

UNRECOGNIZED OCCUPATIONAL DESTRUCTION OF THE TENDON OF THE LONG HEAD OF THE BICEPS BRACHII *

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In 1915 I reported ¹ six instances of destruction of the tendon of the long head of the biceps. This destruction occurred between the region of the humeral tuberosities and the supraglenoid tubercle of the scapula. In five of these cases, the destruction of the tendon was complete and was accompanied by destructive changes in the capsule of the shoulder joint, on the acromion and the humeral tuberosities, in the glenoid cavity, on the head of the humerus, in the acromioclavicular joint, and even on the internal surface of the deltoid itself. In one case, the sixth, considerable portions of the articular capsule and the entire lesser tuberosity also were destroyed. Yet in this case, the tendon of the long head was only displaced anteriorly and downward, lying along the anterior margin of the glenoid cavity and then passing to the intertubercular sulcus, which it reached a centimeter distal to the tuberosities. None of these articulations contained any deposits or other evidences of the existence of recent effusion, and the whole picture suggested that the condition resulted from a low grade, long-standing process.

Since the destruction not only of the capsule and the tendon but even of the articular cartilage and also the changes in the adjacent bone were so extensive, it is evident that the process could not have been acute. No evidence of surgical intervention was present in any of these cases, hence the condition could not have been accompanied by much if any suppuration even in the acute stage of the process, if such there was:

It is regrettable that clinical histories of these cases were unobtainable, for they might have thrown light on the probable cause and the nature of these conditions, for similar findings were not found recorded in the literature up to that time, nor have I learned of similar cases since. Such cases apparently do not appear in clinics and dispensaries, for pathologists and orthopedic surgeons seem to be unfamiliar with them. Nor have I learned that similar cases have been observed in other anatomic laboratories, but if I have overlooked such

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1. Meyer, A. W.: Anatomical Specimens of Unusual Clinical Interest. (2) The Effect of Arthritis Deformans (?) on the Tendon of the Long Head of the Biceps, *Am. J. Orthop. Surg.* **13**:91 (July) 1915.

