Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jasi

Original Article

Clavicular facet of the coracoclavicular joint: Analysis in modern skeletons of the mapuche indigenous individuals

Mariano del Sol [a,b,*], *Bélgica Vásquez* [c], *Iván Suazo* [d], *Mario Cantín* [a,e]

[a] *Professor & Head, Doctoral Program in Morphologycal Sciences, Faculty of Medicine, Universida de La Frontera, Temuco, Chile*

[b] *Professor & Head, Center of Research in Biomedical Sciences, Universidad Autónoma de Chile, Temuco, Chile*

[c] *Professor, Universidad de Tarapacá, Arica, Chile*

[d] *Professor, Universidad Autónoma de Chile, Temuco, Chile*

[e] *Associate Professor, Faculty of Dentistry, Universidad de La Frontera, Temuco, Chile*

ARTICLE INFO

Article history:
Received 30 January 2014
Accepted 10 April 2014
Available online 5 May 2014

Keywords:
Human clavicle
Coracoclavicular joint
Articular facet
Mapuche
Population variations

ABSTRACT

Introduction: The coracoclavicular joint (CCJ) has been used as an anthropological marker for human migration, with a strong presence in Asian population. In South America, studies are scarce and incomplete. The aim was to determine the frequency of articular facet of CCJ in an osteological sample pertaining to Mapuche indigenous population in Chile.

Methods: We used 96 clavicles (48 left and 48 right), and the presence and characteristics of the articular facet on the conoid tubercle were determined by direct observation. Maximum transverse diameter (MTD) and maximum antero-posterior diameter (MAPD) were measured using a digital caliper. The frequency obtained was compared with other osteological studies on worldwide population.

Results: Articular facet was found in 22.9% of the cases. Twelve facets (12.5%) were present on the right side and 10 (10.4%) on the left, with 10 paired bilaterally and two paired unilaterally on the right side. Articular facets were very clear and prominent in 4 cases (4.2%), regularly prominent in 6 (6.3%), and poorly prominent in 14 (14.6%). The facets were usually oval, with an MTD and MAPD of 19.2 and 18.8 mm, respectively, without differences by side.

Discussion: Mapuche ethnic group showed the highest frequency of osteological material reported to date between native South American and global population. Their presence may not be related to a geographical migration, but to other causes such as genetic, environmental, or evolutionary adaptation factors. The study of CCJ as anthropological trait must be addressed through direct observation in osteological material, because radiological studies may underestimate its frequency.

* *Corresponding author*. Tel.: +56 (0) 45 2325600.
E-mail addresses: mariano.delsol@ufrontera.cl, mario.cantin@ufrontera.cl (M. del Sol).

http://dx.doi.org/10.1016/j.jasi.2014.04.004

1. Introduction

Coracoclavicular joint (CCJ) is the articulation between the coracoid process of the scapula and the inferolateral surface of the clavicle. It is a diarthrotic synovial joint between the conoid tubercle of the clavicle and superior surface of the horizontal part of the coracoid process of the scapula.[1–6]

Anatomists have long recognized an articular facet in the region of the conoid tubercle of the clavicle as a rather uncommon osteological feature; several authors noted its occasional presence.[1–3,5,7,8] This facet is usually oval, with the long axis directed horizontal, but sometimes assumes an almost circular shape, with varied size.[5,8] The existence of a CCJ can be indicated by an articular facet on the conoid tubercle or the craniomedial surface of the coracoid process.[2]

Many of the early investigators considered the CCJ to be a rare anomaly, but some authors came to the conclusion that the joint was not rare.[2] Gruber realized the first description of the CCJ in 1861,[5] and its presence had been recognized by radiological, dissecting room, and osteological studies.[1–3,5,9,10] The origin of the CCJ is unknown, although there have been suggested causes such as development, occupations, environment, congenital, genetic, or age.[2,8,9]

Racial variations in the incidence of this joint have been described from osteological material.[1] Cockshott analyzed the prevalence of the CCJ in different geographic regions, concluding that it is highly prevalent in regions of Central Asia (14.5–40.7%), decreasing in North America (1.2–7.4%), until reaching a minimum of 0.4% in the Argentine population and 0.8% in the modern Brazilian population, with a total absence of reports for the Mayan descendant population, and related it to the Bering land bridge migration.[11] According to this author, geographic distribution evidence is incomplete, with a lack of available information on numerous South American indigenous groups.

