Treatment of Complications of Shoulder Arthrodesis

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ABSTRACT: A reconstructive osteotomy was performed to correct symptomatic malposition after arthrodesis of the shoulder in nine of fourteen patients who had complications related to the arthrodesis. The clinical position of the arm in relation to the trunk was determined with the method described by Rowe. Malposition was primarily the result of fusion in more than 15 degrees of either flexion or abduction, or both, coupled with improper rotation, defined as rotation of less than 40 degrees or more than 60 degrees. Reconstructive osteotomy eliminated pain and improved the ability of the patient to perform six activities of daily living.

The complications necessitating operative treatment after the arthrodesis in the remaining five patients included failure of the arthrodesis site to unite (three patients), a wound hematoma at the iliac-crest donor site (one patient), and a superficial wound infection (one patient). Two additional complications — a fracture through a screw-hole in the humerus and a fracture distal to the internal fixation device — occurred after the reconstructive osteotomies for malposition.

All of the complications resolved with treatment. Arthrodesis of the shoulder is a technically demanding procedure that can lead to serious complications that necessitate operative intervention. Careful attention to operative technique and to the position of the arthrodesis are essential.

Arthrodesis of the glenohumeral joint is an established operative procedure. The indications for arthrodesis have included infection of the joint, paralysis (traumatic and as a result of poliomyelitis), osteoarthrosis, rheumatoid arthritis, intractable instability of the shoulder, and irreparable injuries of the rotator cuff[2,4,6,7,11,15,20,21,23,32]. Contemporary indications for glenohumeral arthrodesis include complete brachial plexus injuries; paralysis of the deltoid muscle or loss of the origin of the anterior portion of the deltoid; infection; certain failed revision arthroplasties such as those associated with a large amount of bone loss, persistent infection, or injury of the axillary nerve; and arthrotic changes of the glenohumeral joint in a young person who performs manual labor and in whom a prosthesis is unlikely to remain functional for a lifetime[8,11,16,21,23-25,32].

Many authors have stressed the value of internal fixation for maintaining the position of the humeral and scapular surfaces, especially when both glenohumeral (intra-articular) and acromiohumeral (extra-articular) techniques are used for arthrodesis[18,22,24-26,34]. Although a high rate of fusion has been achieved with this type of arthrodesis, complications have occurred[9]. The purpose of the present study was to describe our experience with the treatment of complications associated with arthrodesis of the glenohumeral joint.

Materials and Methods

Through a retrospective review of the records of all twenty-eight patients who had had an arthrodesis of the shoulder, or a revision of an arthrodesis done elsewhere, performed by us between 1978 and 1992, we identified fourteen patients who had complications. Ten had been referred to us for treatment of complications after an arthrodesis at another institution, and four had had complications after an arthrodesis at the institution of the senior one of us (C. A. R., Jr.).

The patients included eight men and six women, who were twenty-eight to sixty-seven years old (average, forty-two years old) at the time of the primary arthrodesis. The arthrodesis was done on five left shoulders and nine right shoulders. An average of four (range, zero to thirteen) previous procedures on the shoulder had been performed. The complications that led to the revision procedures included wound infection in one patient; wound hematoma at the iliac-crest donor site in one; non-union in three, one of whom also had a fracture of the plate distal to the site of the arthrodesis; and malposition of the shoulder in nine.

All of the patients were interviewed and examined by one of us. At the time of the physical examination, the clinical position of the arm in relation to the trunk

*No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. No funds were received in support of this study.

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TABLE I
DATA ON THE PATIENTS