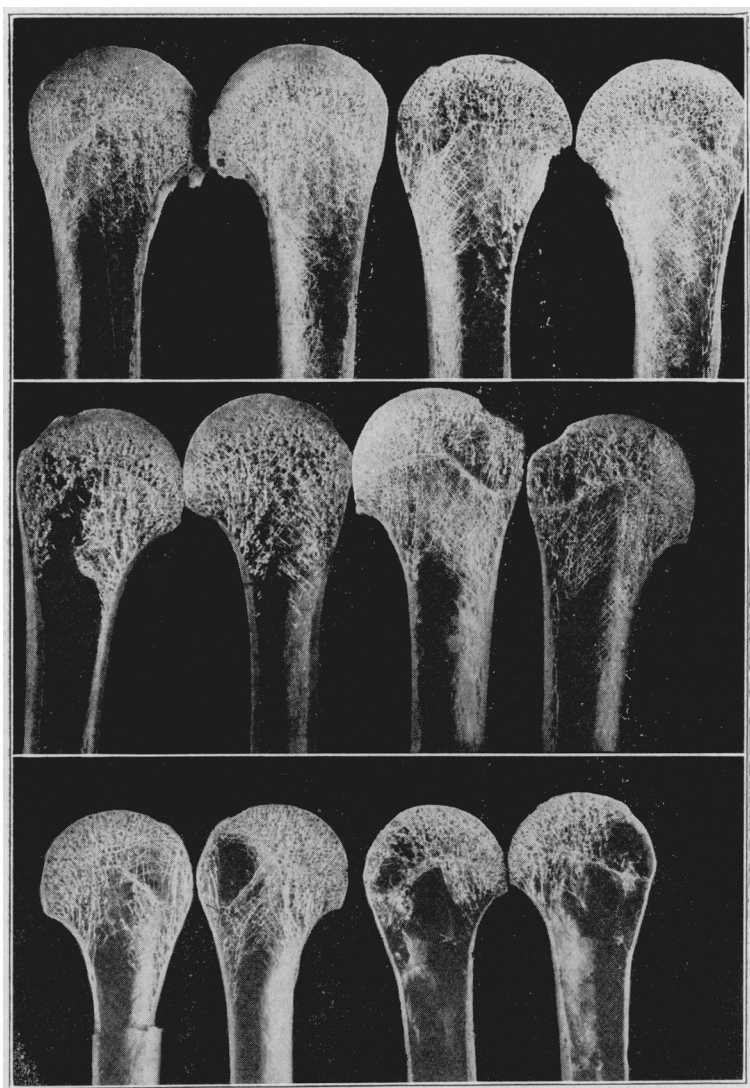


Fig. 1.—Humeri of the first six specimens, bisected longitudinally in a plane approximately parallel to the condylar articular surface.

a report I trust that my attention will be called to it. Since the condition is so surprising it seems strange that the specimens reported in 1915 have not arrested attention sufficiently to have resulted in direct confirmation from other sources, for I have observed seven additional cases since then. Since we have dissected only about sixty cadavers since that time, it is evident that this condition is rather common here. It is possible, though not very probable, that the condition is geographically limited; but one can hardly believe that the occurrence of these



Fig. 2.—Early stage in the destruction of the capsule in a right shoulder joint of a man. The defect in the thickened capsule lies directly above the lesser tuberosity.

cases could be confined to the city of San Francisco, from which we obtained all of our anatomic material. It is true that more arthritic conditions have come to my attention in a single year in our laboratory here, than I saw during four years in other laboratories in which far more dissections were performed; but they seem to fall in a rather different category.

The humerus of each of the six subjects forming the basis of my previous report has been cleaned and bisected longitudinally to permit of inspection of the spongiosa, particularly in the head of the bone.

Although both the humeral tuberosities and the cartilage were partially or wholly destroyed in all these specimens, and although polishing was present somewhere on the head of most of them, the spongiosa contained no gross evidences that there had been suppurative foci previously. This is apparent in Figure 1. Although considerable bone destruction and often also deposition had occurred in the region of the tuberosities of some of these humeri, the underlying spongiosa, nevertheless, was normal. It is true that a large open space is present in the spongiosa under the region of the greater tuberosity in the last two humeri; but as I have previously reported,² such not rarely is the case in normal bones. These free spaces in the spongiosa are apparently due to absorption, usually the result of advancing years. Both of the humeri showing these absorption areas came from senile cadavers, and since the adjacent spongiosa looks entirely normal, and since extremely fine trabeculae bridge the margins of these open spaces, it seems very unlikely to me that one could rightly regard them as old abscess cavities from which an infectious process spread to the joints. This conclusion does not, to be sure, wholly exclude the medulla of these bones as a possible source of infection, if such it was, for many of the cancelli are so large that an infectious process, which did not result in destruction of the spongiosa, perhaps could be located there and spread to adjacent extra-articular structures through the numerous vascular canals in the head of the bone. That, however, seems unlikely, although I am not very competent to judge regarding this matter.

Before considering the possible significance of the findings in the seven cases reported herewith, it will be well to examine them somewhat in detail.

DESCRIPTION OF SPECIMENS

SPECIMEN 7.—The earliest stage in the process of destruction of the articular capsule, of the tendon of the long head of the biceps and of the cartilage on portions of the glenoid cavity of the scapula and on the head of the humerus, which I have observed, is represented, in part, in Figure 2. This view represents the lateral surface of the shoulder joint of the right extremity of a male subject and shows the upper end of the humerus and the upper surface of the scapula in outline merely. The border of the opened subdeltoid bursa is represented immediately above the greater tuberosity, and a defect in the thickened articular capsule is shown in natural size directly in front of the acromion. A portion of the articular cartilage on the humeral head is exposed through this defect and very slight bony changes are visible in this portion of the humeral neck.