The present study was undertaken to find out the frequency of the articular facet on the conoid tubercle of the clavicles in a modern osteological sample pertaining to adult Mapuche indigenous population in Chile.

2. Materials and methods

The materials used in this osteological study consisted of 96 clavicles (48 right and 48 left) obtained from adult Mapuche indigenous cadavers (48 males). The clavicles were obtained from subjects who had died in Temuco, after medicolegal postmortem examination had been conducted. Both clavicles were removed together in one piece with the sternum. The bones were then separated and prepared in the Department of Morphology, University of La Frontera (Temuco, Chile) under traditional gentle maceration technique to remove the soft tissue, and then dried. Nonmedical history or occupations of the deceased were available at the time of autopsy.

In dry clavicles, the presence of the CCJ was determined by inspecting the occurrence of a definite articular facet on the conoid tubercle, and was recorded according to the side by direct observation, with the differences defined by consensus. The following measurements were taken on all articular facets: (1) maximum transverse diameter and (2) maximum antero-posterior diameter using a digital caliper (0.01 mm). Two investigators evaluated the samples independently.

The results were tabulated and the frequency of articular facet on the conoid tubercle of the CCJ was calculated and compared, specifically with those previously reported in osteological studies on other population groups.

3. Results

Out of the 96 examined clavicles, 22 (22.9%) articular facets on the conoid tubercle (CCJ) were found in the study population. Twelve (12.5%) were present on the right side and 10 (10.4%) on the left, with 10 paired bilaterally and two paired unilaterally on the right side. With the numbers available, no significant difference could be detected between the right and left sides (Table 1).

Articular facets of the CCJ on the clavicle were very clear and prominent in 4 cases (4.2%), regularly prominent in 6 (6.3%) (Fig. 1, see superior-right image magnified), and poorly prominent in 14 (14.6%) (Fig. 1, see inferior-right image magnified).

The facets were usually oval, with the long axis directed horizontally. The facets varied in size with a maximum transverse diameter of 19.2 mm and a maximum antero-posterior diameter of 18.8 mm. No significant difference could be detected between right and left sides. The mean of the antero-posterior and transverse diameters of the right clavicles was 12.5 and 15.6 mm, respectively, and that of the left clavicles was 12.5 and 13.4 mm, respectively.

Table 2 shows the prevalence of CCJ in different population groups from previous osteological studies. The frequency of CCJ was found to be higher in Mapuche indigenous population (present study), followed by Asian (Japanese and Korean – 9.9 and 9.8%, respectively), Indian (Punjabi, Northwest Indians, 9.7%), and South African (Black and White, 9.4 and 10%, respectively) populations. and was lower in the Southern Europe population (0.3%).

The degree of asymmetry of the CCJ in the study population showed higher occurrence of the joint on the right (54.5%) than on the left (45.5%) side.

4. Discussion

The frequency of articular facet of clavicles on the CCJ in Mapuche population is the highest reported in osteological studies. Until now, literature had reported osteological material frequencies ranging from 0.3 to 10%.[1,2,8,12,13] This frequency is only comparable with the result reported by Cockshott[9] in Chinese population (21%; on 480 clavicles of

Table 1 – Frequency of articular facet on the conoid tubercle of the clavicles in the Mapuche study population.

	Total	Right	Left
Total Sample	96	48	48
Presence of facet	22 (22.9%)	12 (12.5%)	10 (10.4%)

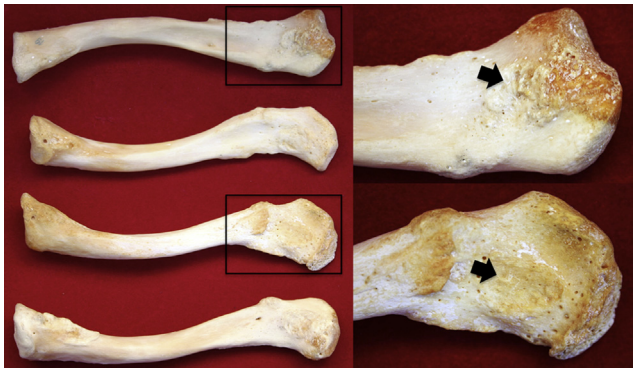

Fig. 1 – Articular facet of the CCJ on the clavicles of Mapuche indigenous population. In superior-right image, is shown a regularly prominent facet with bony roughness (*black arrow*). On inferior-right image a poorly prominent facet (*black arrow*).

