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Coracoacromial arch decompression in rotator cuff surgery

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Abstract In rotator cuff surgery it is important to obtain adequate decompression of the coracoacromial arch. However, it is difficult to localize the impingement site preoperatively. Based on histological and morphological studies and the clinical findings in 45 patients and 15 cadavers, we have tried to determine the impingement site. In addition, as a part of these investigations, we assessed the clinical outcome for 100 patients. Soft tissue decompression was indicated in 12 shoulders, anterior acromioplasty in 67 and anterior acromioplasty with coracoplasty in 21. According to Neer's criteria there were 92 satisfactory and 8 unsatisfactory results. The mean postoperative UCLA score was 33.4 points and the results were rated excellent in 78, good in 18 and fair in 4.

Résumé Dans la chirurgie de la coiffe des rotateurs, il est important d'obtenir une décompression adéquate sous-acromiale, mais il est difficile de localiser la zone de conflit avant l'opération. A partir d'études histologiques, morphologiques et des conclusions cliniques chez 45 malades et 15 cadavres, nous avons essayé de déterminer l'emplacement du conflit. De plus, nous avons évalué le résultat clinique de 100 cas. La décompression des parties molles était indiquée dans 12 épaules, l'acromioplastie antérieure dans 67 et l'acromioplastie antérieure avec coracoplastie dans 21 cas. D'après les critères de NEER, il y avait 92 résultats satisfaisants et 8 médiocres. Le score UCLA moyen postopératoire était à 33,4 points avec 78 résultats jugés excellents, 18 jugés bons, et 4 médiocres.

Introduction

Acromionectomy or lateral acromionectomy with repair of the rotator cuff has been advocated for patients with a rotator cuff tear since the middle of the twentieth century [1,7,11,18]. However, the clinical results of these procedures have been disappointing due to weakness of the deltoid muscle and displacement of the deltoid attachments [16]. In 1972 Neer [14] proposed a new procedure for coracoacromial decompression and called this anterior acromioplasty. Furthermore, in 1983 he described the indications for anterior acromioplasty with soft tissue decompression for patients suffering from the subacromial impingement syndrome [15]. Although interpretation of the previous clinical results of anterior acromioplasty is difficult owing to the heterogeneous patient groups and varying methods of assessment, there was an approximate failure rate of 20% whether the approach was by open operation or performed arthroscopically [8,10].

If the impingement site in patients with a rotator cuff tear is obvious before operation, an appropriate and minimal decompression should, in theory, be possible. This should obtain good results and also preserve stability of the gleno-humeral joint. On the other hand, repetitive mechanical compression forces induce hypertrophy of osseous trabeculum at the impingement site and hypertrophy of the fibrous cartilage layer at the ligament bone junction. The impingement site on the coracoacromial arch in patients with a rotator cuff tear should be assessed preoperatively from clinical findings and morphology.

The purpose of this study was to analyze the location of the impingement site in patients with a rotator cuff tear by clarifying the correlation between histological findings, a morphological analysis of the coracoacromial arch and the clinical findings. We also assessed the outcome in a series of patients treated by decompression based on the results of these investigations.

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Materials and methods

Preliminary study

Sixty anatomical specimens consisting of the anterior portion of the acromion, the coracoacromial ligament and the coracoid were obtained en bloc from 15 cadavers and from 45 patients at the time of surgery. Three patients had undergone arthrodesis of the shoulder, and 42 had been operated on for a rotator cuff lesion. The cadaveric specimens were included in order to obtain a normal baseline for comparison with the histological examinations of the rotator cuff. The operative specimens were fixed in 10% formalin, embedded in paraffin, sliced along the line of the coracoacromial ligament fibers, stained with toluidine-blue and examined by optical microscopy. In the normal histology of the coracoacromial arch the coracoacromial ligament attachment to the acromion and to the coracoid consists of 5 layers: synovium, collagen fiber, non-mineralized fibrous cartilage, mineralized fibrous cartilage and bone (Fig. 1).