Case	Gender, Age at Primary Op. (Yrs.)	Indication for Revision	Before Revision: Position of the Extremity* (Degrees)	Before Revision: Functions Patient Able to Perform† (No.)	After Revision: Complications	After Revision: Position of the Extremity* (Degrees)	After Revision: Functions Patient Able to Perform† (No.)	Duration of Follow-up (Mos.)
1	M, 37	Malposition	30/45/15	3	Fracture distal to plate	15/15/45	6	174
2	M, 67	Wound hematoma at iliac-crest donor site	5/10/45	6		5/10/45	6	109
3	F, 32	Malposition	45/55/20	4		5/15/45	6	86
4	F, 36	Malposition	45/45/35	3	Fracture through screw-hole	20/20/55	6	51
5	M, 44	Malposition	35/40/45	4		10/15/45	6	159
6	M, 41	Malposition secondary to deflation of beanbag during op.	40/10/40	4		5/15/45	6	136
7	M, 30	Wound infection	10/15/40	6		10/15/40	6	36
8	M, 28	Malposition	80/30/80	2		20/15/50	6	30
9	M, 67	Non-union	15/20/45	6		15/20/45	6	26
10	F, 36	Non-union	15/20/45	6		15/20/45	6	67
11	F, 37	Malposition	60/30/35	3		20/15/50	6	24
12	F, 38	Malposition	45/25/45	4		20/15/50	6	26
13	F, 31	Malposition	45/55/20	3		5/15/45	6	85
14	F, 66	Non-union	10/15/45	6		10/15/45	6	24

*The values are given as flexion/abduction/internal rotation.
†We assessed six functions: the ability to sleep on the involved side; to use the involved extremity to dress, to eat, to perform anterior perineal care, and to lift 7.5 kilograms; and to use the hand of the involved extremity at shoulder level.

was determined by the method described by Rowe[27] and the position of flexion, abduction, and internal rotation of the shoulder in relation to the sagittal and transverse planes through the trunk were noted. Radiographs were made of each shoulder to determine healing of the arthrodesis site. The patients were asked if they were satisfied with the procedure, and we documented the patient's ability to sleep on the involved side; to use the involved extremity to dress, to eat, to perform anterior perineal care, and to lift 7.5 kilograms; and to use the hand of the involved extremity at shoulder level.

Eight of the nine patients who were managed for malposition had had the arthrodesis at another institution. In the ninth patient (Case 6), malposition had occurred when the beanbag deflated during primary arthrodesis performed by the senior one of us. In each patient, glenohumeral fusion had occurred with the shoulder in more than 15 degrees of flexion or abduction, or both. Six patients had improper rotation (less than 40 degrees or more than 60 degrees) (Table I). The shoulders were in an average of 47 degrees (range, 30 to 80 degrees) of flexion; 37 degrees (range, 10 to 55 degrees) of abduction; and 37 degrees (range, 15 to 80 degrees) of internal rotation. Before the reconstructive procedure, the nine patients were able to perform an average of three (two, three, or four) of the six functions that we assessed.

Three patients were managed for a non-union following the arthrodesis. Two of them had had the arthrodesis at another institution and were referred to us because of ongoing pain in the shoulder. Both patients had radiographic evidence of a non-union. The third patient (Case 9) had been managed by us. This patient weighed 115 kilograms, and six months after a primary arthrodesis performed with a 4.5-millimeter pelvic reconstruction plate a fracture was noted in the middle of the device. The patient did not have pain, but he was advised to have operative treatment to achieve union.

A wound infection developed at the site of the arthrodesis in one patient (Case 7). Serous drainage was noted four days after the primary arthrodesis, and the patient was returned to the operating room for irrigation and drainage. *Staphylococcus aureus* was grown on intraoperative culture of the wound. Cefazolin was administered intravenously for seven days, followed by a fourteen-day course of cephalexin. The plate and screws were left in place, and the infection resolved.

A superficial hematoma developed at the iliac-crest donor site in another patient (Case 2). The hematoma was evacuated, and the problem resolved.

Operative Technique to Correct Malposition

When fusion occurs in malposition, the extremity does not hang comfortably at the patient's side. Before