both sexes), which were based on radiological study. On comparing the present result with those reported by osteological studies on other ethnic groups, Australian aboriginal had a frequency of 0.7% and Punjabi population had a frequency of 9.7%.[8,14]

Racial variations in the incidence of this joint have been described from osteological material.[1] Among Caucasians, African descents or Europeans rarely occur, but among Asians, particularly among the Japanese, Korean, and Southern Chinese populations, they are more frequent,[2,3,13] as shown in Table 2. Cockshott[11] in a study based on a survey of published material, suggested using studies of the CCJ as a way of understanding the patterns of migration and plotting the relative frequency of CCJ on the global map to demonstrate the diminishing frequency with the increasing distance from the epicenter in China, and related it to the Bering land bridge migration. To support this theory, he showed that South American population has a low frequency, similar to other populations south of China in other continents. Nevertheless, the frequency reported in this study on indigenous Mapuche of Chile completely overthrows this idea. These findings agree with other studies of osteological materials,[1,8] indicating that very slight or negligible racial differences exist in the incidence of the joint.[2]

The existence of a CCJ can be indicated by an articular facet on the conoid tubercle or on the craniomedial surface of the coracoid process.[2] However, it has been noted that quite well-formed articulations could exist without the presence of the prominent bony processes, which could exist without an articular facet.[7,8] For this reason, the frequency of occurrence depends on research and observation methods. In general, the frequency of the joint obtained from radiological studies is lower than that obtained from osteological or dissection studies.[2] Radiographically, the presence of this joint occurs when an articular facet on an enlarged conoid tubercle protrudes from the inferior aspect of the clavicle and a similar facet on the corresponding site on the coracoid process. There is no doubt that a joint is present in such instances. However, an articular facet can exist on the conoid tubercle of the clavicle without forming a "large bony process"[8,11] and it is easy to miss the visualization of this joint.[7,15] Besides, radiologically, because of dependence on mineralization of the structure, some joints will inevitably be missed.[11] Thus, chest X-rays have been generally accepted as an unreliable method for identifying the joint.[2,8,10,15] Despite this, several studies have used this method, where the value of CCJ occurrence is between 0.6 and 21%,[3,9,10] and even 40% in the population of Shanghai (X. Ku Kung-Nin). Thus, these frequencies could be even higher in dissection or osteological studies,[2] and present underestimated results in radiographic studies. For example, on the same sample, Nehme et al[5] reported frequencies of 0.82 and 1.78% through radiological and osteological studies, respectively, which were comparable with those inferred by Fisher et al[10] (0.6 and 6.8%, respectively). On the other hand, the frequency obtained from dissections ranged from 1.7[16] to 30.0%.[17] Some investigators,[2,7,10] reported that the frequency of the CCJ from dissections was higher than or similar to those obtained from osteological materials. It is interesting to

Table 2 – Frequency of the coracoclavicular joint obtained from osteological materials in world population.

Reference	Date	Population/Sample	*n* Shoulders	Frequency[a] (%)	Males[a] (%)	Females[a] (%)	Bilateral[a] (%)	Unilateral[a] (%)
Parsons[24]	1916	England	282	1.4	–	–	–	–
Vallois[25]	1926	Southern Europe	180	2.8	–	–	–	–
Bainbridge and Tarazaga[12]	1956	Southern Europe	358	0.3	–	–	–	–
Jaluvka[26]	1956	Czechoslovakia	491	5.1	–	–	–	–
Ray[14]	1959	Australian aboriginal	292	0.7	–	–	–	–
Abe[13]	1964	Japanese	91	9.9	–	–	–	–
Fischer et al[10]	1971	French	117	6.8	–	–	–	–
Kaur and Jit[8]	1991	Northwest Indian	1000	9.7	7.6	2.1	5.2	4.5
Nalla and Asvat[1]	1995	South African (White)	60	10	5.0	5.0	5.0	5.0
		South African (Black)	180	9.4	5.6	3.9	4.4	5.0
Cho and Kang[2]	1998	Korean	102	9.8	5.9	3.9	8.8	1.0
Gumina et al[3]	2002	Italian	510	1.6	1.2	0.4	Nil	1.6
Nehme et al[5]	2004	French	392	1.78	0.8	0.5	0.5	0.8
Present study	2013	Mapuche Indigenous	48	25	25	Nil	20.8	4.2

[a] The frequencies were calculated as the number of subjects (shoulders) studied.

consider the report by Cockshott,[11] who studied similar populations by using dissection and osteological methods, and found that the frequency was higher in the bone specimens. In our case, we could not compare these frequencies because there are no similar studies that had employed dissection or x-rays to examine Mapuche population.

