THE NATURE AND MORPHOLOGY OF THE COSTOCLAVICULAR LIGAMENT

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Some dubiety and contradiction still attend formal accounts of the anatomy of the costoclavicular (rhomboid) ligament, and great variation of appearance is presented by that region of the clavicle which receives the superior attachment of this ligament. These differences in authoritative opinion and in clavicular configuration prompted an inquiry into the structure and nature of the costoclavicular ligament, the results of which are briefly presented here.

MATERIAL AND METHODS

Examination was made of the secondary markings present upon 153 adult (unsexed) clavicles at the site of attachment of the costoclavicular ligament; the findings are listed in Tables 1 and 2 and discussed below. Observation was made upon the ligament and its associated parts during the routine dissection of twenty-five adult cadavers in the Anatomy Department of this College; special dissection was made of the corresponding structures in eight undisturbed embalmed adults and in two unfixed autopsy specimens of the shoulder girdle removed *en bloc*. The costoclavicular ligament was dissected out and its relevant anatomy studied in eighteen species of primate mammal.

From a fresh cadaver a block of tissue was removed which included the clavicle, the first rib, half the sternal manubrium and the upper portion of the scapula with its coracoid and acromial processes. From this block all muscle tissue (save that of m. subclavius) was carefully removed and the various ligaments were subsequently cleaned. The manubrio-costal end of the preparation being fixed, the clavicle was manipulated in various directions and the effect of its excursions upon the costoclavicular ligament was noted.

PREVIOUS ACCOUNTS OF THE LIGAMENT

In British anatomical teaching the costoclavicular or rhomboid ligament was earliest described (Gray, 1858; Humphry, 1858; Thane, 1882) as consisting of a single plane or sheet of fibres, proceeding superolaterally from the first costal arch to the under surface of the clavicle. Later Macalister (1889) described the fibres as ascending medially from the first rib, as did Frazer (1920), who so figured them. The earliest suggestion of the ligament's possibly bilaminar nature came from Morris (1879), who mentioned decussating fibres; his *Human Anatomy* (1907) stated that 'frequently some of the fibres pass upwards and inwards behind the rest and give the appearance of decussating'—a statement retained by Wood Jones (1915).

The first description of a frankly bilaminar costoclavicular ligament was given by

Poirier (1890) and repeated by Poirier & Charpy (1899). For Poirier this ligament was a 'cône tronqué', with anterior and posterior fibre-layers inclined upwards and outwards. Fick (1904) described the anterior fibres as running upwards and outwards and the posterior as running upwards and inwards. Testut (1905) gave no personal account of the ligament, but quoted Sappey as recognizing two component layers therein. Bryce (1915) described two ligamentous laminae, all the fibres of which passed upwards, outwards and backwards. More recently, Wood Jones (1949) and the centenary edition of *Gray's Anatomy* (1958) gave a simplified account of the two ligamentous planes described by Fick.

Those authorities who admit the presence of two component layers in the costoclavicular ligament are not unanimous concerning the presence of an interposing bursa, where they do not entirely ignore such a structure. Poirier (1890) alone described this bursa fully: he regarded it as constant, though of variable nature, with a lining which might be 'smooth and glistening or rough and reddish'. His account was adopted by Fick (1904). Testut (1905) quoted Sappey's description of a bilaminar ligament having 'lax, cellular tissue between the layers and sometimes a bursa'. Bryce (1915) regarded this bursa as inconstant, but adduced no personal evidence; Wood Jones (1949) was likewise content virtually to adopt Poirier's findings.