The biceps is very well developed and the tendon of the long head perfectly preserved up to the region of the tuberosity. It is entirely free throughout the

2. Meyer, A. W.: The Architecture of the Proximal Extremity of the Humerus, *Anat. Record* **12**:60, 1917.

articulation, and tension on it resulted in movement of the scapula. The superior portion of the capsule of this shoulder joint is from 3.5 to 4 mm, thick and densely fibrous. When the capsule was opened along its inferior border, the cartilage on the head of the humerus and that in the glenoid cavity appeared to be entirely normal. The cartilaginous surface is smooth and glistening and without even a small defect or any evidence of erosion. However, the soft tissues on the inferior surface of the acromion are worn into shreds, apparently from contact with the tuberosities in a position of hyperabduction. The capsular portion of the tendon of the biceps is greatly flattened and shredded, especially on one side, the edges being worn into a fringe for a distance of approximately 4 cm. (Fig. 3).

SPECIMEN 8.—The humeroscapular articulation of the left arm of this female is quite normal. The cartilage is preserved over the whole head of the humerus and also in the glenoid cavity and apparently is of normal thickness. The lesser tuberosity is unaffected, but the greater shows some absorption, roughening, and also some deposition of new bone, especially in the region of the intertubercular sulcus. The capsule is deficient and frayed in its superior portion, and the tendon of the long head of the biceps, which is fused with it,

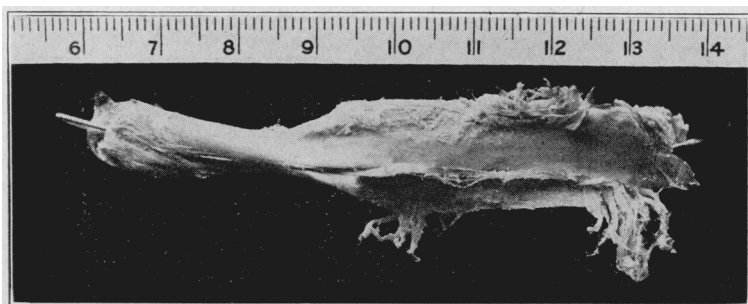


Fig. 3.—Frayed and shredded tendon from Subject 7. The cut scapular end is to the right, and the narrowest part is the intertubercular portion.

is frayed especially along the posterior margin in the region of the tuberosities where it is reached by some remaining strands, only about one fourth the caliber of the normal tendon. The capsule seems thickened in the region of the supraspinatus and the tendon of the latter is firmly fused with it. The fibrous tissue and the periosteum underneath the tip of the acromion are frayed and entirely worn off over small areas on the under surface of the bone. The acromioclavicular joint seems normal, and the same thing applies to the elbow and wrist joints, except that slight erosion of the cartilage is present over a small area of the capitellum.

Since the tendon of the long head of the biceps shows almost complete destruction in this case, and since it also is adherent to the capsule up to the region of the tuberosities, and also because defects are present in the capsule itself and slight bony changes are present on the acromion and tuberosities, one would seem to be justified in concluding that this arm exemplifies a later stage in the process of destruction of the tendon of the long head of the biceps. In fact, this and the previous case are the only ones in which the tendon had not already been anchored in the region of the tuberosities. In the latter region the destruction of the tendon in this case was less evident, while in the former it was almost complete.

SPECIMEN 9.—In this specimen, the left arm of a male, also with splendid muscular development, the tendon of the long head already is anchored to the shaft of the humerus somewhat distal to the tuberosity. The articular capsule is entirely intact except in the region of the lesser tuberosity where it is thin and deficient. The subdeltoid bursa is extensive, and its wall is fused directly with the capsule at the periphery of the deficiency just mentioned. A diverticulum of this bursa extends beneath, and 4 cm. along, the tendon of the short head of the biceps and the coracobrachialis, and also downward for a distance of 3 cm., lying superficial to the tendon of the subscapularis. It is one of the most extensive subdeltoid bursae I have ever seen, and its cavity communicates directly with a humeroscapular articulation in the region of the deficiency above noted.

