



UNIVERSITI PUTRA MALAYSIA

***ANATOMICAL AND RADIOLOGICAL STUDIES OF HUMAN CORACOID
PROCESS IN SELANGOR, MALAYSIA***

MANAL FATHI A.M. TAHER

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**ANATOMICAL AND RADIOLOGICAL STUDIES OF HUMAN CORACOID
PROCESS IN SELANGOR, MALAYSIA**

By

MANAL FATHI A.M. TAHER

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Master of Science**

March 2017



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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

The work is especially dedicated to:

Allah SWT and His Messenger, Prophet Muhammad (SAW)

My supervisor Prof. Dr. Fauziah Othman

My beloved parents (Fathi and Amina)

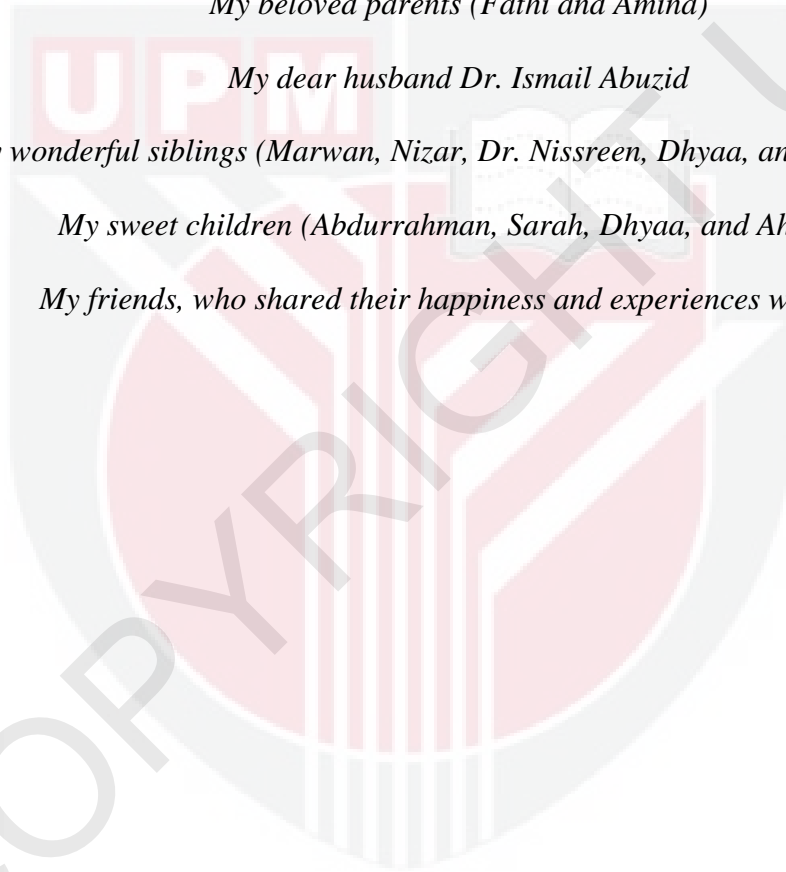
My dear husband Dr. Ismail Abuzid

My wonderful siblings (Marwan, Nizar, Dr. Nissreen, Dhyaa, and Muhamad)

My sweet children (Abdurrahman, Sarah, Dhyaa, and Ahmad)

My friends, who shared their happiness and experiences with me.

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirement for the degree of Master of Science

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March 2017

Chairman : Fauziah Othman, PhD
Faculty : Medicine and Health Sciences

There is scarcity in the literature concerning the anatomy and radiology study of human coracoid process in the diverse Asian population. This research was undertaken to investigate the anatomy of the coracoid process through developing a new dissection approach to access the coracoid process of the human scapula and quantifying the coracoid process morphometry among Indian, Chinese, and Myanmar subjects. This research further investigates the radiology of the coracoid process via quantifying the morphometry and the regional bone mineral density of the coracoid process among Malay and Chinese subjects.