OSTEOLOGICAL EVIDENCE

The 153 clavicles examined revealed distinctive differences in the pattern of the canonical 'rhomboid impression'. Most commonly the costoclavicular ligamentous area was flat; in a considerable number of specimens a distinct pit or depression was present; in a smaller proportion of specimens the relevant area showed an

Table 1. *Nature of costoclavicular area on clavicle*

No. of clavicles examined	Flat	De-pressed	Eleva-ted	Rough	Smooth	Ant. groove	Post. groove	Ant. lip	Post. lip
Right, 78	41	28	9	40	38	3	2	7	25
Left, 75	52	15	8	48	27	3	2	10	35
Total, 153	93	43	17	88	65	6	4	17	60

Table 2. *Characteristics of costoclavicular area*

Combined characters	Right	Left	Total	Percentage of 153 clavicles
Flat and rough	20	28	48	31
Flat and smooth	21	24	45	29
Depressed and rough	15	12	27	18
Depressed and smooth	13	3	16	10·5
Elevated and rough	5	8	13	8·5
Elevated and smooth	4	0	4	2·6

elevation (see Table 1). In most clavicles this ligamentous area was rough, in a minority it was smooth (Table 1). The proportions of combinations of the main features noted are given in Table 2, whence it appears that 60 % of clavicles manifest a 'flat' rhomboid area, 30 % a depression here, and 10 % an elevation of the

bone at this site. The ligamentous area is invariably oval in outline and additionally it may be provided, anteriorly or posteriorly, with either prominent 'lips' or limiting grooves (see Table 1 and Fig. 1).

These findings differ from those of Poirier, who described the costoclavicular attachment area as having most commonly the form of a rough oval eminence, though sometimes the form of an oval fossette, and as being sometimes poorly marked. His suggestions that these osteological differences are due to variations in

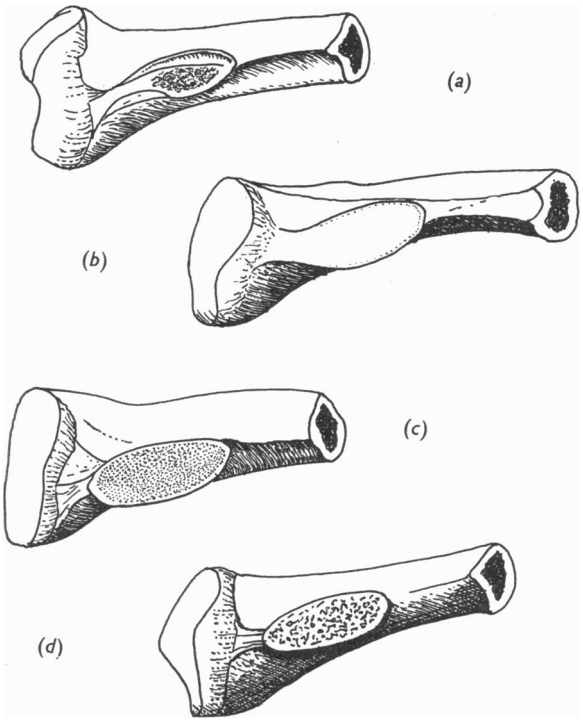

Fig. 1. ***Homo.*** **Varieties of costoclavicular area on clavicle.** a **= rough, flat area with posterior lip;** b **= smooth and flat area;** c **= smooth, depressed area;** d **= rough, elevated area.**

the degree of development of the ligament or to methods of specimen preparation appear to be inadequate; no other attempt at explanation of these differences has, however, been encountered in the literature.

The markings made by the costoclavicular ligament upon the clavicle indicate clearly that medially the ligament must merge with the sternoclavicular joint capsule and that laterally the anterior and posterior components of the ligament are in continuity.

In one clavicle examined the costoclavicular attachment area had the form of a smooth, elevated, faceted apophysis, which established diarthrodial articulation with a corresponding faceted apophysis on the first rib. Poirier (1890) stated that such a variation occurred once in ten specimens (the costoclavicular ligament forming the capsule of the diarthrosis), but he furnished no supportive statistical evidence. In the present study, only four of 153 clavicles (Table 2) manifested the smooth,

elevated apophysis associated with a costoclavicular diarthrodial arrangement. Fick (1904) referred to examples of diarthrodial union between first rib and clavicle reported by Poirier, Luschka, Cruveilhier and Waldeyer, without, however, any mention of statistical incidence. Wood Jones (1949) gave a 10% incidence of the occurrence of costoclavicular diarthroses, but his statement appears to be merely a numerical modification of Poirier's.