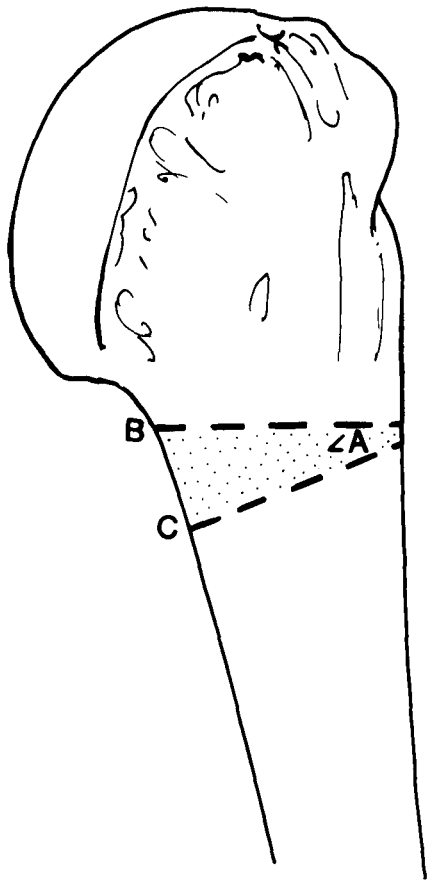

FIG. 1

Scale drawing used to calculate the thickness of the closing-wedge osteotomy needed to correct malposition after arthrodesis (see text).

the corrective osteotomy, the arm is stabilized in a position of sufficient abduction and flexion to alleviate the pain in the shoulder resulting from strain on the scapulothoracic muscles. The difference between this position and that in which the limb will rest in a neutral position in abduction and flexion in relation to the thorax is determined for flexion and abduction. An osteotomy that will correct the malposition then is planned.

A mathematical formula can be used to convert the desired degree of correction of flexion or abduction into the millimeters of thickness of bone that must be removed with a closing-wedge osteotomy to restore the proper angle of the arm. The width (in millimeters) of the proximal part of the humerus, inferior to the glenoid, is determined from the radiographs, after correction for magnification. To correct for magnification, two metal markers are taped to the arm, 100 millimeters apart, and the width of the proximal part of the humerus is multiplied by the distance between the metal markers that is measured on the radiograph; the total is then divided by 100. With this value and the amount (in degrees) of correction that is desired, the thickness of the wedge that must be removed to correct flexion can be calculated from the lateral radiograph and that needed to correct abduction can be calculated from the anteroposterior radiograph by construction of a right triangle[10,30]. The base of the triangle (AB; Fig. 1) is the width of the proximal part of the humerus inferior to the glenoid. Angle A is the amount of angular correction needed to obtain the desired position. From this, the width of the wedge (BC) either is determined from the mathematical formula $BC = \tan A \; AB$ or is measured directly from a scale drawing (Fig. 1).

The amount of internal rotation that is needed is determined by the configuration of the torso. For a very thin patient, it may be necessary to place the arm in 60 degrees of internal rotation so that the hand can easily reach the mouth and the area of the belt buckle; however, for an obese patient, only 40 degrees of internal rotation may be necessary. Internal rotation may be corrected intraoperatively by placing the extremity in the desired degree of internal rotation and stabilizing it in this position.

The operative technique for correction of malposition after an arthrodesis has many similarities with the technique for a primary arthrodesis[25]. The patient is placed in a lateral decubitus position, and the site of the arthrodesis is exposed (Fig. 2-A). Internal fixation, if present, is removed. With use of an oscillating saw, an osteotomy is performed through the cancellous bone, inferior to the site of the arthrodesis. Care must be taken to ensure that the site of the osteotomy exits inferior and lateral to the inferior rim of the original glenoid. To confirm the precise location of the osteotomy, intraoperative radiographs may be made after the intended site of the osteotomy has been marked with a Steinmann pin. The transverse cut is made first, and rotation can be corrected at this point, if necessary. With the arm held in correct rotational alignment, the closing-wedge osteotomy is performed (Fig. 2-B).

After the wedge of bone has been removed and the planned amount of correction has been achieved, the osteotomy site is reduced and is provisionally secured with two large threaded Steinmann pins. The pins are placed from the shaft of the humerus into the glenoid and the body of the scapula (Fig. 2-C). Care is taken to ensure that no pin is placed too anteriorly, in order to avoid injury of the brachial plexus. The pins are kept separated during insertion and are positioned anteriorly and posteriorly along the shaft of the humerus to permit a plate to be contoured to the dimensions of the new arthrodesis. The provisional position then is checked by moving the hand of the involved limb to the mouth, the front of the abdomen, and the anterior perineal area.

