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Descriptive characteristics of the area of origin of the deltoid muscle on the human clavicle. Is it necessary to include new terms in the *Terminologia Anatomica*?

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ABSTRACT

The clavicular portion of the deltoid muscle (CPDM) in the human clavicle does not have a nomenclature in the *Terminologia Anatomica* (TA). This area is relevant in anatomy since the muscle participates in motions of glenohumeral articulation. The aim of this study was to describe the origin of the CPDM and to propose a name for the structure. Dry clavicles of 176 adults were studied, without distinction by sex. An osteometric board was used to measure the maximum length of the clavicles and a digital caliper to measure length of the CPDM's origin, distance from the origin to the sternal end, distance from the origin to the acromial end, distance of the lateral third and middle vertical diameter. The mean of maximum of the distances and CPDM's origin of left/right clavicle do not present significant differences. The CPDM s origin showed a high prevalence of structures as groove and roughened area (over 96% of cases). In conclusion, our definition of the CPDM shows the importance of clearly describing the observed groove and roughened area. Due to the high prevalence of the structures, the authors suggest that the terms "sulcus musculi deltoidei" and "tuberositas musculi deltoidei" be included in the TA to denominate the CPDM's origin on the human clavicle.

Introduction

Within the fields of anatomy and physical and/or forensic anthropology, the term "enthesis" is used to identify the areas where a tendon, ligament or joint capsule is attached to the bone and acts to transmit a tensile load from soft tissues to the skeleton (Apostolakos et al., 2014). These areas are marked by observable structures (Mariotti et al., 2007; Villotte et al., 2010). Analysis of the traces left on osseous remains by muscular activity is especially useful. These marks represent an invaluable source of information, and the changes in the internal and/or external bone architecture, which developed under continuous and prolonged stress from habitual or occupational activities, are known as activity markers (Galtés et al., 2007; Karakostis et al., 2017), or markers of occupational stress (Kennedy, 1983; Scabuzzo, 2012). These traces could reflect the robustness of origins and insertions of fibrous structures by showing moderate to marked impressions, which can have high clinical and anthropological value (Alfaro and Bernal, 2009; Kennedy, 1983). The clavicle is characterized by attachment sites for the costoclavicular, conoid and trapezoid ligaments and for the sternocleidomastoid, trapezius, subclavius, pectoralis major, and deltoid muscles (Johnson et al., 1994; Renfree et al., 2003). The tight relationship in this bone between its shape and the muscles and ligaments that attach to it constitutes the basic platform for

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the shoulder's complete range of motion (Bernat et al., 2014; Lazarus and Seon, 2006). Moreover, the clavicle allows the appendicular and axial skeleton to articulate by means of the sternoclavicular and the acromioclavicular joints. Its structure is complex and plays an important role in the stability, motion and aesthetic aspect of the pectoral girdle (Bernat et al., 2014).

The deltoid muscle is an active participant in all motions at the glenohumeral joint (Lee and An, 2002; Rosso et al., 2014), and many activities of the upper limb require its action (Palastanga and Soames, 2011). This muscle has three portions: clavicular, acromial and spinal (FCAT, 1998). The clavicular portion of the deltoid muscle (CPDM) has its origin in the clavicle's lateral third along its anterior border and superior face (Kumar et al., 1997; Latarjet and Ruiz Liard, 2004; Standring et al., 2005), where the anterior segment A1 of the deltoid muscle mainly participates out of the seven segments observed in this muscle (Sakoma et al., 2011).

The CPDM can be identified by a trace described as roughness of the deltoid (Rouvière and Delmas, 2005) or roughness from the deltoid muscle (White et al., 2011). Other authors identify the area using the concept of a "deltoid tubercle", which is incorrect according to the *Terminologia Anatomica* (TA) since this term (A02.4.01.006) refers to a structure associated with the scapula and not the clavicle (Villarroel et al., 2016). Nevertheless, there is no term in the TA that describes or names this area. In addition, research carried in this field has not delved into its description.

From an anatomical, physical anthropological and forensic point of view, knowing the origin of CPDM is very important, however, there is a lack of detailed description of this area of bone and there is also a lack of precision in the existing literature regarding its morphology and terminology. Consequently, this study aims to describe the origin of CDPM in human clavicles and propose a denomination for its adequate anatomical description.

Materials and methods

Samples of dry clavicles and analytical procedure

This study comprises the anatomical and osteometric description of 176 dry clavicles (96 right and 80 left, without distinction by sex). The inclusion criteria were that they belonged to adults and that they were complete and well preserved. All the clavicles came from the collection in the Laboratory of Anatomy in the Faculty of Natural and Exact Sciences of the Universidad de Playa Ancha, Valparaiso, Chile. Photographs of the samples were captured with a Canon Rebel EOS T3i camera. An osteometric board was used to measure the maximum length of the clavicles (GPM corp, Zurich, Swiss) and for the rest of the measurements a digital caliper (Mitutoyo Corp, Kanogawa, Japan) was used. Osteometric analysis was based on the measurements defined by Buikstra and Ubelaker (1994) and Walters et al. (2010). The measurements and observations carried out included the maximum length of the clavicle, length of the CPDM's origin, length from the origin to the sternal end, length from the origin to the acromial end, length of the lateral third and middle vertical diameter (Fig. 1). Moreover, the measurements of the origin were taken: length of the rough area and groove length (Figs. 2 and 3).

All the procedures were approved by the Ethics Committee of the Universidad de Playa Ancha, Valparaíso, Chile.

Statistics

Data were managed in Microsoft Excel 2007 (Microsoft Corporation) and analyzed using STATA 12 software (Stata Corp. Stata Statistical Software: Release 12. College Station, TX: Stata Corp LP 2011). For the purpose of this study, descriptive analyses, including averages, standard deviations, and percentages, were carried out. Comparisons between clavicle measurements based on laterality were made using a specific test (*t*-test or its non-parametric equivalent according to the results of the Shapiro-Wilk's normality test).

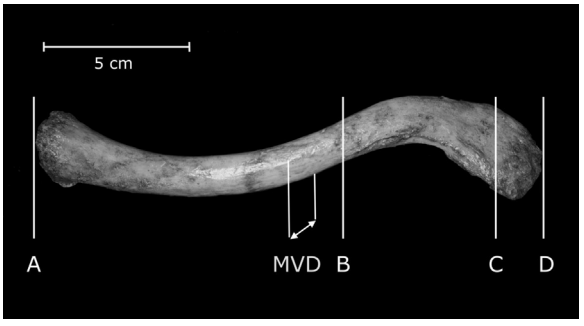

Fig. 1. Representation of the left clavicle's measurements and divisions (Walters et al., 2010). A–D = Maximum length. A–B = Length from origin to sternal end. B–C = Length of the area of origin. C–D = Length from the origin to the acromial end. B–D = Length of the lateral third. MVD = Middle vertical diameter (upper to lower).