All cases with a rotator cuff tear revealed degenerative pathological changes on the undersurface of the acromion and/or the attachment of the coracoacromial ligament to the acromion. The insertion of the coracoacromial ligament to the acromion revealed disruption and hypertrophic changes of the fibrous cartilage (Fig. 2). Similar changes were found on the coracoid process (Fig. 3). According to the direction of the hypertrophic changes of the fibrous cartilage, the histological changes were classified into 3 types: Type A, regular and along the coracoacromial ligament fibers and seemed to have resulted from impingement at the coracoacromial ligament; Type B, irregular and not along the coracoacromial ligament fibers, appearing to impinge directly at the acromion or the coracoid; Type C, a combination of Type A and Type B.

The morphology of the coracoacromial arch was studied from X-ray films (supraspinatus outlet view). The acromion was classified as being flat, curved or hooked, and further classified into short, middle and long types, based upon the position of the antero-inferior tip of the acromion (Fig. 4).

Table 1 shows the distribution of histological changes in relation to the morphology.

No correlation was found between age at the time of surgery and the histological type. All patients having Neer's and Hawkins' impingement sign revealed histopathological changes at the acromion. All cases with a positive horizontal adduction test revealed pathological changes of the coracoid process. All flat type acromions with abnormal histology at the undersurface revealed Type A changes, as did all short type acromions.

Fig. 1 Normal histology of the acromion undersurface and the coracoacromial ligament attachment, consisting of 5 layers: synovium, collagen fiber, non-mineralized fibrous cartilage, mineralized fibrous cartilage and bone

Table 1 Correlation among histological findings and acromial and coracoacromial morphology in 15 cadavers and in 45 patients undergoing shoulder surgery

Histological type	Acromion				Coracoid			
	A	B	C	Normal	A	B	C	Normal
<i>n</i>	17	8	24	11	5	7	11	37
Acromial morphology								
Flat	5	0	0	2	3	0	0	4
Curved	10	2	9	8	1	3	4	21
Hooked	2	6	15	1	1	4	7	12
Coraco-acromial morphology								
Short	5	0	0	4	3	0	0	6
Middle	12	2	17	5	1	2	6	27
Long	0	6	7	2	1	5	5	4

Fig. 2a, b Pathological changes of the acromion undersurface. The insertion of the coracoacromial ligament into the acromion was disrupted and there are hypertrophic changes of the fibrous cartilage. In Type A the fibrous cartilage is hypertrophied regularly along the coracoacromial ligament fibers (a). In Type B the fibrous cartilage layer is irregular and is not seen along the coracoacromial ligament fibers (b). Fissuring of the fibrous cartilage layer, defect of the synovial layer and collagen fiber layer and eburnation can also be seen

Fig. 3 *Pathological changes of the coracoid.* We found 3 types of pathological changes of the coracoid process similar to the pathological changes of the acromion

Fig. 4a-c Coracoacromial morphology was classified in three types from the position of antero-inferior tip of acromion in the coracoacromial arch: short acromion Type A, middle acromion Type B and long acromion Type C. The antero-inferior tip of acromion of short acromion type was apparently more posterior than the bisector of a line connecting the posterior tip of the acromion and the antero inferior tip of the coracoid. Conversely, that of the long acromion type was apparently more anterior to the bisector of this line

Based on these findings we established indications for decompression of the coracoacromial arch, as shown in Table 2. Table 2 shows the indications, based on the above findings, which we established for decompression of the coracoacromial arch. Coracoacromial ligament resection with subacromial bursectomy (soft tissue decompression) is indicated in patients with a flat type acro-

mion and a short acromial coracoacromial arch. The other types of cases require anterior acromioplasty [14]. If a lesion of the acromial undersurface is not seen at operation or by bursoscopy, then only coraco-acromial ligament resection is required. The addition of a coracoplasty [5] is indicated if the horizontal adduction test is positive. However, if there is narrowing of the coraco-humeral space a coracoplasty should also be performed. If a bone spur of the distal clavicle is present then this or the distal end of the clavicle should be excised [13].