Considerable destruction of bone is present in the region of the lesser tuberosity over an area of about 7 sq. cm. Deposition of new bone also has occurred, for this atrophic area is studded with half a dozen bony tubercles from 3 to 6 mm. in diameter and 3 to 4 mm. in height. The superior portion of the capsule, containing the tendon of the supraspinatus, is thickened, and the broad attachment of the latter is displaced downward somewhat. A small closed bursa is located within the thickened capsule itself in the region of fusion of the tendon of the infraspinatus. The cartilage of the humerus is well preserved and appears quite normal, but numerous villi, many of which seem frayed, are located on the under surface of the capsule near its attachment to the superior border of the glenoid cavity. The articular capsule is thickened and fenestrated in its anterior portion near its attachment to the shaft of the humerus directly below the lesser tuberosity. The attachment of the tendon of the long head of the biceps directly distal to the tuberosities is very firm and no remnant of the intra-articular portion could be identified with the unaided eye in cross-sections of the capsule. The cubital, carpal, and the more distal articulations are normal, but the acromioclavicular articulation showed marked bony changes. Both the acromial and clavicular articular surfaces are decidedly roughened and eroded and the cartilage completely destroyed, although the polishing of the acromion is relatively slight.

SPECIMEN 10.—A stage similar to that reported in the preceding specimen is found in the right arm of the same male cadaver, in which all other articulations appear to be normal. In this case also the tendon of the long head of the biceps has secured a firm attachment directly distal to the lesser tuberosity. This attachment is quite comparable to that in the preceding case, and the defects in the capsule also are similar, although somewhat more extensive. The subdeltoid bursa is not so large but the deficiency in the capsule corresponds to more than the anterosuperior half of the head of the humerus. The borders of the capsular defect are thickened, and the dorsal portion receives the displaced tendon of the supraspinatus which has fused firmly with the tendon of the infraspinatus, maintaining however, an attachment to the greater tuberosity although displaced somewhat dorsally. The inferior surface of the acromion shows considerable superficial erosion, which is limited, however, to fraying of the soft tissues. A group of synovial villi is present in the subacromial portion of the subdeltoid bursa, and similar villi also are present on the paraglenoid portion of the articular capsule. The other articulations appear entirely normal and the bony changes seem to be limited to the region of the lesser tuberosity and the intertubercular sulcus. The long head of the biceps is surrounded by the nonadherent synovial sheath for a distance of 5 cm. distal to the tuberosities. This maintains its connection with the joint cavity.

SPECIMEN 11.—This is the left arm of a male subject in which the tendon of the long head of the biceps again is attached immediately distal to the lesser tuberosity as shown in Figure 5. The capsule is deficient in its whole superior extent, its thickened, retracted, dorsal borders containing what seems to be a remnant of the intertubercular portion of the tendon of the long head of the



Fig. 4.—Left arm of a male subject from the front, showing the secondary attachment of the tendon of the long head, the retracted capsule with the tendon of the subscapularis and complete destruction of the superior portion of the capsule. The unusual length of the tendon of the long bicipital head may be noted.

biceps. The thickened portion of the joint capsule is markedly frayed in the region of the greater tuberosity, which is eroded and polished over an area of about 4 sq. cm. As shown in Figure 5, the retracted, thickened anterior portion

of the capsule containing the tendon of the subscapularis has been displaced downward below the level of the head of the humerus. The greater portion of the lesser tuberosity has been destroyed, it being represented by a roughened area to the anterior inferior margin of which the tendon of the subscapularis finds its attachment. The cartilage on the midportion of the humeral head is roughened and almost wholly eroded, but no equivalent area is seen in the glenoid cavity. However, the cartilage is completely eroded near the posterior superior margin of the glenoid cavity and here the underlying bone is polished. This narrow eroded area also extends along the anterior border of the glenoid cavity,