The osteological material may also have been underestimated,[3] i.e., when an articular facet exists without forming a prominent process or when a bony process exists without an articular facet,[2,5] these conditions are not a sign of absence of joint.[7,8] In fact, the CCJ may be revealed only during wet dissections, and the examination of dry bones only shows the frequency of these processes or their articular facet.

The origin of the CCJ is still debated. Although some reasons have been suggested, the factors that induce the development of the CCJ are not clear.[2] Lane[18] and Lewis[7] thought that this joint was an acquired joint seen in laborers, related to particular movements associated with work. After examining the occupations of individuals possessing the joint, Kaur and Jit concluded that there was no relation between the existence of the joint and particular occupations.[8] Nalla and Asvat proposed that the CCJ may develop in individuals having these features so as to facilitate movement, given these space restrictions.[1] An explanation may be that any tissue has an inherent power of response, genetically controlled and inherited, which may be called forth by changes in the environment or use. It is known that localized pressure and friction may induce metaplasia of ordinary connective tissue into cartilage. Also, connective tissue, under certain circumstances, can produce synovial-lined cavities and bursae. Indeed, complete new joints, pseudarthroses, may arise at the site of an ununited fracture.[7] Pillay through family studies, had clearly demonstrated that this anatomical variant is transmitted in a dominant fashion.[15] From all the foregoing statements, the joint is clearly congenital.[7,9] However, Kaur and Jit concluded that CCJ is probably not a congenital anomaly because they could not find an articular facet of this joint in fetuses, neonates, or children under 13 years of age.[8] They further noted that the formation of the joint late in life is probably caused by genetic factors than by environmental factors. Pillay suggested that the CCJ arose from the approximation of the clavicle to the coracoid during early human evolution.[15] This includes the assumption that new, complex movements are possible at the shoulder. Kaur and Jit proposed an alternative view, suggesting that these joints appear after the first decade,[8] and Cho and Kang suggested that the occurrence is related to aging.[2]

According to our results, we believe that a possible explanation for the high frequency is associated with the occupation or type of movement made specifically by Mapuche males, because it corresponds to a population that collects food at ground level; this activity has been performed for hundreds of years, to the present, using both the upper limbs. This also shows a possible genetic influence of evolutionary and hereditary characteristics, strongly associated with environmental factors.

The osteological study in Mapuche samples revealed that the CCJ can be present either bilaterally or unilaterally.[1,2,8,15] In relation to the degree of asymmetry of the CCJ in our study population, the joint exhibited higher occurrence on the right than left side. Olotu et al[19] found a similar asymmetry in indigenous adult Nigerians, with the occurrence on the right and left side being 55.5 and 33.3%, respectively, and bilateral occurrence being 11.11%.

The limitations of the present study include evaluation of only the male's clavicles; however, there was no significant bias, because it had been established that there were no statistically significant differences in CCJ incidence between the sexes in osteological studies.[1,2,8,19] On the other hand, Lewis reported that the joint was more common in males than in females, in a proportion of 11:1.[7]

It is necessary to evaluate the role that this joint could have in the dynamics of the upper limb and stability of the shoulder at the time of injury.[20] This joint has clinical relevance, and is considering being responsible for humeral head fracture,[21] cervicobrachial syndrome,[22] thoracic outlet or costoclavicular syndrome,[19] and decrease in movement.[23] In some cases, clinical symptoms, including shoulder-joint pain radiating to the arm, breast, and neck and persisting during rest and increasing with exercise, have been described. The maximum intensity has been observed to persist at the site of the CCJ. Occasional symptoms include itching of the last four fingers, followed by transient paralysis of the hand,[23] which are correctible with surgery.[5] Thus, knowledge of the presence and frequency of this joint is useful in determining the etiology of shoulder pain and its subsequent management, and is a relevant characteristic in Mapuche population due its high frequency.