Between 1995 and 1997, 100 shoulders in 96 patients (70 men and 26 women) with rotator cuff tear were operated upon. Their average age was 54.8 years (range: 17–84 years). The rotator cuff tear was partial in 25 shoulders, massive in 31 and ‘other’ in 44. Surgical repair of the rotator cuff was achieved in 96 shoulders. The coracoacromial arch was decompressed in all the patients; by soft tissue decompression in 12 shoulders, anterior acromioplasty

Table 2 Indications for coracoacromial arch decompression methods according to histological studies

I	Coracoacromial ligament resection with subacromial bursectomy (soft tissue decompression) if: Flat typed acromion Short acromial coracoacromial arch An apparent lesion of the acromion undersurface is not seen intraoperatively (excluding bursoscopic)
II	Anterior acromioplasty if: Curved and hooked typed acromion Middle and long acromion type of coracoacromial morphology
III	Coracoplasty if: Positive horizontal adduction test There is narrowing of coracohumeral space intraoperatively
IV	Resection of the bony spur or distal clavicle, if: A bony spur of the distal clavicle is observed

in 67, and by anterior acromioplasty with coracoplasty in 21. A resection arthroplasty of the acromioclavicular joint was also performed in 6 cases.

Arthroscopy of the shoulder joint and bursoscopy of the subacromial bursa are performed in the 'beach chair' position before surgery. Any synovial or labral lesions are dealt with by synovectomy, debridement of a fraying labrum or re-attachment of a detached labrum. In bursoscopy, any abnormal findings of the acromion undersurface (e.g. synovium defect, fibrillation of coracoacromial ligament or eburnation) suggest that the impingement has occurred at this site. An antero-posterior incision and deltoid-splitting approach are used to excise the coracoacromial ligament and to perform an anterior acromioplasty as described by Neer [13] and is followed by a rotator cuff repair. Coracoplasty is performed through a delto-pectoral approach. The lateral part of the coracoid is removed to allow good clearance of the coracohumeral space. The detached conjoint tendon is re-attached to the remaining coracoid. The rotator cuff repair is performed following McLaughlin's method [11].

Postoperatively, the arm is placed in an abducted position for 4–6 weeks. Passive exercise of the shoulder joint is performed after a few days, and a continuous passive motion machine with the shoulder at 90° of abduction is usually used. Active exercise in water is started 3–4 weeks after surgery. Resistance exercise starts progressively from 8 weeks after operation.

All patients were assessed by the clinical protocols of Neer [14] and the (University of California, Los Angeles) UCLA's rating for pain and function of the shoulder [3]. According to this rating system a score of 34 or 35 points was rated as excellent, 29–33 as good, 21–27 as fair, and 20 or less as poor. The follow-up period averaged 36.2 months (range: 24–44 months).

Results

Preoperative symptoms decreased in all cases. Following Neer's criteria there were 92 satisfactory and 8 unsatisfactory results. Five of these 8 complained of lack of strength and 3 had persistent pain at the anterior aspect of the shoulder. The mean UCLA score improved from 13.4 points (range: 6–24) to 33.4 points (range: 24–35). Results were rated excellent in 78 shoulders, good in 18 and fair in 4. The range of motion after surgery was 151° of elevation (range: 100–180°), 47° of external rotation (range: 10–70°) and internal rotation to the second lum-

bar spinous process (range: first sacral spinous process to ninth thoracic spinous process). All patients treated with soft tissue decompression were in the group rated 'excellent'. Three patients in the 'fair' group, who had received only an anterior acromioplasty, were diagnosed as having a subcoracoid impingement syndrome.

