AP thickness of the medial border measured at the mid point and 1 cm. away from the edge; (5) the AP thickness of the lateral border at the mid point and 1 cm medial from the edge; (6) the inferior angle; (7) the superior angle; (21) the superoinferior thickness of the coracoid process measured 1 cm. posterior to the tip; (29) the AP thickness of the neck of the glen id parallel to and 1 cm. medial to the glenoid rim; (30) like the 29th item, the AP thickness of the neck 2 cm. away from the rim.

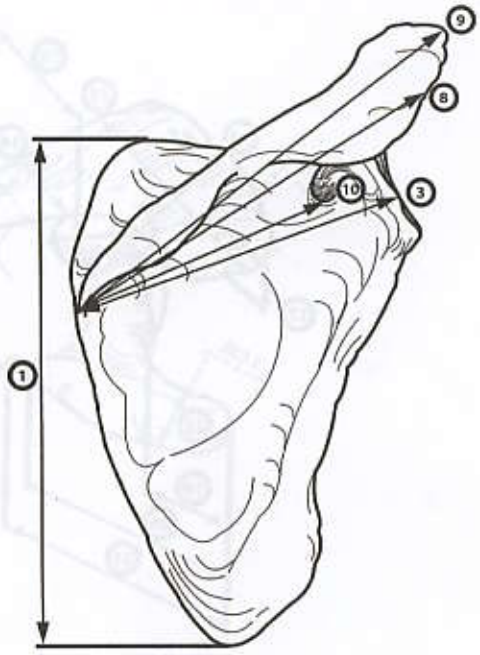

Figure 3. Posterior view of the right scapula illustrated the measurements taken from the posterior surface (1) maximum length of the body of the scapula; (3) the posterior width of the body; (8) the length of the spine of the scapula measured from the mid point on the lateral border of the acromion process to the medial edge that joins the medial border of the scapula; (9) the length of the spine taken from the tip of the acromion process to the medial edge; (10) the distance measured from the medial edge to the spinoglenoid notch.

lateral edge of spinoglenoid notch. 14) The thickness of the acromial neck was measured at its thinnest AP and superoinferior diameter.

Measurement of the acromion process

Four measurements on the acromion process (Figure 4) were 15) the maximum AP length measured

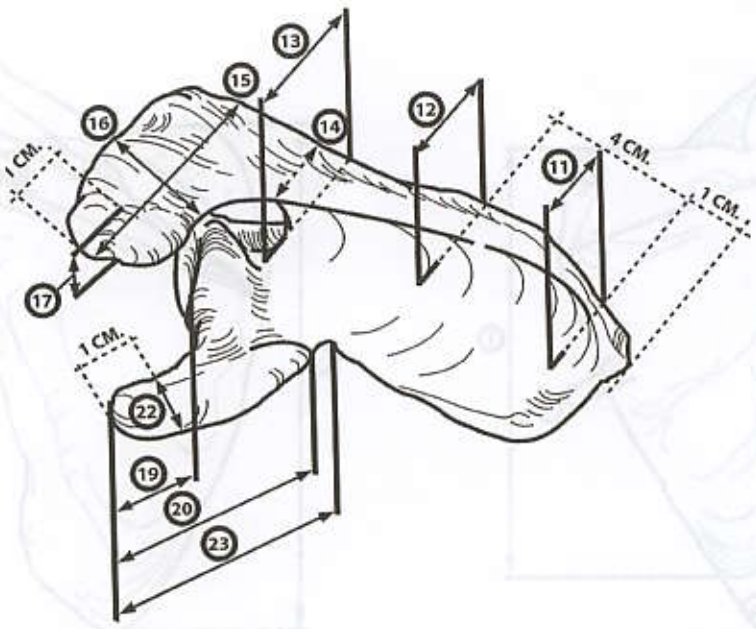

Figure 4. Superior view of the right scapula illustrated the measurements of (11) the AP width of the spine at 1 cm. away from the medial edge; (12) the AP width of the spine at 4 cm. away from the medial edge; (13) the AP width in the plane of the spinoglenoid notch; (14) the thickness of the acromial neck; (15) the AP length of the acromion process; (16) the acromial width taken from the middle part of the acromion and right angle to the AP length; (17) the acromial thickness taken 1 cm. from the tip; (19) the distance of the distal part of the coracoid process projected beyond the glenoid rim; (20) the length of the coracoid process; (22) the AP width of the coracoid process measured 1 cm. medial to the tip; (23) the distance from the tip of the coracoid process to the suprascapular notch.