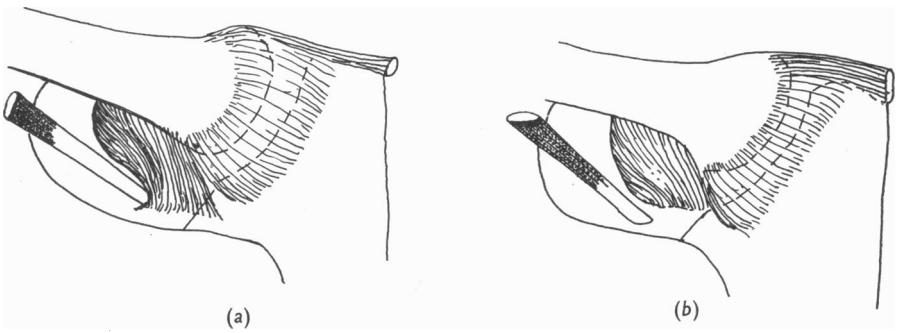

Fig. 2. ***Homo.*** **Costoclavicular ligament in relation to sternoclavicular capsule and subclavius tendon.** ***a*** **= the more usual arrangement;** ***b*** **= subclavius tendon anterior to the ligament.**

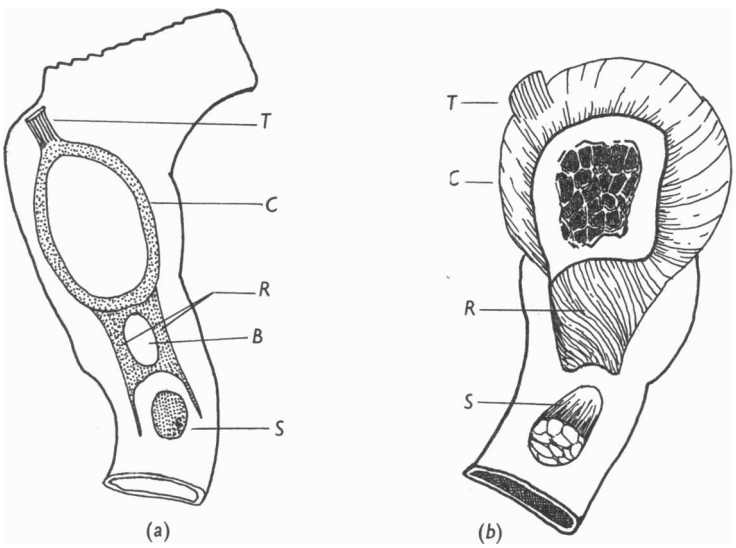

Fig. 3. ***Homo.*** **Mutual relationships of sternoclavicular capsule, costoclavicular ligament and subclavius tendon,** ***a*** **in diagrammatic superior view,** ***b*** **from the lateral aspect.**
B **= costoclavicular bursa;** ***C*** **= sternoclavicular capsule;** ***T*** **= interclavicular ligament;** ***R*** **= costoclavicular ligament;** ***S*** **= subclavius.**

ANATOMY OF COSTOCLAVICULAR LIGAMENT

The costoclavicular ligament is disposed as an inverted, truncated cone, flattened antero-posteriorly (Figs. 2, 3). It averages half an inch in length (or height), three-quarters of an inch in maximal (superior) width and half an inch in thickness. It is not a uniformly solid structure, but is cavitated by the 'bursa' described below. The

walls of this bursal cavity are the anterior and posterior laminae of ligamentous fibres, which are mutually continuous laterally so forming the lateral bursal wall; medially also the ligamentous laminae fuse and abut against the lateral aspect of the sternoclavicular capsular ligament, with which they are continuous. Inferiorly, the apex of this conical structure is attached to the first rib adjacent to the first costal cartilage and usually extends on to the cartilage itself. Superiorly, the ligament is attached to the margins of the oval receptive area on the clavicular 'neck', the fibres gaining insertion into such circumscribing lips or grooves as may there be present.