The dissection approach was carried out on 52 cadaveric shoulders; the cadavers were placed in supine position, and both arms were abducted at an angle of ninety degrees, 90°. Then, the skin incisions were made and separated from the subcutaneous tissues. The deltopectoral groove was located and the deltoid muscle was dissected to expose the coracoid process with all attachments. After the coracoid process was dissected from all attachments, the morphometric measurements were taken using a digital calliper and the ethnical differences were analyzed. The results of this study showed that the average value for the length of the coracoid process (LCP) was 41.97 ± 2.20 mm. The average values for the tip thickness (TTCP) and tip width (TWCP) of the coracoid process were 10.05 ± 1.52 mm and 13.34 ± 1.06 mm, respectively. While, the average values for the base height (BHCP) and base width (BWCP) were 15.45 ± 1.26 mm and 24.34 ± 1.61 mm, respectively. Among the three races, the Myanmar subjects had a significantly smaller LCP compared to both the Chinese and Indian subjects ($p < 0.05$). However, there was no significant difference in LCP between the Indian and Chinese subjects. In TTCP, both the Myanmar subjects and Chinese subjects were significantly smaller than the Indian subjects ($p < 0.05$). However, there was no significant difference between the Chinese and Myanmar subjects. Among the three ethnic groups, there was no significant difference in TWCP. The Myanmar subjects also had a significantly shorter BHCP than the Indian subjects ($p < 0.05$). In contrast, there was no significant difference between the Myanmar and Chinese

subjects ($p>0.05$).

The morphometric measurements were also measured digitally using e-Film (version 2.1.2, Merge Healthcare, Milwaukee, WI) in 66 shoulders from 33 computerized tomographic scans. Similarly, the radiological study found that there were significant ($p<0.05$) differences between the Malay and Chinese subjects in all measurements of the coracoid process except the base thickness (BTCP). The Chinese subjects were found to have a bigger coracoid process than the Malay subjects. Non-significant differences were found between the measurements on the right and left sides coracoid process of all populations ($p>0.05$). There were significant differences between males and females for all measurements ($p<0.05$).

In addition, the same shoulders were also measured digitally using Hounsfield units to quantify the regional bone mineral density of the coracoid process. The BMD for the average tip of the coracoid process and the base of the coracoid process were 281.9 ± 27.10 HU and 370.7 ± 46.66 HU, respectively; which is significantly ($p<0.05$) higher in base than the tip of the coracoid process. Among the ethnic groups, Malay subjects had numerically higher BMD in the tip and base of the coracoid process than the Chinese subjects, however, statistically, these differences were not significantly different ($p>0.05$). Thus, it can be concluded that the morphometry and BMD of the coracoid process are attributed to the ethnicity and the gender.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

**KAJIAN ANATOMI DAN RADIOLOGI KE ATAS CUARAN KORAKOID
MANUSIA DI SELANGOR, MALAYSIA**

Oleh

MANAL FATHI A.M. TAHER

Mac 2017

Pengerusi : Fauziah Othman, PhD
Fakulti : Perubatan dan Sains Kesihatan

Terdapat kurangnya kajian anatomi dan radiologi terhadap cuaran korakoid di kalangan pelbagai populasi Asian. Kajian penyelidikan ini telah dijalankan untuk menyiasat anatomi cuaran korakoid melalui penghasilan dengan pendekatan diseksi baharu untuk mengakses cuaran korakoid daripada skapula manusia; mengukur morfometri cuaran korakoid di kalangan subjek India, Cina dan Myanmar. Kajian ini turut menyiasat cuaran korakoid dengan mengukur morfometri dan bahagian ketumpatan mineral tulang cuaran korakoid di kalangan subjek Melayu dan Cina menggunakan radiologi.

