

Classification and incidence of medial articular surface in Northeastern-Thai clavicles

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Abstract

Introduction: The medial articular surface of dried clavicles have been studied to evaluate sex and age in many races. This morphological investigation in Thai population has never been reported. This study aimed to classify the clavicular medial surfaces and to provide their incidences. **Materials and Methods:** 454 dried clavicles (254 males and 200 females), averaged age (60.69±14.36 years), from KKU Osteological Collection Unit, Department of Anatomy, Faculty of Medicine, Khon Kaen University, were systemically investigated for types and incidence of their medial articular surface. **Results:** The showed that medial articular surfaces of Northeastern-Thais were classified into 6 types: smooth (type 1 = 7.71%), slight granulation (type 2 = 16.74%), coarse granulation (type 3 = 41.63%), nodule formation (type 4 = 1.54%), undulating (type 5 = 24.89%), and degeneration (type 6 = 7.49%), respectively. **Conclusion:** These basic data can be used for teaching the medical and paramedical students and also might be applied in forensic sciences especially identifying of Northeastern – Thai clavicle remains.

Keywords: classification, incidence, medial articular surface, clavicle, Northeastern-Thais.

1 Introduction

In anthropological sciences, the clavicle bone is a key bone that has been used as a sex determination in many races including English (PARSONS, 1916), USA Whites (SINGH and SINGH, 1972), USA Negrose (SINGH and SINGH, 1972), French (OLIVIER, 1951), India (North West) (KAUR, HARJEET SAHNI and JIT, 2002), India (Amntsar zone) (JIT and SINGH, 1966), Greek (PAPAIOANNOU, KRANIOTI, JOVENEUX et al., 2012), and Southern Nigerians (UDOAKA and NWOKEDIUKO, 2013). In addition, the appearance of rhomboid fossa on inferior clavicular surface could be used to distinguish the males from the females (JIT and KAUR, 1986; ROGERS, FLOURNOY and MCCORMICK, 2000; PRADO, SANTOS, CARIA et al., 2009). Moreover, the medial articular surface of clavicle could be used to estimate age of Europeans (KREITNER, SCHWEDEN, RIEPERT et al., 1998; FALYS and PRANGLE, 2015). The medial clavicular epiphysis is also known to be the last bone to fuse among all long bones (>21 years). Therefore, it is the best to be used in reliable age indicator. Previous studies found that complete fusion of the medial articular surface of the clavicle is greater than 18 years (SINGH and CHAVALI, 2011; PATTAMAPASONG, MADLA, MEKJAIDEE et al., 2015; FALYS and PRANGLE, 2015; HOUPERT, REROLLE, SAVALL et al., 2016). In clavicular surface topography, Falys and Prangle (2015) have described and classified the medial articular surfaces of clavicle of Europeans in different ages into six types (Table 1, Figure 1). In Thai population, although age estimation from the medial articular surface in computed tomography (CT) has been reported (PATTAMAPASONG, MADLA, MEKJAIDEE et al., 2015), human dried clavicle have been investigated. These morphological investigations

in Thai race have never been reported. Therefore, this study attempted to classify and investigate the types of medial surface morphology on Northeastern-Thai dried clavicles.

2 Methods and Materials

From identified Northeastern - Thai skeletons from KKU Osteological Collection Unit, Department of Anatomy, Faculty of Medicine, Khon Kaen University, the total 454 dried clavicles (left and right sides from 254 males and 200 females) were used to observe in this study. As described by Falys and Prangle (2015), additional types of clavicular medial articular surfaces investigated in this study except 6 types (smooth, slight granulation, coarse granulation, nodular formation, undulating, and degeneration types) were also observed and systemically recorded.

3 Results

The medial articular surface of 454 dried clavicles from Northeastern-Thai skeletons can be classified into 6 types as shown in Figure 1. Type 1 was smooth type showing flat and smooth (Figure 1). Type 2 was slight granulation type showing fine sand paper (a slightly roughened surface) (Figure 1). Type 3 was coarse granulation type showing very small grains of bone form on the surface, resembling coarse sand. This texture is very rough, like sandpaper (Figure 1). Type 4 was nodule formation type showing at least one round lump of bone which is present on the generally flat surface (Figure 1). Type 5 was undulating type showing irregular and undulating surface (Figure 1). Finally, type 6 was degeneration

type showing increased porosity and highly irregular contours (Figure 1).