In the anterior lamina of the ligament most fibres pass upwards and outwards, the innermost ones being the more vertically disposed; the posterior laminar fibres pass upwards and inwards. The most lateral of the anterior fibres run upwards and backwards to blend with those of the posterior lamina, conferring upon the ligament a twisted appearance in norma lateralis. (Scant attention has been accorded this feature of the ligament: Morris (1907) noted indeed the 'appearance of decussation' and though Fick (1904) gave a detailed account of fibre directions he failed to observe the lateral continuity of the anterior and posterior laminae.)

Medially the ligament is closely applied to the lateral aspect of the sternoclavicular joint capsule, usually without any discernible free border or discontinuity (Fig. 3). In one only of thirty-five subjects dissected was the ligament bilaterally separated from the capsule by some loose fibro-fatty tissue. Fick (1904) stated that frequently the outermost portion of the synovial sac between the intra-articular disc and the clavicle is pinched off to form an independent mucous bursa, which then lies antero-medial to the costoclavicular ligament. No such bursa was observed however during the present investigation.

The 'bursa' of the costoclavicular ligament is invariably present, but its parietes and contents manifest some variation. Occasionally the cavity has a smooth, shining lining akin to synovial membrane and contains a quantity of thin viscid fluid. (This type of bursa would appear to be associated with a smooth, or even smooth and elevated, costoclavicular area on the clavicle.) More frequently, however, the bursal lining is shaggy and irregular, and the cavity is filled with minute lobules of fatty material interspersed with loose fibres and a little free fluid. On no occasion has the bursal cavity been found to communicate with that of the sternoclavicular joint, contrary to Poirier's (1899) finding and Wood Jones's (1949) statement.

RELATIONS OF COSTOCLAVICULAR LIGAMENT

The tendon of origin of m. subclavius lies immediately lateral to the inferior (or apical) attachment of the costoclavicular ligament (Fig. 3, *a*, *b*) and the tendon may indent the ligament's lateral aspect. Very commonly the sheath of m. subclavius gains attachment to the front and back of the ligament which thus forms the medial extremity of that sheath. In some 20 % of subjects the subclavius tendon is attached anterior to the costoclavicular ligament (Fig. 2*b*), and the two layers of the muscle sheath become lost in the loose connective tissue anterior to the ligament. Occasionally also the subclavius sheath is much thickened medially so that its differentiation from the ligament may be impracticable.

Fick (1904) quoted Henle as including in the anterior lamina of the costoclavicular ligament fibres which run anteriorly to the subclavius tendon in direct continuity with the subclavius fascia and as therefore regarding the subclavius tendon to be enveloped by the ligament. Since the conditions referred to by Henle do not invariably obtain, and as judgement herein must often be arbitrary, it would be better to regard the fibres in question as representing merely a thickening of the subclavius muscle sheath.

Whereas continuity of costoclavicular ligament and sternoclavicular capsule is the rule, continuity of the ligament with the subclavius tendon is never encountered, and the same holds good for the arrangement of the corresponding structures in non-human Primates. There is thus no anatomical justification for the view advanced by Bland Sutton (1897) that the costoclavicular ligament represents a degenerated portion of the m. subclavius.

FUNCTIONS OF COSTOCLAVICULAR LIGAMENT

Elevation of the pectoral girdle is limited by this ligament. During clavicular elevation the costoclavicular ligament becomes tense and then acts as a fulcrum, while a further limited gliding of the clavicular 'head' takes place in an inferolateral direction, a movement finally arrested by the postero-superior fibres of the sternoclavicular capsule.

