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Acromioplasty during repair of rotator cuff tears removes only half of the impinging acromial bone

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A R T I C L E I N F O

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CT reconstruction
rotator cuff repair
bone volume
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internal rotation

Level of evidence: Level IV; Case Series; Treatment Study

A B S T R A C T

Background: To date, there is no consensus on when and how to perform acromioplasty during rotator cuff repair (RCR). We aimed to determine the volume of impinging bone removed during acromioplasty and whether it influences postoperative range of motion (ROM) and clinical scores after RCR.
Methods: Preoperative and postoperative computed tomography scans of 57 shoulders that underwent RCR were used to reconstruct scapula models to simulate volumes of impinging acromial bone preoperatively and then compare them to the volumes of bone resected postoperatively to calculate the proportions of desired (ideal) vs. unnecessary (excess) resections. All patients were evaluated preoperatively and at 6 months to assess ROM and functional scores.
Results: The volume of impinging bone identified was 3.5 ± 2.3 cm^3, of which 1.6 ± 1.2 cm^3 (50% ± 27%) was removed during acromioplasty. The volume of impinging bone identified was not correlated with preoperative critical shoulder angle (r = 0.025, P = .853), nor with glenoid inclination (r = −0.024, P = .857). The volume of bone removed was 3.7 ± 2.2 cm^3, of which 2.1 ± 1.6 cm^3 (53% ± 24%) were unnecessary resections. Multivariable analyses revealed that more extensive removal of impinging bone significantly improved internal rotation with the arm at 90° of abduction (beta, 27.5, P = .048) but did not affect other shoulder movements or clinical scores.
Conclusions: Acromioplasty removed only 50% of the estimated volume of impinging acromial bone. More extensive removal of impinging bone significantly improved internal rotation with the arm at 90° of abduction.

Subacromial outlet-impingement is a frequent cause of shoulder pain, caused by intrinsic changes within the tendon, or by extrinsic compression of the latter between the humerus and the acromion.[3] Over the last decade, arthroscopic acromioplasty has been widely performed as an adjuvant procedure to rotator cuff repair (RCR) to increase subacromial space, which could decrease wear of the repaired tendon,[43,46] though there is little evidence to support this theory at present. Although MacDonald et al[40] observed that RCR without adjuvant acromioplasty was associated with higher reoperation rate, recent studies reported no direct clinical benefits of adjuvant acromioplasty in the short- or midterm.[6,7,36-38,42,47,52,55] Many patients may not benefit from acromioplasty, either because they do not require it or due to insufficient removal of impinging bone.[39] Dynamic evaluations revealed that

Ethical approval for this study protocol was approved by the Medical Ethics Committee of Geneva University Hospital (CCER 15-151). All patients provided written informed consent for their participation and for the use of their data and images for research and publishing purposes.

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impingement is less anterior than previously thought and that acromioplasty significantly reduces subacromial impingement, without the need for coracoacromial ligament resection.[49] The coracoacromial ligament is never completely detached in this procedure particularly as there were no other impingement zones observed.

Despite numerous studies on this field, there is no consensus on when and how to perform acromioplasty, as the location and extent of bone removal are determined subjectively by the surgeon, on either preoperative radiographs or during surgery. The resection levels depend on surgeon experiences[27] (anterior,[8,13,26,44,46] lateral,[28,34] medial,[13] or inferior[13,26,44]), and the volume of necessary acromial resection is difficult to estimate.[27,50] Some authors suggested removing 5 or 10 mm of the lateral aspect of the acromion, solely in patients at high risk of retear (severe tendinopathy, thickness tear >50%) or those with large critical shoulder angles (ie,