The Table 1 shows the incidence of the medial articular surface investigated in this study. Of 454 samples (averaged age 60.69±14.36 years), it was found that the percentages of 6 types of medial articular surface observed in Northeastern - Thai clavicles were 7.71% (type 1 smooth), 16.74% (type 2 slight granulation), 41.63% (type 3 coarse granulation), 1.54% (type 4 nodule formation), 24.89% (type 5 undulating), and 7.49% (type 6 degeneration), respectively (Table 1). In males, it was found that the percentages of type 1, 2, 3, 4, 5 and 6 were 3.52%, 8.15%, 18.72%, 0.88%, 10.57%, and 2.20%, respectively

(Table 1). In females, the incidences of type 1, 2, 3, 4, 5 and 6 were 4.19%, 8.59%, 22.91%, 0.66%, 14.32%, and 5.29%, respectively (Table 1). Obviously, the percentages of the type 3 and type 5 were increased especially in females (22.91% and 14.32%). In contrast, numbers of type 4 were decreased in both males and females (Table 1).

As compared Table 1 (N=454) to the samples known both sexes and ages (N=243), it was found that the percentages of 6 types of clavicular medial articular surface were similar. There were 9.06% (type 1), 14.4% (type 2), 40.33% (type 3), 2.05% (type 4), 25.92% (type 5), and 8.23% (type 6), respectively (Table 2). In contrast to type 4, the percentages of the type 3

Table 1. Incidence of medial clavicular articular surface types observe in Northeastern-Thais clavicle with known sexes (N=454).

Gender	Age average	N	Type1	Type2	Type3	Type4	Type5	Type6
Males	61.39±15.25	254	16 (3.52%)	37 (8.15%)	85 (18.72%)	4 (0.88%)	48 (10.57%)	10 (2.20%)
Females	60±13.46	200	19 (4.19%)	39 (8.59%)	104 (22.91%)	3 (0.66%)	65 (14.32%)	24 (5.29%)
Total	60.69±14.36	454	35 (7.71%)	76 (16.74%)	189 (41.63%)	7 (1.54%)	113 (24.89%)	34 (7.49%)

Table 2. Incidence of medial articular surface of clavicle between male and female clavicle with known both ages and sexes (N=243).

Gender	Age average	N	Type1	Type2	Type3	Type4	Type5	Type6
Males	61.39±15.25	135	12 (4.94%)	16 (6.58%)	57 (23.46%)	2 (0.82%)	36 (14.81%)	12 (4.94%)
Females	60±13.46	108	10 (4.12%)	19 (7.82%)	41 (16.87%)	3 (1.23%)	27 (11.11%)	8 (3.29%)
Total	60.69±14.36	243	22 (9.06%)	35 (14.4%)	98 (40.33%)	5 (2.05%)	63 (25.92%)	20 (8.23%)



Figure 1. Photographs showing 6 different types of medial articular surface observed in Northeastern - Thai clavicles. (A) smooth (type 1); (B) slight granulation (type 2); (C) coarse granulation (type 3); (D) nodule formation (type 4); (E) undulating (type 5); and (F) degeneration (type 6), respectively.

and type 5 were increased especially in males (23.46% and 14.81%) and those of type 4 were decreased in both sexes (Table 2).