Depression of the clavicular lateral extremity produces compression of the costoclavicular ligament between clavicle and first rib. (When apposed clavicular and costal apophyses exist, their actual contact is ensured by this movement and the bursa functions as the synovial component of a diarthrodial joint.) Again the costoclavicular ligament acts as a fulcrum and further depression of the shoulder region is limited by the interclavicular ligament and the intra-articular meniscus.

Protraction of the clavicular lateral extremity produces a limiting tension in the posterior laminar fibres of the costoclavicular ligament and in the anterior capsular fibres; retraction conversely produces a limiting tension of the anterior laminar fibres of the ligament and in the posterior capsular fibres; the axis of movement in each case is vertically through the clavicle between ligament and capsule. Clavicular rotation in the long axis is limited by the costoclavicular ligament—backward rotation of the clavicular 'head' by its anterior, and forward rotation by its posterior, fibres.

The costoclavicular ligament is the effective inferior ligament of the sternoclavicular joint (as appreciated by Henle, Poirier, Testut and Fick), and is capable of maintaining clavicular stability even after division of the joint capsule and its contained meniscus. As a whole it resists upward displacement of the clavicle 'head'; it likewise counters the upward pull of the clavicular head of m. sternomastoideus and the lateral pull of the clavicular portion of m. pectoralis major.

Johnston's (1909) statement that the costoclavicular ligament is 'always tense, even when the upper extremity is hanging by the side' is not confirmed by present observations, which discover the ligament, under such conditions, to be lax and frequently, indeed, to form a cushion between clavicle and first rib. Only at the end of a particular range of movement does the ligament become maximally tense. Johnston also stated that the costoclavicular ligament was responsible for clavicular

elevation being permitted by an upward rotation of the anterior surface of the bone; but observation on the above-mentioned special preparation showed that pure elevation can and does occur independently of any such rotation.

COMPARATIVE ANATOMY

The literature of comparative anatomy contains remarkably little concerning the costoclavicular ligament, syndesmology being generally the most neglected system in comparative studies of either particular forms or natural groups. This paucity of information applies notably to the Primates (*sensu lato*). The canonical zoological treatises afford no information, and special monographs disappointingly little.

Thus Dobson (1882–90) on the Insectivora in general, Le Gros Clark (1926) on *Ptilocercus lowii*, Woollard (1925) on *Tarsius spectrum*, Beattie (1927) on *Hapale jacchus*, Sonntag (1923, 1924) on *Pan satyrus* and *Pongo pygmaeus*, and Raven (1950) on *Gorilla gorilla* omit all reference to the costoclavicular ligament. Ayer (1948) notes its presence in *Semnopithecus entellus* and its continuity with the sternoclavicular joint capsule. Osman Hill (1953–57) states only that 'in some Platyrrhini (*Ateles*, according to Parsons) the chief synovial articulation is between clavicle and first rib, but usually the clavicle is connected to the first rib only by the accessory (rhomboid) ligament, which is well developed in *Tarsius* and monkeys, being connected also to the capsular ligament in the former'. He is silent regarding the costoclavicular ligament in Pithecoidea.

In view of such scantiness of available comparative information, the anatomy of the costoclavicular ligament was investigated in the non-Primate hedgehog (*Erinaceus europaeus*) and Egyptian fruit bat (*Rousettus aegypticus*), and in the following Primates: ringtailed lemur (*Lemur catta*), Bosman's potto (*Perodicticus potto*), thicktailed bushbaby (*Galago crassicaudatus*), slow loris (*Nycticebus coucang*), tarsier (*Tarsius spectrum*), marmoset (*Hapale jacchus*), squirrel monkey (*Saimiri sciurea*), weeper capuchin (*Cebus apella*), woolly monkey (*Lagothrix humboldtii*), red-handed tamarin (*Mystax midas*), howler (*Alouatta seniculus*), crabeating macaque (*Macaca irus*), mona monkey (*Cercopithecus mona*), patas monkey (*Erythrocebus patas*), black and white colobus (*Colobus polykomos*), silvery gibbon (*Hylobates lar leuciscus*), orang (*Pongo pygmaeus*) and chimpanzee (*Pan satyrus*). Two specimens each of tarsier, potto, marmoset, tarmarin and howler were dissected; the orang and chimpanzee were young animals; in all specimens the ligaments of the two sides were dissected.