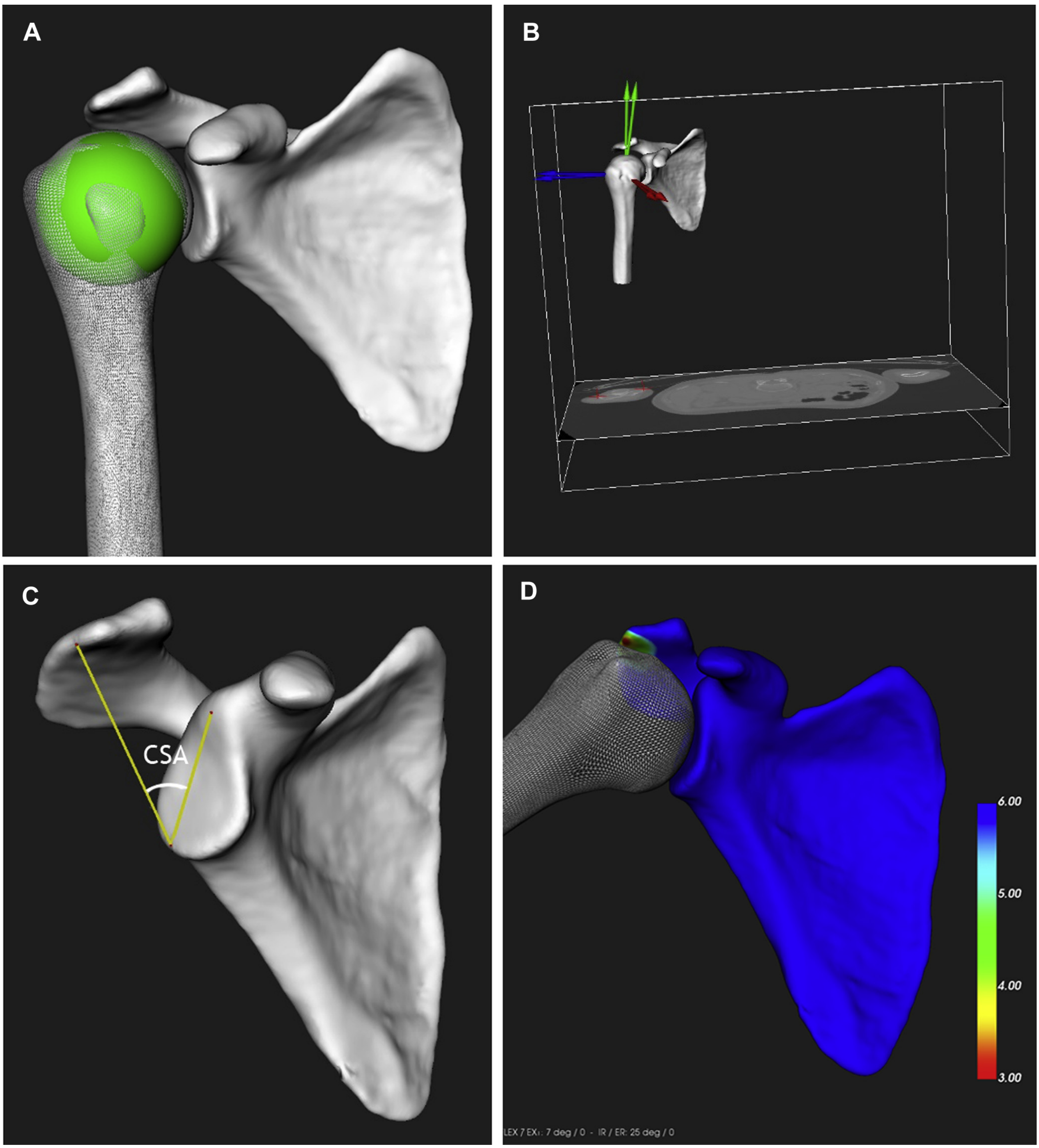

Figure 1 (**A**) Glenohumeral center computation by fitting a sphere on the humeral head. (**B**) Bone coordinates systems computation. (**C**) CSA measurement. (**D**) Visualization of the humeroacromial distance during motion. (red color = minimum distance, other colors = areas of increased distance). *CSA*, critical shoulder angle.