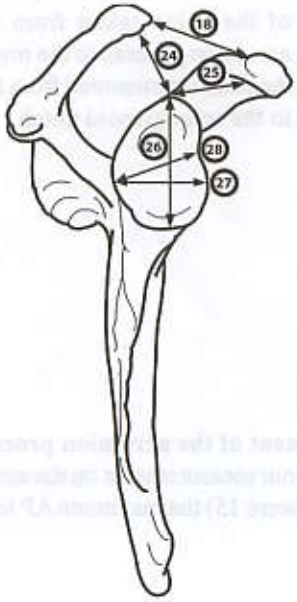

Figure 5. Lateral view of the right scapula and the measurement of (18) the coracoacromial distance; (24) the minimum distance from the superior rim of the glenoid to the inferior surface of the acromion process; (25) the minimum distance from the superior glenoid to the inferior surface of the coracoid process; (26) the maximum superoinferior length of the glenoid fossa; (27) the maximum AP length of the glenoid fossa; (28) the AP length measured from the most posterior rim of the glenoid to the glenoid notch.

along middle of acromion, 16) the acromial width measured in the mediolateral plane across the mid acromion process and right angle to its AP length, 17) the acromial thickness was taken from 1 cm. medial to the tip of the acromion process, and 18) the coracoacromial distance was measured from the most anterior border of the acromion to the tip of the coracoid process(Figure 5).

Measurement of the coracoid process

Five measurements on the coracoid process (Figure 4) were 19) the distance by which the tip of the coracoid process projected beyond the rim of the glenoid, 20) the length of the coracoid process taken from the tip to its horizontal part, 21) the coracoid thickness (Figure 2) measured in a superoinferior direction 1 cm. posterior to its tip, 22) the coracoid width measured in an anteroposterior direction 1 cm. medial to its tip, and 23) the distance between the tip of the coracoid process and the base of the suprascapular notch (Figure 4).

Measurement of the head of the scapula and the glenoid fossa

Seven measurement were carried out on the lateral angle of the scapula or glenoid fossa (Figure 5), by measuring the minimum distance from the superior rim of the labrum glenoid to 24) the inferior surface of the acromion process and 25) inferior surface of the coracoid process. The dimension of the glenoid fossa with attached labrum glenoidal was measured, including 26) the maximum superoinferior diameter of the glenoid, 27) maximum AP diameter of the glenoid from posterior rim to anterior rim, 28) the distance from the previous posterior rim to the glenoid notch on the anterior rim, and the AP thickness of the neck of the glenoid (Figure 2) parallel to the surface of the glenoid fossa 29)1 cm. and 30) 2 cm. medial to the glenoid surface.

RESULTS

Generally, the costal surface of the scapula presented a broad concavity, called subscapular fossa. The medial two-thirds of the fossa were marked by several oblique ridges and run upward laterally (Figure 6). These ridges gave attachment to the tendinous insertion of the subscapularis muscle. Several

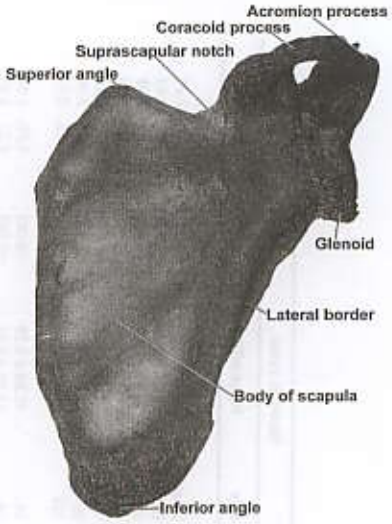

Figure 6. An anterior view of a dissected scapula that is free from attached muscles and soft tissue. Standard terminology of its anatomic region was indicated.

inconsistent bony crests were also presented along its borders, particularly on the inferior angle. The measurement results are shown in Table 1. The average total maximum length of the body of the scapula was 13.93 ± 1.11 cm. (mean ± standard deviation); in male cadavers it was 14.87 ± 0.76 cm and 13.11 ± 0.67 cm. in female scapula. The average maximum length of the scapula was significantly longer in the male scapula. The average width of the scapula body measured from the medial edge of the spine joined with the medial border to the anterior and posterior rims of the glenoid were 10.30 ± 0.78 cm. and 10.47 ± 0.77 cm., respectively. The mean AP thickness of the lateral border was 0.82 ± 0.20 cm. thicker than the medial border of 0.12 ± 0.08 cm. All of the inferior angles were acute, with mean 40.88 ± 5.29 degrees, while the superior angle was rather obtuse with an average of 84.29 ± 9.43 degrees. The inferior angle was significantly different between genders but not in the superior angle.