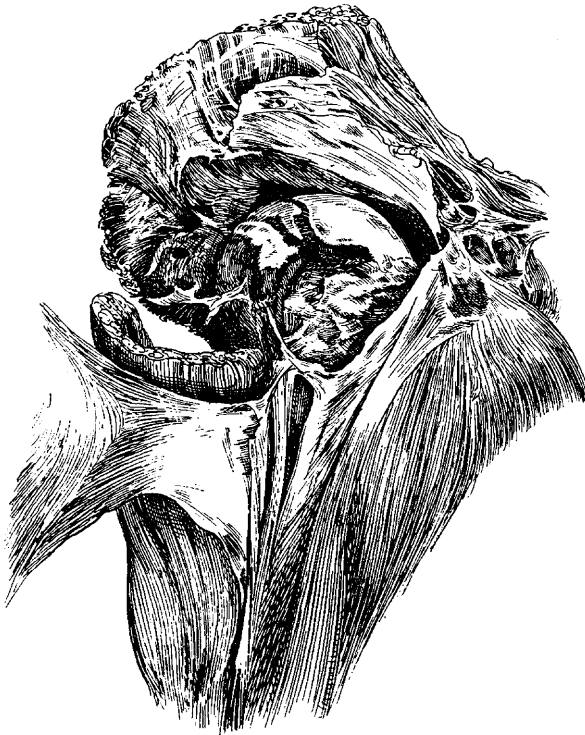


Fig. 5.—Right shoulder joint with the deltoid cut and reflected, showing the point of secondary attachment of the tendon of the long head, the partly occluded intertubercular sulcus and a third head of the biceps obtaining attachment to the tendon of the pectoralis major. Two-thirds natural size.

and inspection of the entire articulation shows that it was contact with this margin that caused the erosion of the cartilage at the most prominent portion of the humeral head. The under surface of the acromion is worn and polished over almost its entire extent, apparently in consequence of contact with a similar, although smaller, area on the greater tuberosity, during a position of extreme abduction. The rest of the joints are normal.

SPECIMEN 12.—A more advanced stage is illustrated by the right arm of a similar subject, a portion of which is represented in Figure 5. As will be noticed, the deltoid has been reflected, and the entire joint cavity has been

laid open. The tendon of the long head of the biceps is attached directly distal to the lesser tuberosity and a third head gains insertion into the tendon of the pectoralis major. The greater tuberosity is considerably eroded and decidedly polished. The under surface of the deltoid is frayed near its acromial attachment as a result of contact with the greater tuberosity. The under surface of the acromion is worn and polished so as to fit exactly a similar area on the greater tuberosity when the arm is placed in a position of hyperabduction and outward rotation. The acromioclavicular ligament and the inferior surface of the capsule of the acromioclavicular joint are entirely destroyed and small areas of the exposed articular surfaces are polished from contact with the head of the humerus and with each other. The capsule of the shoulder joint is destroyed almost completely, only the thickened margin remaining along the anterior border between the region of the coracoid and the acromion. Except for the margin in the region of the tuberosity, the cartilage is present over the entire humeral head and appears quite normal in depth, thickness, and consistency, both over the head of the humerus and in the glenoid cavity.