Pendekatan diseksi telah dijalankan ke atas 52 bahu-bahu kadaver; yang mana mayat telah diletakkan dalam posisi terlentang horizontal dan kedua-dua tangan telah di posisikan pada sudut 90 darjah dari kedudukan bahu. Kemudian, insisi kulit telah dilakukan untuk memisahkannya daripada tisu-tisu subkutaneus. Alur deltopectoral telah di cari dan otot deltoid telah dibedah untuk mendedahkan cuaran korakoid bersama semua tisu yang terlampir dengannya. Selepas cuaran korakoid telah diasingkan dari semua tisu lampiran, ukuran morfometrik diambil dengan menggunakan angkup digital, kemudian perbezaan etnik dari rekod telah dianalisis. Keputusan kajian ini menunjukkan bahawa nilai purata bagi panjang cuaran korakoid (LCP) adalah 41.97 ± 2.20 mm. Nilai purata bagi ketebalan hujung (TTCP) dan lebar hujung (TWCP) pada cuaran korakoid adalah 10.05 ± 1.52 mm dan 13.34 ± 1.06 mm masing-masing, manakala nilai purata bagi ketinggian pangkal (BHCP) dan lebar pangkal (BWCP) adalah 15.45 ± 1.26 mm dan 24.34 ± 1.61 mm, masing-masing. Di antara tiga kaum tersebut, subjek Myanmar mempunyai LCP yang lebih kecil berbanding dengan kedua-dua etnik Cina dan India secara signifikan ($p < 0.05$). Walau bagaimanapun, tiada perbezaan yang signifikan dalam LCP antara subjek India dan Cina. Kedua-dua subjek Myanmar dan Cina secara signifikan mempunyai TTCP yang lebih kecil berbanding subjek India ($p < 0.05$). Walau bagaimanapun, tiada perbezaan signifikan di antara subjek Cina dan Myanmar. Antara ketiga-tiga kumpulan etnik tiada perbezaan yang signifikan pada TWCP. Subjek Myanmar juga mempunyai

BHCP yang ketara lebih pendek daripada subjek India ($p < 0.05$). Sebaliknya, tiada perbezaan yang signifikan di antara subjek Myanmar dan Cina ($p > 0.05$).

Ukuran morfometrik juga diukur secara digital dengan menggunakan e-Film pada 66 bahu dari 33 imbasan tomografik berkompuser. Begitu juga, kajian radiologi mendapati bahawa terdapat perbezaan yang signifikan ($p < 0.05$) di antara subjek Melayu dan Cina dalam semua ukuran korakoid kecuali ketebalan pangkal (BTCP). Subjek Cina mempunyai cuaran korakoid yang lebih besar daripada subjek Melayu. Perbezaan yang tidak signifikan ditemui antara ukuran cuaran korakoid di bahagian kanan dan kiri semua populasi ($p > 0.05$). Terdapat perbezaan yang signifikan antara cuaran korakoid lelaki dan perempuan dalam semua ukuran ($p < 0.05$).

Di samping itu, bahu yang sama juga diukur secara digital dengan menggunakan unit Hounsfield untuk mengukur ketumpatan mineral tulang (BMD) pada bahagian di cuaran korakoid. Nilai puncak BMD pada purata hujung cuaran korakoid dan pangkal cuaran korakoid adalah 281.9 ± 27.10 dan 370.7 ± 46.66 HU, masing-masing, dan pangkal cuaran adalah lebih tinggi secara signifikan daripada hujung cuaran korakoid ($p < 0.05$). Antara kumpulan etnik tersebut, subjek Melayu mempunyai BMD yang lebih tinggi di hujung and pangkal cuaran korakoid berbanding dengan subjek Cina, walaupun perbezaannya tidak signifikan secara statistik ($p > 0.05$). Dengan ini, kesimpulan boleh dibuat bahawa morfometri dan BMD cuaran korakoid boleh dipengaruhi oleh ciri etnik dan jantina.

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I certify that a Thesis Examination Committee has met on 15 March 2017 to conduct the final examination of Manal Fathi A.M. Taher on her thesis entitled "Anatomical and Radiological Studies of Human Coracoid Process in Selangor, Malaysia " in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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LIST OF ABBREVIATIONS