In all these forms the costoclavicular ligament manifested a striking uniformity of conformation and was clearly nothing more than the functionally specialized inferior component of the sternoclavicular joint capsule. In the specimens of *Erinaceus*, *Galago*, *Loris*, *Tarsius* and *Saimiri* examined, the ligament (Fig. 4*a*, *b*) was in nowise specially distinguishable from that capsule: in *Rousettus*, where the capsule was notably thin, the costoclavicular ligament (Fig. 5*a*) was prominent and extremely well developed; in the other forms studied its anatomical entity was sufficiently apparent. In the gibbon, orang and chimpanzee specimens the ligament was particularly wide; in the *Perodicticus*, *Hapale* and *Alouatta* specimens (Fig. 6) it was bifascicular; in the *Macaca irus* specimen alone was it somewhat separated from the

sternoclavicular capsule by a forward herniation of the synovial lining thereof as a small intervening bursa; in *Saimiri* and in *Mystax* the cavity of the sternoclavicular joint and the bursa of the costoclavicular ligament were continuous and the costoclavicular ligament was thereby rendered partially bilaminar. Otherwise the attachments and relations of the costoclavicular ligament, in the forms examined, displayed an almost monotonous anatomical similarity.

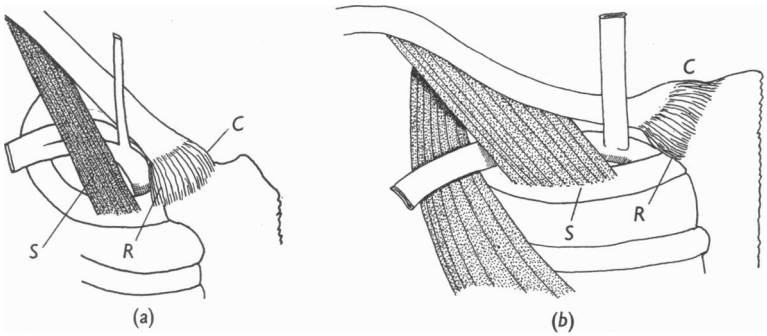

Fig. 4. Unemphatic type of costoclavicular ligament (the ligament being an undifferentiated portion of the sternoclavicular capsule) in (*a*) *Erinaceus europaeus*, (*b*) *Tarsius spectrum*. (Labelling as in preceding figure.)

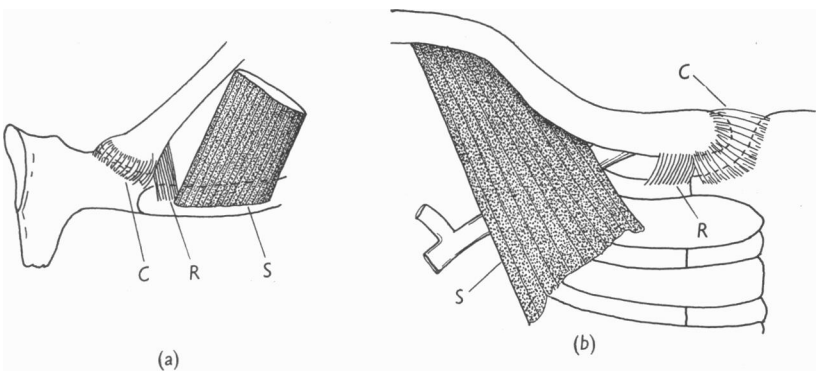

Fig. 5. Emphatic type of costoclavicular ligament, in (*a*) *Rousettus*, (*b*) *Hylobates*. (Labelling as in preceding figures.)