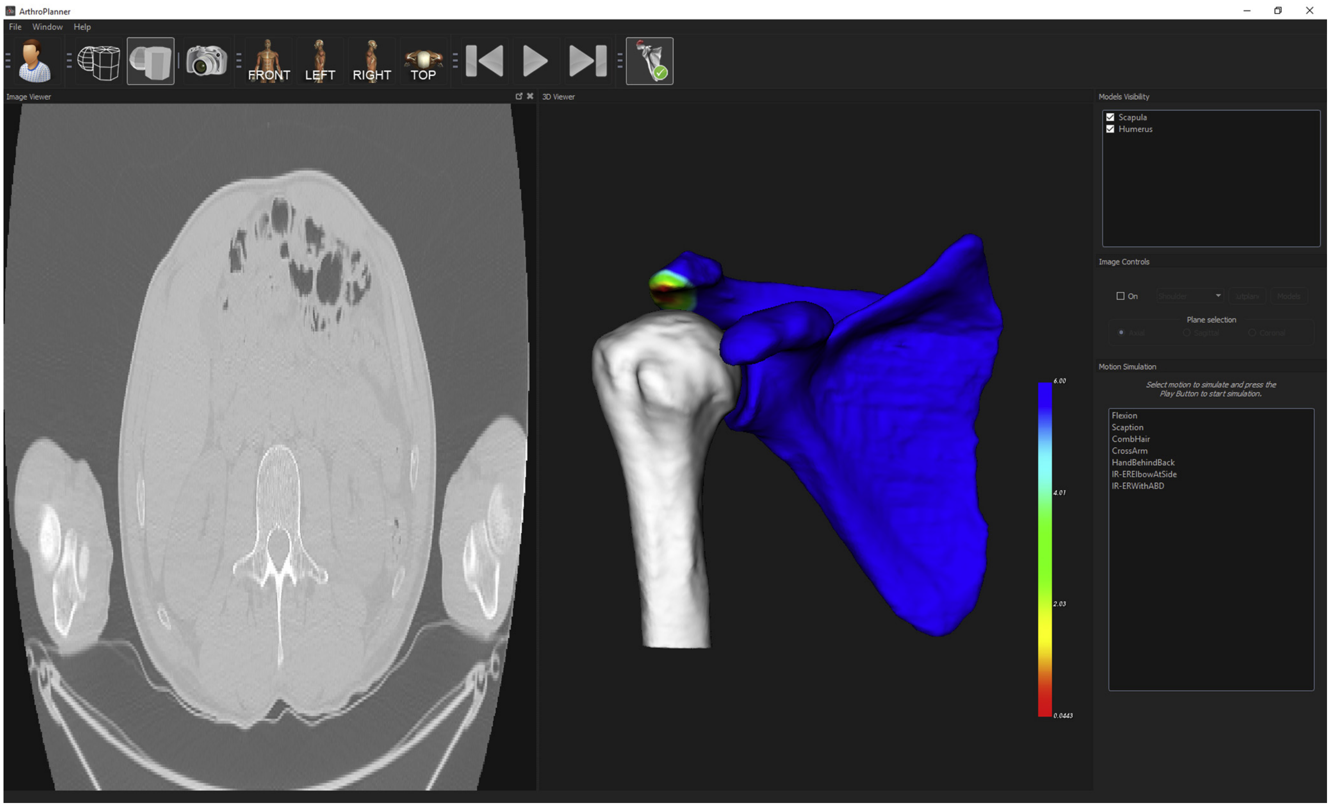

Figure 2 3D viewer with the simulation and visualization tools. The window on the right shows the acromial resection plan.

CSAs >35°).[28,35] Recent studies[20,33] criticized the use of such thresholds, arguing that small variations in patient position could significantly change the CSA on anteroposterior radiographs, and that in some cases acromioplasty may not decrease the CSA at all.

To the authors' knowledge, there is only 1 published study that dynamically investigated subacromial impingement in 3 dimensions.[9] We, therefore, aimed to determine the volume of impinging bone removed during acromioplasty and whether it influences postoperative range of motion (ROM) and clinical scores after RCR. The hypothesis was that more extensive removal of impinging bone would significantly improve postoperative ROM and clinical scores in the short term.

Material and methods

Patients

We prospectively enrolled 127 adult patients scheduled to undergo RCR of full-thickness supraspinatus tears (isolated or with posterior extensions to the infraspinatus) between July 2015 and March 2016. The indications for surgery were confirmation of full-thickness tendon tear using magnetic resonance imaging, and persistence of pain and symptoms despite 6 months of conservative treatment, with correction of scapulothoracic dyskinesis. We excluded patients who had (1) previous shoulder surgery, (2) acute trauma, (3) chronic dislocation, (4) preoperative infection, (5) rotator cuff arthropathy with glenohumeral osteoarthritis and superior migration of the humeral head, (6) psychiatric problems that precluded informed consent or inability to read or write, (7) fatty infiltration of grade 3 or 4,[30] (8) incomplete documentation, or (9) concomitant subscapularis tears.

Identification of impinging bone

All patients had preoperative computed tomography (CT) scans of the entire scapula and humerus using a Lightspeed VCT 64-row system (General Electric, Milwaukee, WI, USA). Three-dimensional (3D) bone reconstructions were produced using Mimics (Materialise NV, Leuven, Belgium) before manipulating them using a validated software ArthroPlanner (Artanim Foundation, Meyrin, Switzerland).[9]