1st SI	First Skin Incision
2nd SI	Second Skin Incision
3rd SI	Third Skin Incision
ACR	American College of Radiology
ADH	Anatomy Dissection Hall
ANOVA	Analysis of variance
B	Black
BHCP	Base Height of Coracoid Process
BMD	Bone Mineral Density
BMI	Body Mass Index
BTCP	Base Thickness of Coracoid Process
BWCP	Base Width of Coracoid Process
CB	Clavicle Bone
CBM	Coracobrachialis Muscle
Cm	Centimetre
CP	Coracoid Process
CT	Computed Tomography
CV	Cephalic Vein
DBT	Deltoid Branch of Thoracoacromial artery
DEXA	Dual Energy X-ray Absorptiometry
DICOM	Digital Imaging and Communication in Medicine
DM	Deltoid Muscle
DPA	Dual Photon Absorptiometry
DXR	Digital X-ray Radiogrammetry
F	Female
GHHS	Golden Horses Health Sanctuary
HU	Hounsfield Unit
JN	Jugular Notch
Kg	Kilogram
Kg/m ²	kilogram / square meter
LCP	Length of Coracoid Process
<i>M</i>	Mean
M	Male
mm	Millimetre
N	Sample Size
P	Significance
PBM	Peak Bone Mass
PhD	Doctor of philosophy
PM	Pectorals minor
PMM	Pectorals Major Muscle
QCT	Quantitative Computed Tomography
QUS	Quantitative Ultrasound
ROI	Region of Interest
SAW	Sallallahu alaihi wasallam
SD	Standard Deviation
SEXA	Single Energy X-ray Absorptiometry
SHB	Short Head of Biceps

SIDM
SPA
SWT
TTCP
UPM
USA
W

Small Incision in Deltoid Muscle
Single Photon Absorptiometry
Subhanahu Wata'alah
Tip Thickness of Coracoid process
Universiti Putra Malaysia
United States of America
White



CHAPTER 1

INTRODUCTION

1.1 Background of the study

The scapula presents a unique anatomical shape and function, which has made the anatomical study of the scapula a subject of extensive investigation (Torrens *et al.*, 2009; Polguy *et al.*, 2011; Oladipo *et al.*, 2015). Furthermore, this anatomical structure has several important osseous features including the scapular spine, acromion, and coracoid process (Frank *et al.*, 2013; Singh *et al.*, 2013). The major concern is referred to the anatomy of coracoid process due to the peculiar anatomical shape of this scapular process (Bhatia *et al.*, 2007). In addition, in clinical practice, the coracoid process contributes to the many surgical and pathological conditions of the shoulder joints (Higgins *et al.*, 2012). The anatomy of the coracoid process can be understood in a better manner by studying the morphometry of this anatomical structure. Morphometric analysis of the coracoid can be very valuable to anatomists, radiologists, forensic pathologists, and orthopaedics (Cabezas *et al.*, 2016). Despite the enormous effort taken by anatomists and researchers in studying the anatomic morphometry of the coracoid process, successful dissection method to access the coracoid process appear to be limited. Dissecting human cadavers is necessary when attempting to study the anatomy of a human skeleton (McLachlan, 2004). One of the most fundamental principles for studying the anatomy of the coracoid process is how to approach and access the coracoid process (Fathi *et al.*, 2015).

Currently, a deltopectoral approach is the standard method for dissecting and studying the anatomy of the coracoid process. However, this approach does not allow unobstructed visualization of the entire coracoid process (Fathi *et al.*, 2015). Traditionally, in dissection books, to access any part of the scapula one has to dissect the entire pectoral region (Tank, 2008), that is time consuming and renders the pectoral regions unfit to continue studying. Therefore, this study developed an alternative approach to access the coracoid process in human cadavers.

The morphometry of the coracoid process has been a topic of interest to various researchers (Gumina *et al.*, 1999; Piyawinijwong *et al.*, 2004; Lian *et al.*, 2016). Early researchers noted the variability of coracoid morphometry, since the morphometry of the coracoid process showed differences (Schulz *et al.*, 2005). Numerous studies on Caucasian subjects, especially in Europe have provided a reference value for the morphometry of the coracoid process (Rios *et al.*, 2007; Salzmann *et al.*, 2008; Dolan *et al.*, 2011). However, only a few studies have been conducted on the Asian populations (Piyawinijwong *et al.*, 2004; Kavita and Singh, 2013). Although, some research was done on interethnic variation in European populations (Rios *et al.*, 2007; Ljungquist *et al.*, 2012), until now, there is limited about the interethnic variation in Asian populations. Moreover, very little has been

reported on the morphometry of the coracoid process in relation to gender in our environment.