4 Discussion

In Thailand, the classification and age estimation of medial articular surface of dried clavicle have never been reported. In recent study, the types of medial articular surface were similar to that investigated in European clavicles (FALYS and PRANGLE, 2015) which were also classified into 6 types (smooth, slight granulation, coarse granulation, nodule formation, undulating and degeneration). Age estimation of medial articular surface of dried clavicle has been studied from radiographs (GALSTAUN, 1937; JIT and KULKARNI, 1976), computed tomography (CT) (KREITNER, SCHWEDEN, RIEPERT et al., 1998; PATTAMAPASONG, MADLA, MEKJAIDEE et al., 2015; HOUPERT, REROLLE, SAVALL et al., 2016), dry bones (MCKERN and STEWART, 1957; WEBB and SUCHEY, 1985), and fresh bones (SINGH and CHAVALI, 2011). On maturation of the medial clavicle, previous studies have reported the age estimation in many populations observing in epiphyseal development of Germany (KREITNER, SCHWEDEN, RIEPERT et al., 1998), Northwest Indian (SINGH and CHAVALI, 2011), Serbian (MILENKOVIC, DJUKIC, DJONIC et al., 2013), Thais (PATTAMAPASONG, MADLA, MEKJAIDEE et al., 2015), European (FALYS and PRANGLE, 2015) and French (HOUPERT, REROLLE, SAVALL et al., 2016). They suggested that medial clavicular epiphysis started to be completely closed between 16 to 30 years (average 23 years). In this study, medial clavicular epiphysis was not observed because it cannot be clearly investigated on dry bones as described in Falys and Prangle (2015). For this study, type 3 (coarse granulation) and type 5 (undulating) were mostly found in the age range between 60 to 79 years (data not shown). It is possible that the old clavicles had the changing of medial articular surface than the younger one. Also, this changing may associate with local careers such as agricultural occupations mostly found in rural areas of Northeastern Thais. Such careers, the shoulder movements from agricultural activities might also involve in the degeneration of medial articular surface. These accumulated affects from shoulder movements might appear over age of 50 years. In addition, many reports showed that the medial articular surface of clavicle has bone remodeling after injuries (SFEROPOULOS, 2003; BARTONÍČEK, FRIC and LUNÁČEK, 2008; KOCH and WELLS, 2012). Similar to injury effects, it is also assumed that the extreme activities at upper extremities from careers such as farm or none farm labors may induce the remodeling of medial articular surface of clavicle. Previous studies reported that ossification completion of medial clavicle epiphysis was from 18 to 30 years (KREITNER, SCHWEDEN, RIEPERT et al., 1998; ZHAO, DONG, ZHENG et al., 2011). Besides all basic data of dried clavicles observed in this study can be used for teaching the medical and paramedical students, these fundamental knowledges can also be applied in sex and age determinations of forensic sciences especially identifying of Northeastern – Thai clavicle remains.

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References

- BARTONÍČEK, J., FRIC, V. and LUNÁČEK, L. Fractures of sternal end of the clavicle: current concept review. *Rozhledy v Chirurgii*, 2008, vol. 87, n. 9, p. 480-485. PMID:19174950.
- FALYS, CG. and PRANGLE, D. Estimating age of mature adults from the degeneration of the sternal end of the clavicle. *American Journal of Physical Anthropology*, 2015, vol. 156, n. 2, p. 203-214. PMID:25327699. <http://dx.doi.org/10.1002/ajpa.22639>.
- GALSTAUN, G. A study of ossification as observed in Indian subjects. *The Indian Journal of Medical Research*, 1937, vol. 25, n. 1, p. 267-324.
- HOUPERT, T., REROLLE, C., SAVALL, F., TELMON, N. and SAINT-MARTIN, P. Is a CT-scan of the medial clavicle epiphysis a good exam to attest to the 18-year threshold in forensic age estimation? *Forensic Science International*, 2016, vol. 260, p. 103.e1-103.e3. PMID:26786142. <http://dx.doi.org/10.1016/j.forsciint.2015.12.007>.
- JIT, I. and KAUR, H. Rhomboid fossa in the clavicles of North Indians. *American Journal of Physical Anthropology*, 1986, vol. 70, n. 1, p. 97-103. PMID:3728658. <http://dx.doi.org/10.1002/ajpa.1330700114>.
- JIT, I. and KULKARNI, M. Times of appearance and fusion of epiphysis at the medial end of the clavicle. *The Indian Journal of Medical Research*, 1976, vol. 64, n. 5, p. 773-782. PMID:184039.
- JIT, I. and SINGH, S. The sexing of adult clavicles. *The Indian Journal of Medical Research*, 1966, vol. 54, n. 6, p. 551-571. PMID:5947020.
- KAUR, H., HARJEET SAHNI, D. and JIT, I. Length and curves of the clavicle in Northwest Indians. *Journal of the Anatomical Society of India*, 2002, vol. 51, n. 2, p. 199-209.
- KOCH, MJ. and WELLS, L. Proximal clavicle physcal fracture with posterior displacement: diagnosis, treatment, and prevention. *Orthopedics*, 2012, vol. 35, n. 1, p. 108-111. PMID:22229601.
- KREITNER, KF., SCHWEDEN, FJ., RIEPERT, T., NAFE, B. and THELEN, M. Bone age determination based on the study of the medial extremity of the clavicle. *European Radiology*, 1998, vol. 8, n. 7, p. 1116-1122. PMID:9724422. <http://dx.doi.org/10.1007/s003300050518>.
- MCKERN, T.W. and STEWART, T.D. Skeletal age changes in young American males: analyzed from the standpoint of age identification. Natick: *Quartermaster Research and Development Command*, 1957. [Technical report, EP-45].
- MILENKOVIC, P., DJUKIC, K., DJONIC, D., MILOVANOVIC, P. and DJURIC, M. Skeletal age estimation based on medial clavicle: a test of the method reliability. *International Journal of Legal Medicine*, 2013, vol. 127, n. 3, p. 667-676. PMID:23329360. <http://dx.doi.org/10.1007/s00414-012-0791-6>.
- OLIVIER, G. Anthropologie de la Clavicule. III, La Clavicule due Francis. *Bulletins et Memoires de la Société d'Anthropologie de Paris*, 1951, vol. 2, n. 4, p. 121-157. <http://dx.doi.org/10.3406/bmsap.1951.2889>.
- PAPAIIOANNOU, VA., KRANIOTI, EF., JOVENEANUX, P., NATHENA, D. and MICHALODIMITRAKIS, M. Sexual dimorphism of the scapula and the clavicle in a contemporary Greek population: Applications in forensic identification. *Forensic Science International*, 2012, vol. 217, n. 1-3, p. 1-7. PMID:22138028. <http://dx.doi.org/10.1016/j.forsciint.2011.11.010>.
- PARSONS, FG. On the proportions and characteristics of the modern English clavicle. *Journal of Anatomy*, 1916, vol. 51, n. Pt 1, p. 71-93. PMID:17103806.
- PATTAMAPASONG, N., MADLA, C., MEKJAIDEE, K. and NAMWONGPROM, S. Age estimation of a Thai population based on maturation of the medial clavicular epiphysis using computed tomography. *Forensic Science International*, 2015, vol. 246, p.