First, generic bone models were produced using a template-fitting approach (WrapX, R3DS, Russia), and biomechanical parameters were computed to describe motions of the glenohumeral joint. The articular center was automatically calculated by a “sphere fitting” technique (Fig. 1, *A*).[53] Second, bone coordinate systems were established for the scapula and humerus (Fig. 1, *B*) based on the definitions suggested by the International Society of Biomechanics.[60] Morphologic parameters were then measured to analyze individual shoulder anatomy and included the CSA[45] and glenoid inclination (Fig. 1, *C*). Third, motion was applied at the humerus with real-time evaluation of impingement, and the minimum humeroacromial distance was measured.[12,31,57] A color scale was also used to map the variations of humeroacromial distance on the scapular surface (Fig. 1, *D*). Given the thickness of the soft tissues, subacromial impingement was indicated when the computed humeroacromial distance was <6 mm.[10,12,19] To test a variety of realistic movements, a motion database of daily activities (eg, cross arm, comb hair, hand behind back) was used in addition to standard kinematic sequences (eg, elevation, scaption). Finally, the acromial resection plan was defined based on the 3D simulation results, and simulation data were exported in a simple 3D viewer that allowed surgeons to replay all simulations, observe impingements dynamically, and fine-tune the resection plan (Fig. 2).

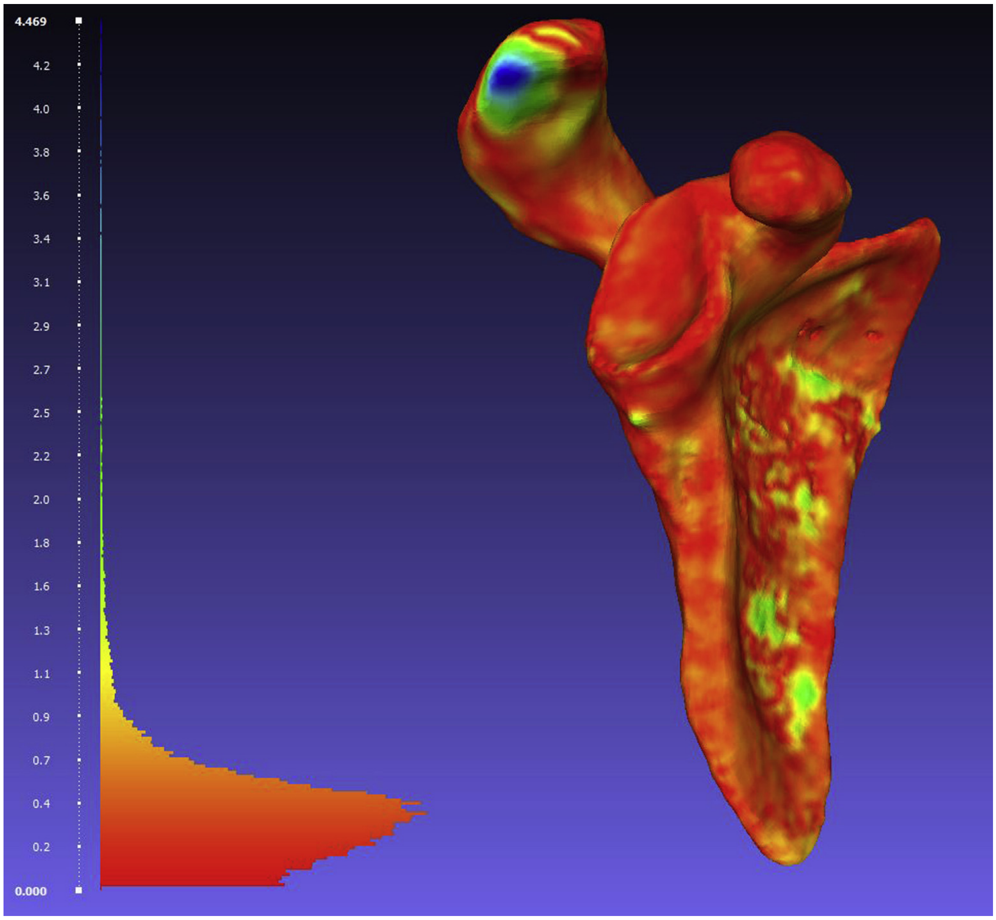

Figure 3 Visualization of the point-to-mesh distances on the preoperative model. The colors represent the variations of distance between the preoperative and postoperative models. The blue color denotes the zones of maximum distance (= maximum bone removal). The postoperative model that is superposed on the preoperative model is not shown for clarity.