On the other hand, measurement of the bone mineral density (BMD) is necessary to determine the amount of bone and bone loss at the scanning site and to predict the risk of bone fracture or therapeutic efficacy (Knowles, 2015). It is well known that the BMD is influenced by site, gender, and ethnicity (Henry and Eastell, 2000; Goh *et al.*, 2004). Recently, researchers in clinical and medical field have shown an increased interest in scapular BMD (Daalder *et al.*, 2016). Several researchers demonstrate that the BMD of the scapular is different from one part to other (Schulz *et al.*, 2002; Daalder *et al.*, 2016). Although some research has been carried out to determine the BMD in the scapula, only one study have attempted to investigate the BMD in the coracoid process (Beranger *et al.*, 2014). Beranger's analysis does not take account of the tip of the coracoid process, nor does it examine the ethnic differences in the coracoid BMD. Similarly, the above-mentioned study was carried out in an European population, specifically on French people. To the best of our knowledge, there is a scarcity of literature concerning differences in the coracoid process BMD in different regions, genders, and ethnicities.

1.2 Problem statement

In the clinical anatomy and orthopaedic community, there is a great need to understand the morphometry and the bone mineral density of the coracoid process and the factors that determine its form. It is well known that the Asian population has smaller bones and lower BMD than their western counterparts (Zengin *et al.*, 2015; Cabezas *et al.*, 2016). Because of the comparatively smaller stature of Asians, several anatomists, surgeons, and researchers believe that it is important to establish data for the Asian population. Although morphometric measurements of the coracoid process from some Asian countries are presently available – India (Kavita and Singh, 2013) and Thailand (Piyawinijwong *et al.*, 2004) – the measurements of the majority of the Asian population and comparative data between Asian populations have not been previously described in the literature. In addition, only one study has been conducted to measure the BMD of the coracoid process; this study was carried out in France and was restricted to one region and correlates the BMD to the age (Beranger *et al.*, 2014). Currently, the deltopectoral approach has been used as a reliable approach and has been used as a reliable dissection method to access the coracoid process. However, it has a number of disadvantages (Fathi *et al.*, 2015). Hence, developing a new dissection method to access the coracoid process that is faster, easier, and reliable, is needed in medical research.

1.3 Significance of the study

This study seeks to extend the knowledge concerning the anatomy and radiology of the coracoid process of the human scapula. The study investigates the morphometry and BMD of the coracoid process in a diverse Asian population. To date, no studies

conducted that seek to determine the morphometry and BMD of the coracoid process in Malaysia. Furthermore, the dissection method to access the coracoid process is not described in the literature. Therefore, the knowledge from this study can raise awareness of the importance of ethnic differences in the morphometry and BMD of the coracoid process within the Asian population. Moreover, this knowledge can be beneficial in clinical anatomy, orthopaedic surgery, and forensic medicine.

In addition, the present study has developed a new dissection method that will help to access the coracoid process faster and easier in medical research and academic study. Indeed, the information obtained from the current study to determine the ethnic differences in the morphometry and BMD can be applied at some point in the future to prevent certain shoulder surgery complications especially in Malaysian populations.

1.4 Research hypothesis

1. There is an association between the differences in the morphometric measurements and bone mineral density of the coracoid process and differences in ethnicity.
2. The deltopectoral approach is not reliable for fully exposing the coracoid process for research and academic study.

1.5 Research objectives

1.5.1 General objective

To study the anatomy and radiology of the human coracoid process of the scapula in cadavers available at the Anatomy Dissection Hall (ADH), Universiti Putra Malaysia (UPM), and CT scans from normal subjects at the Golden Horses Health Sanctuary (GHHS).

1.5.2 Specific objectives

1. To develop the easy, fast and accessible dissection method to access the coracoid process
2. To determine the anatomical morphometric measurements of the coracoid process in cadavers and computed tomographic data, and determine ethnic, gender, and side differences.
3. To measure the bone mineral density of the coracoid process, and determine regional, ethnic, gender, and side differences.

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