The complete morphological independence of the costoclavicular ligament from the m. subclavius was emphatically apparent in every specimen of every form examined. There was never evident the slightest sign (or even hint) of continuity between this ligament and the subclavius tendon. The ligament is demonstrably a derivative of the capsule of the sternoclavicular articulation and no valid anatomical basis exists for the Bland Sutton (1897) hypothesis which would derive the costoclavicular ligament by degeneration from the subclavius muscle.

The human costoclavicular ligament is distinguished by its relatively large size, its conical or cylindrical fibre-disposition, its bursal cavity and its attempted modification (occasionally successful) towards a diarthrodial joint.

Factors responsible for the development of an emphatic costoclavicular ligament

would appear to be: (*a*) wide range of clavicular movement, (*b*) the necessity for strengthening inferiorly the sternoclavicular articulation, (*c*) the habitual posture of the trunk.

In the Chiroptera and the higher Primates at least the forelimb is relieved of much of the mechanical burden of supporting the body weight and is endowed with an unusual range of independent movement for flight (Chiroptera) or prehension. Under such new physical conditions as the sternoclavicular joint must consequently

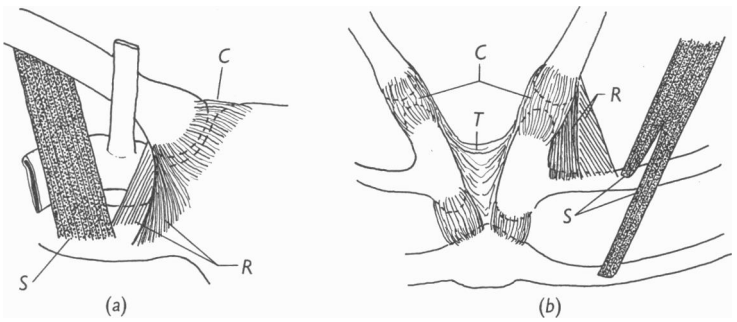

Fig. 6. Bifascicular type of costoclavicular ligament, in (*a*) *Hapale*, (*b*) *Alouatta*. (Labelling as in preceding figures.)

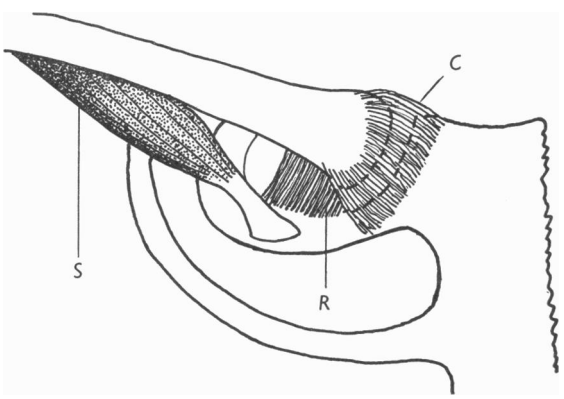

Fig. 7. Wide emphatic form of costoclavicular ligament in *Pongo*. (Labelling as in preceding figures.)

meet, the costoclavicular ligament acquires an enhanced development and importance as the necessary stabilizer of the fulcrum situate alongside the clavicular head, and becomes more readily recognizable as an anatomical entity.

Nevertheless, despite forelimb 'emancipation', in no subhuman Primate is the forelimb not employed, to some degree and on some occasions, as a supportive, rather than a prehensible, organ. (Probably the Gibbon alone dispenses habitually with forelimb body support.) And in no Primate save man is the trunk borne habitually erect and the forelimb completely relieved of all engagement in habitual stance or progress. Hence, in man, an ensuing qualitative difference in the mechanics of the sternoclavicular joint, the necessity for a particular inferior strengthening of

that joint and the appearance of the distinctively human costoclavicular ligament—an ancestral syndesmosis attempting functional modification in the direction of a diarthrodial joint.

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