Surgery

The patients were operated by 1 experienced surgeon (A.L.). The size and location of tears were confirmed arthroscopically, after subacromial bursectomy but before rotator cuff débridement. Single- or double-row techniques were used to repair the torn tendons, based on their length and mobility,[14,21] and biceps tenodesis or tenotomy was performed in all cases regardless of whether the long head of the biceps was pathologic or normal, as per the recommendations of Godeneche et al.[29] In our study, acromioplasty was limited to the impingement site, preserving the coracoacromial ligament and flattening a hooked or curved acromion.[1]

Postoperative rehabilitation

All patients followed a standard postoperative rehabilitation protocol[23] that required wearing abduction slings for the first 4 weeks. Immediately after surgery, patients were encouraged to perform shrugging, protraction, and retraction of the shoulder girdles, as well as intermittent exercises of the elbow, wrist, and hand; and external rotation of the arm to neutral position while wearing their slings. During the first 4 weeks, patients performed progressive passive overhead stretches and external rotation with the arm at the side. Active ROM exercises started at 4 weeks, and progressive strengthening started at 3 months.[11,23]

Clinical assessment

All patients were assessed preoperatively and at a follow-up of 6 months, noting (1) shoulder forward flexion and rotations using a digital goniometer (Dartfish, Alpharetta, GA, USA) on a video-recorded physical examination, (2) pain on visual analog scale (pVAS), (3) Constant score,[16] (4) the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) score,[51] and (5) Subjective Shoulder Value (SSV).[18] Data collection and measurements were performed by an independent observer (O.R.) blinded to the study design and purpose.

Radiographic assessment

Six months after surgery, a postoperative CT scan of the operated shoulder was acquired and reconstructed in 3D to assess the volume of residual impinging bone. To reduce potential reconstruction errors, the same imaging protocol was used pre- and postoperatively to ensure the 3D reconstruction parameters were the same. Moreover, the segmentation was performed by the same experienced reader (C.C.). The typical error magnitude in this segmentation process is about 0.5 mm. The preoperative and postoperative bone reconstructions were then registered and compared to quantify the volumes of acromial bone removed (Fig. 3). An ultrasonographic assessment was also performed to evaluate repair integrity following the classification of Sugaya et al[15,56] by an experienced musculoskeletal ultrasonography specialist (K.F.C.).

Table I
Pre- and intraoperative data (n = 57 shoulders)

Variable	Mean ± SD or n (%)	Range
Preoperative		
Age at index operation	57.3 ± 8.9	33.0-74.0
Critical shoulder angle, degrees	40.6 ± 5.5	29.8-52.5
Glenoid inclination, degrees	82.5 ± 8.5	41.1-98.8
Male sex	31 (54.4)	
Operation on dominant side	42 (73.7)	
Smokers	4 (7.0)	
Worker compensation status	7 (12.3)	
Type of RCT		
Isolated supraspinatus	18 (31.6)	
Supraspinatus and infraspinatus	39 (68.4)	
Intraoperative		
Surgical duration, min	61.8 ± 17.5	35.0-110.0
Suture technique		
Single-row	31 (54.4)	
Double-row	26 (45.6)	
Biceps procedures		
Tenodesis	27 (47.4)	
Tenotomy	30 (52.6)	
Coracoacromial ligament resection	0 (0.0)	
Distal clavicle resection	24 (42.1)	

RCT, rotator cuff tear; *SD*, standard deviation.

Statistical analysis

Descriptive statistics are presented in terms of mean and standard deviation. Shapiro-Wilk tests were used to assess the normality of distributions. Multivariable linear regressions were performed to determine associations of net improvements in range of motion and clinical scores, with 8 independent variables (ie, CSA, glenoid inclination, dominant arm, clavicle resection, biceps procedure, volume of impinging bone identified, proportion of impinging bone removed, and proportion of unnecessary bone removed). A priori power analysis was not performed for this study, but considering the recommendations of Austin and Steyerberg of 2 subjects per variable,[2] the minimum sample size required to perform a multivariable linear regression with 8 variables is 16 patients. Statistical analyses were performed using R, version 3.3.2 (R Foundation for Statistical Computing, Vienna, Austria). *P* values <.05 were considered statistically significant.

Results

Of the 127 patients screened for eligibility, 61 were excluded because they had concomitant subscapularis tears, 1 patient did not require acromioplasty, 2 declined to participate, 5 refused to undergo postoperative CT scans, and 1 was lost to follow-up. This left a study cohort of 57 patients, comprising 31 men and 26 women aged 57 ± 8.9 at index surgery (Table I). The operation involved the dominant arm in 42 patients (74%), and the supraspinatus tear was isolated in 18 patients (32%) and with posterior extensions to the infraspinatus in 39 patients (68%). The preoperative CSA and glenoid inclination were 41° ± 5.5° and 83° ± 8.5°, respectively. Six months after surgery, ROM and clinical scores had improved significantly (Table II), and the repair integrity was of Sugaya type I in 35 shoulders (61%), type II in 21 (37%), and type V in 1 (2%).