The spine of the scapula was a prominent bone plate obliquely across the back of the body of the scapula and separated the supraspinatus fossa from the infraspinatus fossa. It began at the medial border

Table 1. The measurement of the scapula.

Measurement	Total		Male			Female			Statistics value		
	min	max	Mean ± SD	min	max	Mean ±SD	min	max	Mean ±SD	p-value	95% CI of Diff.
Body of Scapula											
1.length of Scapula	11.57	15.96	13.93 ± 1.11	13	15.96	14.87 ± 0.76	11.57	14.48	13.11 ± 0.67	<0.001	1.40, 1.97
2 ant. Width	8.96	11.92	10.30 ± 0.78	9.62	11.92	10.93 ± 0.53	8.96	10.65	0.72 ± 0.46	<0.001	1.01, 1.41
3 post. Width	8.66	11.47	10.47 ± 0.77	9.59	11.47	10.76 ± 0.48	8.66	10.48	9.57 ± 0.49	<0.001	0.99, 1.38
4.AP thick of medial border	0.03	0.39	0.12 ± 0.08	0.03	0.39	0.14 ± 0.09	0.03	0.23	0.09 ± 0.04	0.001	0.02, 0.08
5.AP thick of lateral border	0.46	1.32	0.82 ± 0.20	0.55	1.32	0.95 ± 0.17	0.46	1.15	0.69 ± 0.13	<0.001	0.20, 0.32
6.inferior angle	25	50	40.88 ± 5.29	25	52	42.43 ± 5.11	25	50	39.42 ± 5.09	0.005	0.95, 5.06
7.superior angle	53	112	84.29 ± 9.43	53	110	83.62 ± 9.37	65	112	84.92 ± 9.54	0.499	-5.12, 2.51
Spine of scapula											
8.length from mid acromion	11	15	12.49 ± 0.93	12	15	13.24 ± 0.60	11	13	11.80 ± 0.59	<0.001	1.19, 1.68
9.length from tip acromion	11	15	12.89 ± 0.94	13	15	13.64 ± 0.59	11	14	12.19 ± 0.61	<0.001	1.21, 1.69
10.distance: med.edge to SG notch	7	9	8.12 ± 0.65	8	9	8.65 ± 0.38	7	8	7.62 ± 0.43	<0.001	0.86, 1.18
11.AP width 1 cm.from med. border	0.3	1.20	0.60 ± 0.15	0.30	1.20	0.65 ± 0.15	0.40	0.80	0.56 ± 0.12	0.002	0.03, 0.14
12.AP width 4 cm.from med. border	1.14	2.76	1.78 ± 0.29	1.37	2.58	1.88 ± 0.26	1.14	2.76	1.69 ± 0.29	0.001	0.08, 0.31
13.AP width at SG notch	3.30	5.30	4.15 ± 0.43	4	5.30	4.48 ± 0.27	3.30	4.90	3.83 ± 0.27	<0.001	0.54, 0.76
14.thickness of acromial neck	0.45	1.14	0.77 ± 0.14	0.67	1.14	0.88 ± 0.09	0.45	0.95	0.67 ± 0.11	<0.001	0.16, 0.25
Acromion process											
15.length of acromion	3.45	5.67	4.41 ± 0.47	3.96	5.45	4.73 ± 0.34	3.45	5.67	4.00 ± 0.37	<0.001	0.47, 0.76
16.width of acromion	1.69	3.42	2.50 ± 0.37	1.69	3.42	2.62 ± 0.36	1.81	3.35	2.39 ± 0.35	0.003	0.07, 0.36
17.thickness of acromion	0.36	1.19	0.72 ± 0.15	0.62	1.19	0.81 ± 0.13	0.36	1.07	0.64 ± 0.12	<0.001	0.12, 0.22
18.coracoacromial distance	1.93	3.84	3.11 ± 0.41	1.93	3.84	3.27 ± 1.42	2.18	3.55	2.95 ± 0.34	<0.001	0.16, 0.47
Coracoid process											
19.projection beyond glenoid	0.20	1.90	0.91 ± 0.36	0.30	1.80	0.94 ± 0.38	0.20	1.90	0.88 ± 0.35	0.459	-0.09, 0.21
20.length of coracoid process	3.33	5.13	4.04 ± 0.41	3.50	5.31	4.32 ± 0.35	3.33	4.37	3.78 ± 0.24	<0.001	0.42, 0.66
21.coracoid thickness	0.48	1	0.74 ± 0.12	0.61	1	0.82 ± 0.09	0.48	0.90	0.66 ± 0.09	<0.001	0.11, 0.19
22.coracoid width	1.08	1.81	1.46 ± 0.19	1.16	1.81	1.57 ± 0.15	1.08	1.75	1.35 ± 0.15	<0.001	0.16, 0.28
23.distance:tip to SSC notch	4.01	6.21	4.84 ± 0.39	4.40	6.21	5.08 ± 0.34	4.01	5.15	4.61 ± 0.28	<0.001	0.34, 0.60
Glenoid											
24.min distance: glenoid to acromion	1.17	2.68	1.87 ± 0.28	1.35	2.40	1.94 ± 0.24	1.17	2.68	1.81 ± 0.31	0.026	0.01, 0.24
25.min distance: glenoid to coracoid	1.04	2.10	1.50 ± 0.21	1.04	2.10	1.53 ± 0.18	1.13	1.99	1.48 ± 0.22	0.380	-0.04, 0.12
26.SI diameter of glenoid	2.75	4.39	3.58 ± 0.35	3.33	4.39	3.81 ± 0.22	2.75	3.93	3.36 ± 0.30	<0.001	0.34, 0.56
27.max AP diameter of glenoid	2.15	3.62	2.73 ± 0.31	2.19	3.39	2.91 ± 0.26	2.15	3.62	2.56 ± 0.25	<0.001	0.24, 0.45
28.AP diameter to glenoid notch	2.05	3.13	2.60 ± 0.26	2.31	3.13	2.78 ± 0.18	2.05	2.98	2.43 ± 0.21	<0.001	0.27, 0.43
29.thickness of neck: 1 cm. from rim	0.90	2.90	1.91 ± 0.37	0.90	2.90	2.14 ± 0.33	1.10	2.40	1.68 ± 0.26	<0.001	0.34, 0.57
30.thickness of neck: 2 cm. from rim	0.47	1.78	1.02 ± 0.27	0.60	1.78	1.21 ± 0.24	0.47	1.30	0.84 ± 0.15	<0.001	0.28, 0.44