The site of the arthrodesis is stabilized with a 4.5-millimeter pelvic reconstruction plate. A 4.5-millimeter dynamic compression plate is preferred for patients who weigh more than 100 kilograms. The length of plate needed to secure the osteotomy site is determined by the need to have three screws proximal to the acromion

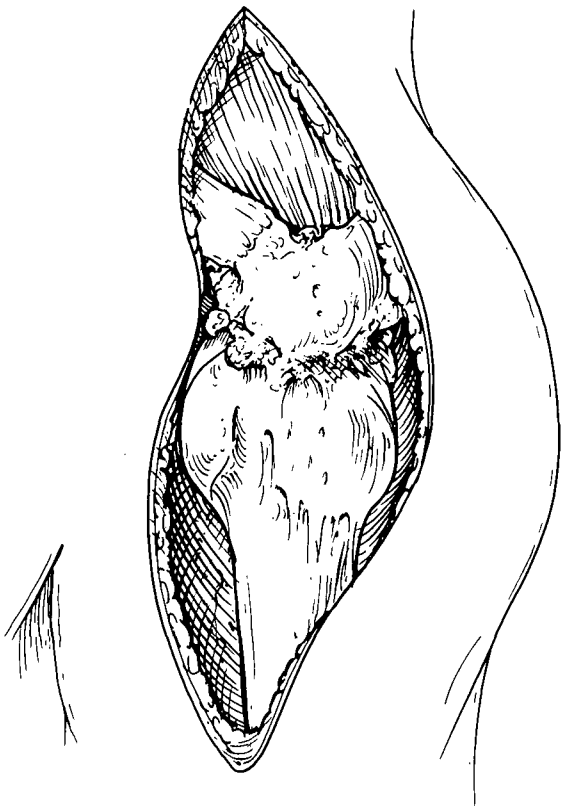

FIG. 2-A

Figs. 2-A through 2-D: Drawing showing the operative technique of reconstructive osteotomy.

Fig. 2-A: The site of the primary arthrodesis is completely exposed.

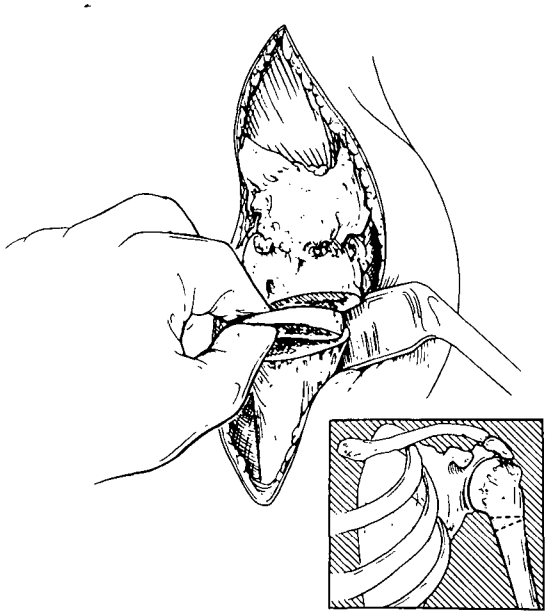

FIG. 2-B

An inferior osteotomy is performed just inferior and lateral to the original glenoid.

and three screws able to achieve purchase in two cortices each in the shaft of the humerus distal to the level of the osteotomy (Fig. 2-D). A ten or twelve-hole plate was used in each patient in the present series. Bone-grafting should be done when complete coaptation of the osteotomy site has not been achieved. When the volume of autogenous bone recovered from the osteotomy is not sufficient for grafting, additional bone should be taken from the pelvis. Additional bone was needed in four of the revision procedures but not in any of the primary arthrodeses.

Postoperatively, the arm is placed in a sling; no patient needed additional immobilization. Range-of-motion exercises of the elbow, wrist, and hand are begun on the morning after the operation. Two days after the procedure, the patient may begin to use the extremity for activities of daily living, such as eating, washing the face, shaving, and brushing the teeth. The sutures are removed two weeks postoperatively, and use of the sling is discontinued three weeks after the operation.