The volume of impinging bone identified was 3.5 ± 2.3 cm^3, of which 1.6 ± 1.2 cm^3 (50% ± 27%) was removed during acromioplasty (Table III). The volume of impinging bone identified was not significantly correlated with preoperative CSA ($r = 0.025$, $P = .853$),

Table II
Pre- and postoperative clinical data (n = 57 shoulders)

Variable	Mean ± SD	Range	*P* value*
Foward flexion			<.001
Preoperative	99.5 ± 42.8	15.0-170.0	
Postoperative	144.3 ± 24.6	55.5-176.0	
Net improvement	44.8 ± 48.6	−70.0 to 139.0	
External rotation (elbow at side)			<.001
Preoperative	25.9 ± 15.1	0.0-75.0	
Postoperative	40.0 ± 15.6	12.0-80.0	
Net improvement	14.2 ± 20.1	−35.0 to 52.0	
External rotation (with arm at 90° abduction)			<.001
Preoperative	38.3 ± 21.9	2.0-90.0	
Postoperative	54.8 ± 22.6	0.0-90.0	
Net improvement	15.9 ± 30.7	−65.0 to 80.0	
Internal rotation (with arm at 90° abduction)			<.001
Preoperative	17.6 ± 18.5	−7.0 to 85.0	
Postoperative	30.9 ± 21.0	0.0-90.0	
Net improvement	13.1 ± 24.0	−37.0 to 78.0	
pVAS			<.001
Preoperative	6.6 ± 1.9	2.0-10.0	
Postoperative	2.3 ± 2.2	0.0-9.0	
Net improvement	−4.4 ± 2.6	−9.0 to 4.0	
Constant score			<.001
Preoperative	39.9 ± 18.7	6.0-79.0	
Postoperative	67.1 ± 20.2	15.0-100.0	
Net improvement	27.3 ± 23.4	−27.0 to 82.0	
ASES			<.001
Preoperative	41.0 ± 17.6	8.3-80.0	
Postoperative	77.1 ± 18.3	30.0-100.0	
Net improvement	36.1 ± 20.5	−13.4 to 78.6	
SSV			<.001
Preoperative	48.1 ± 21.5	9.0-80.0	
Postoperative	77.7 ± 16.2	30.0-100.0	
Net improvement	29.6 ± 23.7	−20.0 to 81.0	

pVAS, pain on visual analog scale; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *SSV*, Subjective Shoulder Value; *SD*, standard deviation.
* *P* values for differences between pre- and postoperative data.

Table III
Volumes of acromial bone identified and removed (n = 57 shoulders)

Variable	Mean ± SD	Range
Impinging bone identified, cm^3	3.51 ± 2.27	0.46-9.43
Of which removed, cm^3	1.59 ± 1.24	0.04-5.94
%	49.6 ± 27.1	4.2-100.0
Total bone removed, cm^3	3.68 ± 2.20	0.45-8.91
Of which unnecessary resection, cm^3	2.09 ± 1.64	0.06-8.36
%	53.1 ± 24.3	8.0-97.1

SD, standard deviation.

nor with glenoid inclination ($r = -0.024$, $P = .857$). The total volume of bone removed was 3.7 ± 2.2 cm^3, including 2.1 ± 1.6 cm^3 (53% ± 24%) of unnecessary resections.

Multivariable regression analyses revealed that internal rotation with the arm at 90° of abduction improved significantly less for dominant arms (beta −16.5, confidence interval −30.7, −2.3; P = .024) but significantly more with removal of impinging bone (beta 27.5, confidence interval 0.28, 54.7; P = .048) (Table IV). Multivariable regression analyses revealed no associations, however, between improvements in other shoulder movements or clinical scores and any of the variables considered (Table V).

Discussion

The principal findings of the present study are that adjuvant acromioplasty removed only 50% of the impinging bone identified on preoperative CT reconstructions, and that there was a positive correlation between the proportion of impinging bone removed and improvements in internal rotation with the arm at 90° of abduction. The proportion of impinging bone removed was not associated, however, with any other improvements in postoperative shoulder mobility or clinical scores. The hypothesis that more extensive removal of impinging bone would significantly improve postoperative ROM and clinical scores cannot be entirely confirmed. Although these findings may be pertinent and meaningful, it would be inappropriate to draw any conclusions at this stage, because impingement is about symptoms rather than the size of a certain bone on radiographs or CT. It would therefore be misleading to arbitrarily define impingement with a certain amount of bone, as impingement is mainly about cuff function and the interaction between dynamic stability and bone contact.