Significance at p-value <0.05. All measurements are in centimeters.
The numbers of the measurement are consistently used in this study and correspond to those illustrated in the figures.
Abbreviation : AP= anteroposterior, cm.= centimeter, SG = spinoglenoid, SSC = suprascapular, rim = glenoidal rim.

with a smooth triangular area and gradually elevated to become the acromion process on the lateral end. The spine was triangular and flattened downward; the apex pointed toward the vertebral border. It was presented with three borders; the anterior border was attached to the posterior surface of the body of the scapula, the posterior border was broad and the longest and the lateral border was curved laterally as a spinoglenoid notch. The average total length of the spine of the scapula measured from the middle of the lateral border of the acromion process to the medial edge was 12.49 ± 0.93 cm. the mean length of the spine was longer (12.89 ± 0.94 cm.) with the measurement taken from the tip of the acromion process. The total mean distance between the medial edge of the scapula and the spinoglenoid notch was 8.12 ± 0.65 cm. The average AP width of the spine, 1 cm. and 4 cm. away from the medial edge of the spine, was 0.6 ± 0.15 cm. and 1.78 ± 0.29 cm., respectively. The total mean AP width of the spine taken at the plane parallel to the spinoglenoid notch was 4.15 ± 0.43 cm.

The acromion process formed the summit of the shoulder with an oblong appearance, curved forward and upward so that it overhung the glenoid fossa. Together the coracoid process and coracoacromial ligament formed the secondary socket for the shoulder joint. The mean distance between the coracoid and acromial processes measured from the tips of both was 3.11 ± 0.41 cm. The mean thickness of the acromion neck was 0.77 ± 0.14 cm. The dimension of the acromion process was 4.41 ± 0.47 cm. for the mean length of total cases. The mean width of the acromion process taken at a right angle to the acromion length was 2.5 ± 0.37 cm.; the mean thickness measured at 1 cm. away from the tip was 0.72 ± 0.15 cm.