Results

The duration of follow-up after the reconstructive procedure averaged six years (range, two to 14.5 years). After the nine osteotomies to correct malposition, the average position of the shoulder was 13 degrees of flexion (range, 5 to 20 degrees), 16 degrees of abduction (range, 15 to 20 degrees), and 48 degrees of internal rotation (range, 45 to 55 degrees). Postoperatively, all nine patients had relief of chronic pain in the shoulder

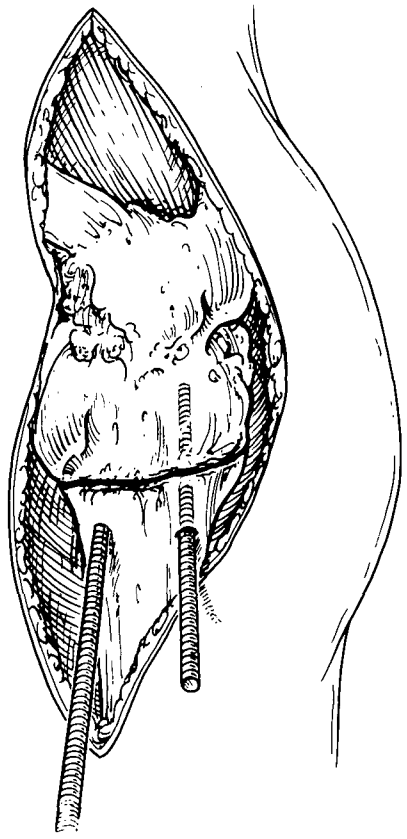

FIG. 2-C

The proper position of the extremity for arthrodesis is determined and is provisionally held with Steinmann pins.

and were able to perform all of the six activities of daily living that we assessed.

A fracture occurred in two patients who had had a reconstructive osteotomy. One patient (Case 1) had the hardware removed one year after the osteotomy and fell three months later, sustaining a fracture of the humerus distal to the site of the arthrodesis. The fracture was treated with immobilization of the arm in a sling, and union occurred without a substantial change in the position of the shoulder. The second patient (Case 4) had pain in the shoulder six months after the osteotomy. Radiographs demonstrated lucency around the distal three screws in the plate. At operative exploration, a fracture of the proximal part of the humerus was found in the region of the long cancellous-bone lag-screw that had been used at the time of the initial arthrodesis at another institution. A second plate was applied to the posterior aspect of the humerus, and grafting was done with bone taken from the iliac crest. The fracture united, and the symptoms resolved (Table I).

Two of the three patients who were managed for non-union of the arthrodesis site had union after the reconstructive procedure performed at our institution (Figs. 3-A and 3-B). The third patient was advised to have a repeat operation and subsequently did so at another institution. A repeat examination demonstrated that a successful union had been obtained. There were no long-term problems in the two patients who were managed for a wound infection or hematoma at the iliac-crest donor site; a successful fusion was achieved in each patient.

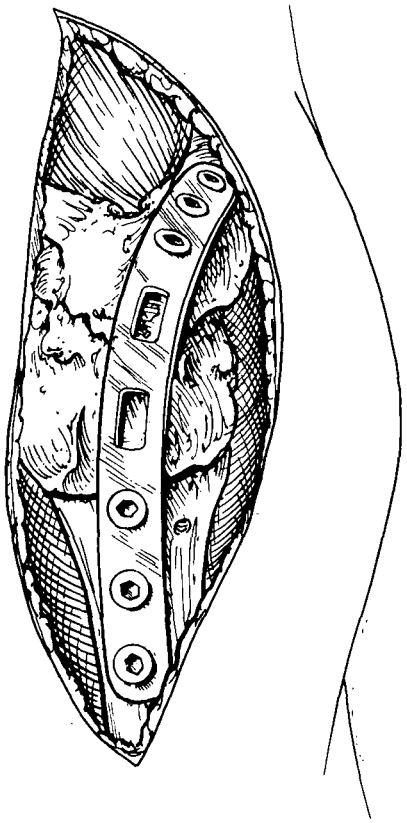

FIG. 2-D

Final appearance, before closure and after application of a contoured plate.