SPECIMEN 13.—This is represented by the right arm of a male subject and illustrates a still more advanced stage of this condition. As shown in Figure 6, the cartilage over the head of the humerus is very largely eroded; large polished areas are present, and the tuberosities are almost wholly destroyed. The under surface of the acromion again is worn and polished and calcific deposits are present in various portions of the capsule and in the coraco-acromial ligaments. In this case, too, the deltoid acted as the capsule of the joint, and the acromioclavicular joint was laid open in consequence of wear from contact with the greater tuberosity. Almost the entire margin of the glenoid cavity is eroded, but cartilage is present over the rest of the surface. A remnant of the missing tendon of the long head of the biceps possibly may be detected still in the thickened retracted portion of the capsule which hoods the upper half of the glenoid cavity. This remnant of the capsule is interposed between the glenoid cavity and the head of the humerus, which had been elevated against the acromion.

COMMENT

That the disappearance of the tendon in these cases is not due to disuse is fully established by an examination of the same tendons in a case of congenital hydrocephalus in a woman more than 40 years of age. This woman had been partly paralyzed from birth, and although fibrous ankylosis had supervened in the right humeroscapular articulation, thus practically immobilizing this joint, and although the tendon of the biceps was atrophic, it nevertheless could be traced in its entirety although adherent to the joint capsule. It is interesting that it was more difficult to trace this tendon in the left than in the right shoulder joint of this body, although fibrous ankylosis was absent in the latter in which complete erosion of the articular cartilages had taken place and the whole interior surface of the dorsal and inferior portions of the capsule were covered by numerous long and large synovial villi. Except for the complete erosion of the articular cartilages in this joint and the excellent polishing present over the whole of the articular

surfaces, the entire picture was totally different in these two joints from that in those with destruction of the long head of the biceps.

Although erosion, polishing, some eburnation and small exostoses are commonly present in cases of arthritis, these are not the most prominent conditions in the specimens here reported. Next to destruction of the tendon of the long head of the biceps with secondary attachment of the tendon stump distal to the lesser tuberosities, nothing strikes



Fig. 6.—Lateral view of right shoulder joint of a male. This shows the most advanced stage of destruction. The deltoid acted as capsule to the joint.

one's attention so forcibly as its total destruction by friction. That friction is very largely if not wholly responsible is indicated by the fraying and fringing of the other soft parts and also by fraying and shredding of the tendon itself. It is surprising and extremely significant that destruction of the tendon can reach a considerable degree in a shoulder joint with cartilages wholly intact and with but a small capsular defect, at a time when the tendon is almost wholly free from adhesion to the capsule.

The first defects in the capsule occur in the region of the tuberosities, and erosion of its external surface often is present in this region alone, although corresponding wear is evident in the soft parts on the inferior surface of the acromion. Since the eroded and polished areas always fit exactly when placed in contact, one cannot doubt that the erosion occurs in a position of marked abduction and external rotation of the arm. This also is the only position in which the under surface of the deltoid in the region of the acromion could become frayed from contact with the greater humeral tuberosity. That the capsular defects always are more pronounced in the region of the latter, even when not wholly confined to it, and that they seem to begin here may be due to folding of the capsule and friction from contact of the greater tuberosity with the acromion, in a position of marked abduction and external rotation of the arm.

Whatever the associated conditions may be, it would seem that these capsular defects result from repeated and long-continued use of the arm in a position of marked abduction and external rotation. This is indicated especially by the antecedent fraying of the soft tissues on the under surface of the acromion with accompanying abrasion in the region of the tuberosities. It would also seem that the irritation and trauma resulting from this friction might bring on a subdeltoid bursitis antecedent to the destruction of this bursa. This unavoidable trauma to the soft parts undoubtedly would also be followed by a protective reaction in the superior portion of the capsule and thus cause thickening of it. However, as soon as the capsule has been worn through near the region of the greater tuberosity, the rough surface of the latter can come in contact with the capsular portion of the tendon of the long head of the biceps and begin its erosion and final destruction.