Subacromial impingement occurs most frequently in abduction, and is exacerbated by internal rotation.[48,58,59,61] Our results are consistent with these observations, as we found a positive correlation between the proportion of impinging bone removed and improvements in internal rotation with the arm at 90° of abduction. In fact, our results suggest that complete removal of impinging bone could improve internal rotation by up to 27°. This is particularly relevant as internal rotation with the arm at 90° of abduction is correlated with hand-behind-back range of motion, known to be essential for daily activities. There are, however, multiple factors that influence postoperative ROM, so it would be incorrect and potentially dangerous to conclude that more bone removal alone could improve shoulder mobility or resolve functional limitations.

To date, there is no current consensus on when and how to perform acromioplasty, as the location and extent of bone removal are determined subjectively by the surgeon, on either preoperative radiographs or during surgery. The resection levels depend on surgeon experiences (anterior,[8,13,26,44,46] lateral,[28,34] medial,[13] or inferior[13,26,44]), and the volume of necessary acromial resection is difficult to estimate.[27,50]

Numerous authors questioned the benefits of acromioplasty as an isolated or adjuvant procedure.[5,7,25,42,47,55] Although some authors found that it improved quality of life and decreased the reoperation rate, others reported no real clinical benefits. Our data revealed no associations between impinging bone removal and improvement in clinical scores 6 months following RCR, which may be because impingement is about symptoms rather than the size of a certain bone on radiographs or CT. Furthermore, because subscapularis tears usually result from anterior impingement with the coracoid,[17] the authors preferred to exclude shoulders with concomitant subscapularis tears, which represented 48% of the initial cohort. This proportion is consistent with the observations of Denard et al,[22] who estimated the prevalence of subscapularis tears to be nearly 30% in all arthroscopic shoulder surgery and up to 59% in rotator cuff procedures. Either way, the present findings warrant further investigations with longer follow-up, as tendon degeneration can extend over several decades, and as patient-specific planning and instrumentation are becoming increasingly popular for shoulder surgery. Understanding whether such technologic trends can improve the accuracy of identifying and/or removing impinging bone could guide surgeons and engineers in optimizing their techniques, software, or devices.

Table IV
Multivariable regression analysis of range of motion improvements (57 shoulders)

Variable	FF		ER (elbow at side)		ER (arm at 90° abduction)		IR (arm at 90° abduction)	
	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value
Impinging bone identified, cm^3	−0.92 (−8.81, 6.97)	.816	0.47 (−2.78, 3.71)	.774	−2.86 (−7.66, 1.95)	.238	−0.34 (−3.86, 3.18)	.845
Impinging bone removed, %	−3.27 (−64.25, 57.72)	.915	13.11 (−11.98, 38.20)	.299	1.41 (−35.69, 38.52)	.939	27.49 (0.28, −54.69)	**.048**
Unecessary bone removed, % of TBR	14.82 (−58.26, 87.90)	.685	16.95 (−13.11, 47.02)	.263	−41.24 (−85.71, 3.23)	.068	−10.39 (−42.98, 22.21)	.525
Critical shoulder angle	−0.66 (−3.19, 1.87)	.602	−0.21 (−1.25, 0.83)	.685	−0.09 (−1.63, 1.45)	.908	−1.02 (−2.15, 0.11)	.075
Glenoid inclination	−0.33 (−1.95, 1.29)	.682	0.01 (−0.65, 0.68)	.973	−0.43 (−1.41, 0.55)	.382	−0.14 (−0.86, 0.59)	.708
Operation on dominant side	−28.23 (−60.02, 3.56)	.081	−0.17 (−13.25, 12.91)	.979	−10.78 (−30.12, 8.57)	.268	−16.48 (−30.66, −2.30)	**.024**
Distal clavicle resection	−0.96 (−33.36, 31.44)	.953	−13.20 (−26.54, 0.13)	.052	−7.15 (−26.86, 12.57)	.470	−10.44 (−24.89, 4.01)	.153
Biceps procedures								
Tenotomy	Ref		Ref		Ref		Ref	
Tenodesis	−2.43 (−32.54, 27.68)	.872	−2.10 (−14.49, 10.29)	.735	7.37 (−10.95, 25.69)	.423	7.22 (−6.22, 20.65)	.286

TBR, total bone removed; *FF*, foward Flexion; *β*, regression coefficient; *CI*, confidence interval; *ER*, external rotation; *IR*, internal rotation.
Bold indicates significant *P* values.