FIG. 3-A

Figs. 3-A and 3-B: Case 9. A sixty-seven-year-old man who had had a primary arthrodesis at another institution.

Fig. 3-A: A preoperative radiograph revealed a non-union at the site of the arthrodesis and the hardware still in place.

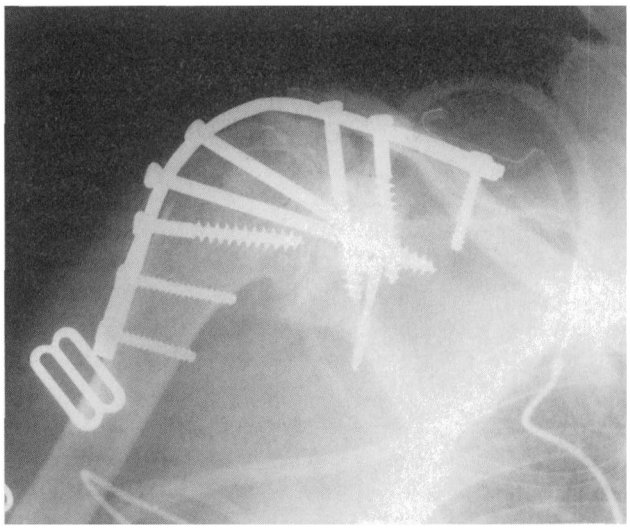

FIG. 3-B

A postoperative radiograph showed the appearance after removal of articular cartilage and application of a compression plate and screws. A drill-bit, which broke during the operative treatment, is also visible. Breakage of hardware during operative reconstruction after an arthrodesis is not infrequent. To date, we have not found migration of broken hardware in any patient.

Discussion

Although glenohumeral arthrodesis is reliable and provides durable results, it can be associated with serious complications. Previous investigators[1,3,7-9,24,25,31] have mentioned complications sparingly when reviewing the outcome of this procedure. One of the more troubling

complications is malposition of the extremity.

Malposition necessitated operative treatment when there was abduction or flexion of more than 15 degrees or rotation of less than 40 degrees or more than 60 degrees, or all three. These positions of abduction, flexion, and internal rotation were originally recommended by Barr et al.[1] for patients who had had an arthrodesis for problems associated with infantile paralysis. In their report, published in 1942, they recommended that the arthrodesis be performed with the extremity in 50 degrees of abduction, 20 degrees of flexion, and 25 degrees of internal rotation, so that the patient could use the hand above the head.

Recommendations for similar positions are found in a number of other reports[8,12,14,17,19,29]. As late as 1961, Moseley[21] advocated that the arthrodesis be performed with the shoulder in 70 to 90 degrees of abduction, 15 to 25 degrees of flexion, and 25 to 30 degrees of external rotation. We recommend a position of 10 to 15 degrees of abduction, 10 to 15 degrees of flexion, and enough internal rotation to enable the patient to reach the mouth, belt buckle, and contralateral shoulder and axilla comfortably. With the patient standing, the extremity should hang comfortably at the side and the scapula should be flat against the thorax.

Arthrodesis performed in a position outside of these parameters has resulted in chronic pain in the shoulder[13]. When the shoulder is in excessive abduction or flexion, the extremity will not hang comfortably at the side. In addition, the scapula is medially or posteriorly rotated, resulting in strain on the scapulothoracic muscles and chronic pain. All of the patients who had malposition had chronic aching of the shoulder and were dissatisfied with the outcome of the primary arthrodesis. These findings appear to contradict the assertion of some that the position of the extremity after an arthrodesis has little effect on the outcome[9].

Function was improved after the reconstructive osteotomies for malposition. This result is in agreement with the findings of Rowe[28], who stated that a well positioned extremity makes an important difference in the satisfaction and the function of the patient. However, the position of the arthrodesis may differ according to the body habitus of the patient. Instead of recommending a specific position, we suggest a position that allows the extremity to rest comfortably at the side with the patient standing and that enables the hand to reach the mouth, the contralateral shoulder and axilla, the front of the shirt, the front zipper and front pocket on pants, and the belt buckle.

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