Although the supposed course of events is merely an inference from the findings in these cases, it quite satisfactorily accounts for all the changes observed, profound though they are. It also accounts for the fact that the pathologic picture in these cases is not wholly comparable to that usually presented in arthritis. The new bone formation, present to some extent in most of these cases, in the region of the tuberosities and in the intertubercular sulcus, may be merely the result of traumatic irritation of the periosteum. Likewise the inflammatory reaction evoked here and in the adjacent soft parts may be responsible for the invariable anchoring of the divided tendon in the region directly distal to the lesser tuberosity.

When the extracapsular lengths of the remaining tendons in cases in which the intracapsular portion was absent were compared with normal tendons, the greater length of the former was very evident. This is noticeable in Figure 4. This increase in length of the tendon between

the muscular portion of the long head and its attachment to the lesser tuberosity may be due in part to atrophy of the muscular belly, but I do not think that this is an important factor. It would seem more probable that the increased length of the extracapsular portion of the tendon is due to retraction in consequence of division near its scapular insertion. However, since this portion of the destroyed tendon not always is longer than the corresponding portion of the normal tendon, it would seem that the tendon sometimes gains attachment in the region of the tuberosity before it is divided, thus limiting the extent of the retraction. This attachment well may result from trauma of the soft parts in this region in consequence of contact with the acromion.

I have not, to be sure, overlooked the possibility of cases of partial congenital absence of the tendon of the long head. Although I have

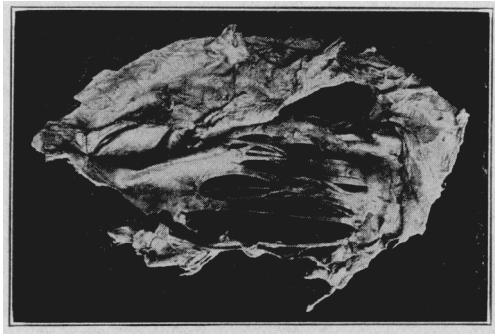


Fig. 7.—The thickened, trabeculated interbursal septum from the patellar bursae.

seen but two such cases, they gave me a totally different impression, and I think they may be easily excluded.

The uniformity and the very apparent significance of these findings led me to consider the possibility of an occupational cause, although at first the destruction seemed too extensive to permit of such an assumption. It always had seemed to me that whatever the process responsible for this extensive destruction of the bursa, capsule, tendon and cartilage, it was extra-articular rather than intra-articular. It was because of this fact that I placed an interrogation point in the title of my previous report. The condition did not seem to be primarily arthritic.

It seems possible that long-continued use of the upper extremity in such a posture might easily result in a subdeltoid bursitis, an extension of which to the articulation itself after the production of friction defects in the capsule, easily might complicate the picture; but the arthritic changes always seemed to be of secondary importance. The entire

absence of any evidence of pathologic changes in the spongiosa of the humeri in the first six cases also encouraged me to continue to look for an extra-articular cause. Since the soft tissues on the under surface of the acromion were frayed in many of the cases in which the region of the greater tuberosity also showed slight wear although the capsule and the tendon were wholly preserved, it seemed quite evident that the destructive agent must be friction from contact of the greater tuberosity with the acromion. This was illustrated very well by cases in which this friction had resulted only in slight fraying of the surfaces of contact—the greater tuberosity and the acromion—all else being normal.