Table V
Multivariable regression analysis of clincal score improvements (57 shoulders)

Variable	pVAS		ASES		Constant score		SSV	
	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value	β (95% CI)	*P* value
Impinging bone identified, cm^3	−0.28 (−0.68, 0.11)	.159	0.10 (−3.27, 3.48)	.952	−0.75 (−4.50, 3.00)	.689	−0.24 (−4.17, 3.68)	.901
Impinging bone removed, %	1.40 (−1.66, 4.47)	.361	−2.22 (−28.30, 23.86)	.865	14.21 (−14.78, 43.20)	.329	1.17 (−29.18, 31.53)	.938
Unecessary bone removed, % of TBR	−0.40 (−4.08, 3.27)	.826	−2.93 (−34.18, 28.33)	.851	−6.92 (−41.66, 27.82)	.690	1.98 (−34.39, 38.36)	.913
Critical shoulder angle	−0.01 (−0.14, 0.11)	.841	0.15 (−0.93, 1.24)	.778	0.01 (−1.19, 1.21)	.987	0.19 (−1.07, 1.45)	.760
Glenoid inclination	0.06 (−0.02, 0.14)	.156	0.04 (−0.65, 0.73)	.910	−0.07 (−0.83, 0.70)	.865	−0.07 (−0.87, 0.74)	.866
Operation on dominant side	−0.04 (−1.64, 1.55)	.956	−6.96 (−20.56, 6.63)	.308	−12.75 (−27.87, 2.36)	.096	−10.36 (−26.18, 5.47)	.194
Distal clavicle resection	−0.29 (−1.91, 1.34)	.726	−4.83 (−18.69, 9.02)	.486	−4.89 (−20.29, 10.51)	.526	−4.75 (−20.88, 11.38)	.557
Biceps procedures								
Tenotomy	Ref		Ref		Ref		Ref	
Tenodesis	1.32 (−0.19, 2.83)	.086	−5.77 (−18.65, 7.11)	.372	−5.37 (−19.69, 8.94)	.454	3.56 (−11.43, 18.55)	.635

TBR, total bone removed; *pVAS*, pain on visual analog scale; *β*, regression coefficient; *CI*, confidence interval; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *SSV*, Subjective Shoulder Value.

Some authors reported greater risks of retear following RCR in patients with large CSA, who may require resections of 5 or 10 mm of acromial bone laterally.[34,41] Although Gerber et al[28] reported an association between the acromial shape and rotator cuff disease, the cause-and-effect relationship could not be established, rendering such thresholds unfounded.[24] As subacromial impingement results from a dynamic mechanism, and because evaluating the CSA on anteroposterior radiographs is somewhat inaccurate, our study casts new perspectives on the real efficacy of acromioplasty. It is interesting that we found no correlation between CSA and volume of impinging bone identified, which suggests that subacromial impingement is a complex phenomenon, specific to patient morphology, and should therefore be studied dynamically. It is also worth noting that we found considerable proportions of unnecessary bone removed. We therefore believe that improving intraoperative tools such as surgical guides or robotic assistance for acromioplasty could optimize impinging bone removal while reducing unnecessary resections.

Strengths and limitations

The main strengths of this study are its prospective design, the strict selection of patients, the unique technique used to plan acromioplasty, and the analysis of postoperative bone removal. Furthermore, only 1 surgeon and 1 independent examiner were involved in the evaluations, which ensured consistency of surgical techniques and subjective assessments. However, this study has several limitations. First, clinical and radiographic follow-up were limited to 6 months, though it has been demonstrated that most rotator cuff tears occur within the first 6 months after surgery and are less frequent thereafter.[4,32] Second, it is uncertain whether the observed improvements in shoulder motion can be attributed to removal of impinging bone or to tendon repair and physiotherapy,[54] as there is no control group that did not undergo acromioplasty, nor postoperative measurement of CSA. Third, the simulation did not include scapulothoracic motion, though all patients had conservative treatment preoperatively, including correction of scapulothoracic dyskinesia. Moreover, the simulation was based on standard kinematic sequences and daily activities that represent shoulder ROM but not specific to the individual motion of the patient under evaluation and suffering from different pathologies. Finally, estimating bone to be removed required pre- and postoperative CT images that exposed patients to radiations.

Conclusion

Acromioplasty removed approximately 50% of impinging bone identified on preoperative CT reconstructions. Greater removal of impinging bone could improve internal rotation with the arm at 90° of abduction but not any other shoulder mobility or clinical outcomes. Further studies with longer follow-up and larger cohorts are needed to evaluate whether impinging bone removal is associated with greater improvements of clinical scores. These findings should motivate engineers and surgeons to improve software for acromioplasty planning.

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