The coracoid process was thick and curved from the upper part of the scapula neck, ran upward medially at first and later changed direction to project forward laterally as the horizontal part of the coracoid process. The average length of the coracoid process measured from its straight portion was 4.04 ± 0.41 cm.; the average AP width was 1.46 ± 0.19 cm. and the average superoinferior thickness was 0.74 ± 0.12 cm. The average distance of the projected tip of the coracoid process that protruded beyond the glenoid surface was 0.91± 0.36 cm. The base of the coracoid processs continued with the superior border of the scapula which was interrupted by a notch called the suprascapular notch. The distance between the tip of the coracoid process and the bottom of the suprascapular notch was 4.84 ± 0.39 cm.

The glenoid fossa situated at the lateral angle of the scapula was projected laterally and faced slightly forward to form an articular surface for the glenohumeral joint. The fossa was concave and oval; an indentation was inconsistently found on its anterior rim, the glenoid notch, leading to the glenoid fossa had a teardrop appearance. The average glenoid dimension, measured with the labrum glenoidal in situ, were 3.58 ± 0.35 cm. for mean maximum superoinferior length, 2.73 ± 0.31 cm. for average maximum anteroposterior width and 2.6 ± 0.26 cm. for mean AP width taken from the post. rim to the glenoid notch. The average minimum distances between the superior glenoid rim to the inferior surface of the acromion process and inferior surface of the coracoid process were 1.87 ± 0.28 cm. and 1.5 ± 0.21 cm., respectively. The average thickness of the scapula neck in the AP direction parallel to the surface of the glenoid at 1 cm. and 2 cm. medial to the glenoid rim were 1.91 ± 0.374 cm. and 1.02 ± 0.27 cm., respectively.

All the measurements of the scapula in Thai male cadavers were significantly larger ($p<0.05$) than those taken from Thai female cadavers (Table 1), with the exception of the following in which there were no differences: superior angle, the distance of coracoid projection which extended beyond the glenoid surface, and the minimum distance from the superior glenoid to the inferior surfaces of the acromion and coracoid processes. There were no differences in all the measurements between the right and left side of the scapulas.

DISCUSSION

The osseous dimensions of the scapula have been presented and the gender dimorphism has been demonstrated to confirm that the scapulas taken from Thai male cadavers were larger than the scapulas from female cadavers[8,10]. The body of the scapula was characterized as a very thin osseous plate (Figure 6)

and rather translucent so that it would be impossible to accept any conventional pins or screws[11] for fixation. The medial and lateral borders were thicker than the former, especially the lateral border of the male scapulas which would be sufficient to support the fixation in the arthrodesis procedure for scapula instability or scapulothoracic arthrodesis in fascioscapulohumeral muscular dystrophy[12]. The thickness of the lateral border in male cadavers ranged from 0.46 - 1.32 cm; in some cases, it was more than 1 cm. thick which would have enough bone mass to be an implanted site for endosseous dental implants in microvascular mandibular reconstruction but not in female cases[13].

The dimensions of the spine of the scapula and acromion process were large enough to support screw, pin or wire for fracture stabilization of the acromioclavicular joint[14] or arthrodesis of the shoulder joint[15]. The dimensions of the acromion process and minimum distance between its inferior surface and superior rim of the glenoid cavity were particularly important in acromioplasty in arthroscopic subacromial decompression or acromioclavicular arthritis[15]. The mean coracoacromial distance in the male scapula was significantly larger than that found in the female scapula while the minimum distance from the superior glenoid to the inferior surfaces of the coracoid and acromion processes were not different in both genders. However, these spatial data provided useful information for portal placement for shoulder arthroscopy and acromioplasty.

Despite the rarity of direct injury to the coracoid process[16], the information of the coracoid process and adjacent structures were essential for clinical research. The suprascapular notch was situated medially to the root of coracoids and covered by a variable transverse scapular ligament to form a suprascapular foramen. Within the foramen, the suprascapular nerve traveled through and, in some cases the anterior coracoscapular ligament[17] was found. These features are of importance in suprascapular nerve entrapment which causes the supraspinatus and infraspinatus muscles to waste[18].

The shape and dimension of the glenoid fossa play a role on the mobility and stability of the glenohumeral joint. The stability of the joint depends on the concavity compression and the effectiveness of this stabilization mechanism is determined by the concavity of the glenoid and the direction in which the concave surface is pointed[19]. The dimension of the glenoid fossa and the thickness of its neck provide important information for designing and fitting of a glenoid component for shoulder arthroplasty[4,20]. The average diameters of the glenoid fossa from this study are smaller compared to those carried out in westerner cadavers[8]; thus commercial scapula prosthesis for Thais should considered the matched size and the fitting of the component. The thickness of the neck of the scapula also provides the anatomic information for osteotomy of the neck in order to reestablish a posterior stability of the shoulder[21].