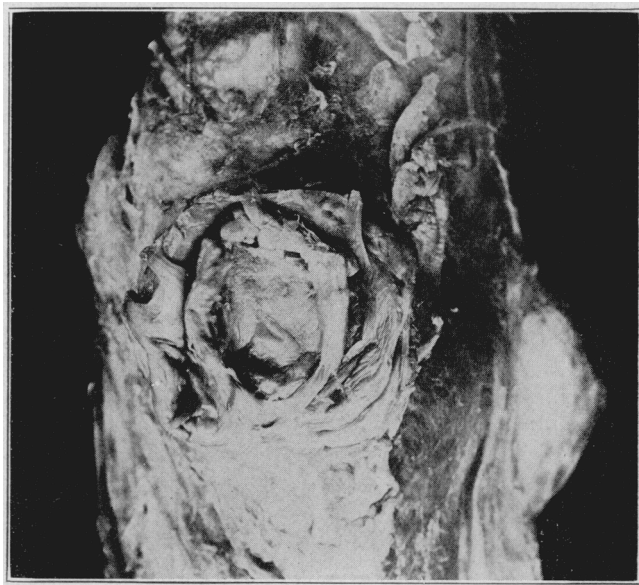


Fig. 8.—Subcutaneous and subfascial bursae in the region of the right olecranon, the eroded surface of which forms the base of the deeper bursa. The thickened, cut, reflected trabeculae, especially on the internal surface of the left wall of the superficial bursa, may be noted.

It is somewhat surprising, to be sure, that the thirteen specimens at hand were divided almost equally between right and left arms, for an occupational condition affecting the arms might be expected to affect them approximately in the ratio of right and left handedness. This would cease to be true, however, in all occupations in which no particular skill in the use of the arm is involved, so that the worker could turn from one to the other arm with almost equal facility. Both tendons were destroyed in only one person, and since the arms of two females are included it would seem that several occupations are involved.

I regret exceedingly that it is not possible to verify my explanation from the histories of these cases; but the facts are so unequivocal that I no longer can doubt that the cause of this destruction really is an occupational one.

One might perhaps expect that repair of the tendon would occur or even that such constant use of the arm might result in its hypertrophy. It must be remembered, however, that the posture in which the arm is placed in these movements is rather an abnormal one and that the tendon itself is not subjected to unusual strains but to direct friction from contact with a rather roughened surface which is wholly avoided in the more usual movements of the arm. In a position of extreme abduction and outward rotation, neither tendon nor capsule nor bursa could be expected to show much resistance. Moreover, it is not at all unlikely that tendons have very little regenerative power. This probably would be true especially of such tendons as that of the long head of the biceps which undoubtedly has a relatively poor blood supply. Since none of the twelve shoulders in which the tendon had been destroyed completely contained abrasion products, these apparently are absorbed. I am at a loss to know what the digestive agent is; but the problem is no greater than in cases of abrasion products in connection with erosion of the articular cartilages.

The destruction of the subdeltoid bursa and the joint capsule in these cases reminds one strongly of cases of "housemaid's knee" and "miner's elbow," in which the dense fascial wall between the subcutaneous and subfascial bursae not rarely are shredded from wear, as represented in Figure 6, a photograph of the intervening septum from the patellar region. This septum often is thickened decidedly as well as completely fenestrated, or even trabeculated, and it does not seem improbable that it might ultimately be destroyed completely.

There usually is only one subcutaneous bursa in the region of the olecranon. Rarely, however, two bursae, a superficial and a deep, are located here, wholly comparable to those usually present in the patellar region. The wall of the superficial bursa over the olecranon invariably is thickened when a subfascial bursa is present. This is particularly true of the interbursal septum since the deep fascia over the olecranon is relatively thin. It is evident that long continued use apparently results in extraordinary thickening of it, for it not rarely is 3 mm. thick. In two instances recently observed, these thick interbursal septums, which very evidently must have developed from the deep fascia in response to use, had become fenestrated and were densely fibrous, almost cartilaginous in character. Trabeculae of dense connective tissue also were contained on the inner surface of the bursal walls and in both these cases the olecranon was devoid of periosteum over its

most prominent portion, hence a part of the base of the deeper bursa was formed by bare bone. The size of these bursae alone indicates that there must have been considerable irritation and effusion; but it seems rather surprising that overuse, which results in thickening of the walls, the formation of a deeper bursa and greater thickening of the interbursal septum, also may result in destruction of the septum of the periosteum and erosion of the underlying bone. In both these cases fenestrae and trabeculae were found in the thickened wall between the two bursae, and the condition here was entirely comparable to what one not infrequently finds in the patellar region.