Discussion

The coracoacromial arch has an inferior concave smooth surface consisting of the anterior undersurface of the acromion and the coracoacromial ligament [6]. It provides a strong ceiling for the shoulder joint along which the tendons must glide during all shoulder movements. If there is subacromial bursitis, a space-occupying lesion in the subacromial space (i.e. calcification), prominence of the greater tubercle after a fracture, or where there is a deficiency of rotator cuff function, then impingement of the tendinous cuff against the coracoacromial arch will occur [7]. Repeated mechanical stress from the impingement induces changes in the fibrocartilage and in the subchondral bone. In this study we found histopathological changes in all our patients with a rotator cuff tear. These changes were classified into 3 types according to the direction of the hypertrophic changes of the fibrous cartilage. Ogata and Uhtoff [17] speculated that a traction force on the coracoacromial ligament caused the pathological changes of Type A. Conversely, Type B had the pathological changes of 'osteoarthritis'. Therefore, these changes appear to have been the result of direct impingement at the acromion or coracoid. Type C pathological changes caused impingement of the acromion and/or the coracoid against the coracoacromial ligament. Variations of the coracoacromial arch occur. In this study patients who had a short acromion revealed the same changes as found with a Type A pathological acromion. A patient with a short acromion seems to have impingement at the coracoacromial ligament and will require resection of the coracoacromial ligament (a soft tissue decompression). In our series all 12 patients who had a soft tissue decompression of the coracoacromial arch obtained excellent results. These findings suggest that in the presence of a short acromion type of coracoacromial arch, soft tissue decompression is indicated. Patients with a long acromion have Type B pathological acromion changes and with impingement at the undersurface of the acromion. When there is direct impingement at the undersurface of the acromion an anterior acromioplasty rather than soft tissue decompression is advised. However, anterior acromioplasty will provoke the upward migration of the humeral head with resulting anteroposterior instability of the glenohumeral joint. In our series 3 patients had a subcoracoid impingement syndrome due to the upward migration of the humeral head after an anterior acromioplasty. However, coracoplasty is not a universally accepted surgical procedure in patients with a rotator cuff tear, we suggest adding coracoplasty with anterior acromioplasty because of 3 or 4 fair results re-

vealed a subcoracoid impingement syndrome after an anterior acromioplasty. Thirty per cent of specimens in this histological study revealed pathological changes of the coracoid process, and no problems followed partial coracoid resection.

In this study the impingement site on the coracoacromial arch in patients with a rotator cuff tear was suggested by the histopathological changes in the fibrous cartilage of the coracoacromial ligament attachment to bone. Several methods were used to determine whether this site was exposed to mechanical stress [4,9,12]. Pressure-sensitive film designed for the wrist joint was used to measure pressure distribution [9]. Although these pressure-sensitive films are useful to assess the site of mechanical compression, the impingement site is difficult to determine preoperatively and it is difficult to use the film intraoperatively. Estimation of the density distribution of subchondral bone by computed tomography (osteodensitometry) is a useful guide to the presence of long-term mechanical stress [12]. Although it is possible to assess the distribution of long-term direct mechanical compression forces, this cannot define completely any pathological changes resulting from the traction force acting on the enthesis of the coracoacromial ligament.

Evanko and Vogel [4] reported a difference in small proteoglycan synthesis in the tendon at the site of compression and traction of the tendon. If further immunohistological studies of the point of attachment of the coracoacromial ligament to bone prove to be helpful, then the causes of the histopathological changes of the fibrocartilage layer at this site may be clarified.

Cofield [2] reported an average success rate of 85% following rotator cuff surgery, but only anterior acromioplasty was used to decompress the coracoacromial arch. Our success rate using Neer's criteria was 92%. Although the lack of shoulder strength in patients with a massive rotator cuff tear was a difficult problem, most patients were relieved of their pain. In conclusion, site-specific decompression without overaggressive removal of the coracoacromial arch appears to improve the clinical results of rotator cuff surgery.

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