CONCLUSION

The morphometric study on the shape and dimensions of the scapula in Thais shows that there is a dimorphism difference between male and female scapulas. It also provides useful and pertinent information for various surgical procedures involving fixation of a scapula fracture, resection and reconstruction of scapula tumor and the reestablishment of the stability of the glenohumeral joint.

REFERENCES

1. Soames RW. Skeletal system. In : Williams PL, editor. Gray's Anatomy. 38th ed. New York : Churchill Livingston; 1995: 425-736.
2. Owen BD, Goss TP. Surgical approaches for glenoid fractures. Tech Shoulders Elbow Surg 2004; **5:** 103-15.
3. Hubbard D. Scapular fracture. Cur Opin Orthop 2004; **15:** 254-56.
4. Witting JC, Bickels J, Wodajo F, Kellar-Graney KL, Malawer MM. Constrained total scapula reconstruction after resection of a high-grade sarcoma. Clin Orthop Related Res 2002; **397:** 143-55.
5. Gálp CB. Surgical treatment of sprengel's deformity of the scapula. Scripta Medica (BRNO) 2001; **74:** 245-54.
6. Khairouni A, Bensahel H, Csukonyi Z, Desgrippes Y, Pennecot GF. Congenital high scapula. J Pediat Orthop 2002; **11:** 85-88.
7. Vrettos BC, Wallace WA, Neumann L, Frostick SP. Total scapular replacement: Medium-term follow-up. J Shoulder Elbow Surg 2004; **13:** 472-75.

8. von Schroeder HP, Kuiper SD, Botte MJ. Osseous anatomy of the scapula. Clin Orthop Related Res 2001; **383:** 131-39.
9. Ebraheim NA, Xu R, Haman SP, Miedler JD, Yeasting RA. Quantitative anatomy of the scapula. Am J Orthopedics 2000; **29:** 287-92.
10. Mallon WJ, Brown HR, Volger III JB, et al. Radiographic and geometric anatomy of the scapula. Clin Orthop 1992; **277:** 142-54.
11. de Beer JF, Berghs BM, van Rooyen KS, et al. Displaced scapular neck fracture : A case report. J shoulder Elbow Surg 2004; **13:** 123-25.
12. Berne D, Laude F, Laporte C, Fardeau M, Saillant G. Scapulothoracic arthrodesis in fascioscapulohumeral muscular dystrophy. Clin Orthop Related Res 2003; **409:** 106-13.
13. Beckers A, Schenck C, Klesper B, Koebke J. Comparative densitometric study of iliac crest and scapula bone in relation to osseous integrated dental implants in microvascular mandible reconstruction. J Craniomaxillofac Surg 1998; **26:** 75-83.
14. Galatz LM, Barrett S, Williams GR. Injuries to the acromioclavicular joint. Sport Med Arthros Rev 2001; **9:** 44-51.
15. Mohammed NS E-S. A Simple method of shoulder arthrodesis. J Bone Joint Surg (Br) 1998; **80B**: 620-23.
16. Lim KE, Wang CR, Chin KC, Chen CJ, Tsai CC, Bullard MJ. Case report: Concomitant fracture of the coracoid and acromion after direct shoulder trauma. J Orthrop Trauma 1996; **10:** 437-39.
17. Avery BW, Pilon FM, Barclay JK. Anterior coracoscapular ligament and suprascapular nerve entrapment. Clin Anatomy 2002; **15:** 383-86.
18. Clein LJ. Suprascapular entrapment neuropathy. J Neurosurg 1975; **43:** 337-42.
19. Lazarus MD, Sidles JA, Harryman II DT, Matsen, III FA. Effect of a chondral-labral defect on glenoid concavity and glenohumeral stability : A cadaveric model. J Bone Joint Surg 1996; **78A:** 94-102.
20. McFarland EG, Chronopoulos E, Kim TKK. New trends in shoulder arthroplasty. Cur Opin Orthrop 2002; **13:** 275-80.
21. Graichen H, Koydt P, Zichner L. Effectiveness of glenoid osteotomy in atraumatic posterior instability of the shoulder associated with excessive retroversion and flatness of the glenoid. International Orthorp 1999; **23:** 95-99.