- 123.e1-123.e5. PMID:25466155. <http://dx.doi.org/10.1016/j.forsciint.2014.10.044>.
- PRADO, FB., SANTOS, LSM., CARIA, PHF., KAWAGUCHI, JT. PREZA, A., DARUGE JUNIOR, E., SILVA, RF. and DARUGE, E. Incidence of clavicular rhomboid fossa (impression for costoclavicular ligament) in the Brazilian population: Forensic application. *The Journal of Forensic Odonto-Stomatology*, 2009, vol. 27, n. 1, p. 12-16. PMID:22717953.
- ROGERS, NL., FLOURNOY, LE. and MCCORMICK, WF. The rhomboid fossa of the clavicle as a sex and age estimator. *Journal of Forensic Sciences*, 2000, vol. 45, n. 1, p. 61-67. PMID:10641920. <http://dx.doi.org/10.1520/JFS14641J>.
- SFEROPOULOS, NK. Fracture separation of the medial clavicular epiphysis: ultrasonography findings. *Archives of Orthopaedic and Trauma Surgery*, 2003, vol. 123, n. 7, p. 367-369. PMID:12838434. <http://dx.doi.org/10.1007/s00402-003-0542-8>.
- SINGH, J. and CHAVALL, KH. Age estimation from clavicular epiphyseal union sequencing in a Northwest Indian population of the Chandigarh region. *Journal of Forensic and Legal Medicine*, 2011, vol. 18, n. 2, p. 82-87. PMID:21315303. <http://dx.doi.org/10.1016/j.jflm.2010.12.005>.
- SINGH, SP. and SINGH, S. Identification of sex from the humerus. *The Indian Journal of Medical Research*, 1972, vol. 60, n. 7, p. 1061-1066. PMID:4661453.
- UDOAKA, AL. and NWOKEDIUKO, AU. Radiologic evaluation of clavicular morphology in Southern Nigerians. *International Journal of Morphology*, 2013, vol. 31, n. 1, p. 94-99. <http://dx.doi.org/10.4067/S0717-95022013000100014>.
- WEBB, PO. and SUCHEY, JM. Epiphyseal union of anterior iliac crest and medial clavicle in a modern multiracial sample of American males and females. *American Journal of Physical Anthropology*, 1985, vol. 68, n. 4, p. 457-766. PMID:4083337. <http://dx.doi.org/10.1002/ajpa.1330680402>.
- ZHAO, H., DONG, XA., ZHENG, T., QING, SH., DENG, ZH. and ZHU, GY. Skeletal age estimation of sternal end of clavicle in Sichuan Han nationality youth using thin-section computed tomography. *Fa Yi Xue Za Zhi*, 2011, vol. 27, n. 6, p. 417-420. PMID:22393589.

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