5. Conclusion

The CCJ in the Mapuche ethnic group showed the highest frequency reported to date in osteological material from a native South American and global population, suggesting that their presence may not be related to a geographical migration, but to other causes, such as genetic, environmental, or evolutionary adaptation factors. The study of CCJ as an anthropological trait must be addressed through direct observation of the bone material, because radiological studies may underestimate its frequency.

Conflicts of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Nalla S, Asvat R. Incidence of the coracoclavicular joint in South African populations. *J Anat*. 1995;186:645–649.
2. Cho BP, Kang HS. Articular facets of the coracoclavicular joint in Koreans. *Acta Anat*. 1998;163:56–62.
3. Gumina S, Salvatore M, De Santis R, et al. Coracoclavicular joint: osteologic study of 1020 human clavicles. *J Anat*. 2002;201:513–519.
4. Faraj AA. Bilateral congenital coracoclavicular joint. Case report and review of the literature. *Acta Orthop Belg*. 2003;69:552–554.

5. Nehme A, Tricoire JL, Giordano G, et al. Coracoclavicular joints. Reflections upon incidence, pathophysiology and etiology of the different forms. *Surg Radiol Anat*. 2004;26:33–38.
6. Cheung TF, Boerboom AL, Wolf RF, et al. A symptomatic coracoclavicular joint. *J Bone Jt Surg Br*. 2006;88:1519–1520.
7. Lewis OJ. The coraco-clavicular joint. *J Anat*. 1959;93:296–303.
8. Kaur H, Jit I. Brief communication: coracoclavicular joint in Northwest Indians. *Am J Phys Anthropol*. 1991;85:457–460.
9. Cockshott WP. The coracoclavicular joint. *Radiology*. 1979;131:313–316.
10. Fischer L, Vuillard P, Blanc JF, et al. The coracoclavicular joint (apropos of 3 clinical cases, 56 cadaveric dissections and of the examination of 228 osseous specimens). *Lyon Med*. 1971;225:1257–1260.
11. Cockshott WP. The geography of coracoclavicular joints. *Skelet Radiol*. 1992;21:225–227.
12. Bainbridge D, Tarazaga SG. A study of the sex differences in the scapula. *J R Anthropol Inst*. 1956;86:109–134.
13. Abe K. On the coraco-clavicular joint and its incidence. *Acta Anat Nippon*. 1964;39:227–231.
14. Ray LJ. Bilateral coraco-clavicular articulations in the Australian aboriginal. *J Bone Jt Surg Br*. 1959;41:180–184.
15. Pillay VK. The coracoclavicular joint. *Singap Med J*. 1967;8:207–213.
16. Schlyvitch B. Über den Articulus coracoclavicularis. *Anat Anz*. 1937;85:89–93.
17. Poirier P. La clavicule et ses articulations, bourse sereuse des ligaments costoclaviculaire trapezoide et conoide. *J Anat Physiol*. 1890;26:81–103.
18. Lane AW. Some points in the physiology and pathology of the changes produced by pressure on the bony skeleton of the trunk and shoulder girdle. *Guy's Hosp Rep*. 1886;38:321.
19. Olotu JE, Oladipo GS, Eroje MA, et al. Incidence of coracoclavicular joint in adult Nigerian population. Scientific research and essays. *Sci Res Essay*. 2008;3:165–167.
20. Bhatia DN, de Beer JF, du Toit DF. Coracoid process anatomy: implications in radiographic imaging and surgery. *Clin Anat*. 2007;20:774–784.
21. Frasseto F. Tre casi di articolazione coraco-clavicolare osservati radiograficamente sul vivente. *Chir Org Mov*. 1921;5:116–124.
22. Del Valle D, Giordano A. Sindrome doloroso cervicobrachial originado por articulacion coracoclavicular. Operacion-curacion. *Rev Argentino-Norteamericana Cien Med*. 1943;1:687–693.
23. Hall FJS. Coracoclavicular joint; rare condition treated successfully by operation. *Br Med J*. 1950;1:766–768.
24. Parsons FG. On the proportions and characteristics of the modern English clavicle. *J Anat*. 1916;51:71–93.
25. Vallois HV. Les anomalies de l'omoplate chez l'homme. *Bull Soc Anthropol*. 1926;7:20–37.
26. Jaluvka V. Articulus coracoclavicularis. *Cesk Morfol*. 1956;4:99.