Shoulder arthrodesis with a reconstruction plate

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Abstract From 1995 to 2005, arthrodesis with a reconstruction plate was performed for eight shoulders. The average follow-up period was 44 months. The indications for shoulder arthrodesis were joint destruction as a sequel of tuberculous arthritis, malignant bone tumour, pyogenic arthritis, failed arthrodesis and paralysis of the brachial plexus. The evaluation criteria included bony union and pain. Two cases of malignant tumour required an homologous bone graft due to severe bone deficit—a fracture that occurred in the distal part of the arthrodesed shoulder after removing the plate. With the exception of these two cases, severe pain or other complications did not occur in any other case. Shoulder arthrodesis with a reconstruction plate was judged to be a useful method for glenohumeral salvage in cases without severe bone deficit. Further, additional treatment methods should be considered to prevent fracture that may occur as a result of severe bone deficit.

Résumé De 1995 à 2005, nous avons réalisé huit arthrodeses d'épaule avec une plaque de reconstruction. Le suivi moyen a été de 44 mois. Les indications ont été les suivantes: destruction articulaire d'origine tuberculeuse, tumeurs malignes, arthrite, échec d'arthrodèse et paralysie du plexus brachial. Les critères d'évaluation ont été les suivants: fusion osseuse articulaire et douleur. Deux cas de

tumeurs malignes ont nécessité la réalisation d'une greffe secondaire à une fracture de la partie distale de l'arthrodèse après ablation de matériel. En dehors de ces deux cas, nous n'avons pas observé de douleurs importantes ou d'autres complications. L'arthrodèse avec plaques de reconstruction spéciale est une technique que nous avons trouvée relativement facile dans le cas où il n'y avait pas de pertes de substance osseuse majeure. De plus, il est nécessaire d'envisager un traitement complémentaire pour prévenir les fractures qui peuvent survenir en cas de defect osseux important.

Introduction

Shoulder arthrodesis has become a relatively rare surgical procedure after the introduction of shoulder arthroplasty and the reduced frequency of objective indications. Nevertheless, it can be considered inevitable for (1) restoration of shoulder joint stability, (2) provision of stability in flail shoulder following damage to the brachial plexus, (3) correction of failed shoulder arthroplasty, (4) resection of tumour at the shoulder joint and (5) treatment of joint infection-induced severe joint destruction [7]. Shoulder arthrodesis with compression screw, dynamic compression plate (DCP) and reconstruction plate have been introduced, and external fixation has also been reported as a means to achieve successful arthrodesis [3, 16]. In particular, shoulder arthrodesis with reconstruction plates has merits in that the plate can be bent easily and accurately depending on the anatomical location, there is relatively less skin stimulation since the internal fixation used has few protrusions and adequate bone arthrodesis can be achieved. Therefore, arthrodesis with a reconstruction

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plate is recommended by many researchers [10, 15]. In this study, we confirm the clinical benefits of shoulder arthrodesis with a reconstruction plate through follow-up examinations and suggest treatment solutions for any complications.

Materials and methods

In this study, we followed up eight patients (six men and two women) who had undergone shoulder arthrodesis with a reconstruction plate from January 1995 to December 2005; the surgery was performed for five left and three right shoulders by one surgeon. The average follow-up period was 44 months (range: 17–92 months). The average age of the patients at the time of surgery was 45.9 years (range: 14–84 years). The indications for shoulder arthrodesis were joint destruction as a sequel of tuberculous arthritis (two cases), malignant bone tumour (two cases), pyogenic arthritis (two cases), failure of the first shoulder arthrodesis (one case) and paralysis of the brachial plexus (one case). Autologous bone grafting was performed in one of the two tuberculous arthritis cases. In the two bone tumour cases, after removing the osteosarcoma, autologous and homologous bone grafting were performed simultaneously to correct severe bone deficit (Table 1).

We employed the standard position—15° abduction, 15° flexion and 40° internal rotation. The joints were fixed after confirming the position at which the hand of the affected side could reach the mouth and the groin.

For all of the patients, we used 4.5-mm ten-hole pelvic reconstruction plates and fused the glenoid fossa, humerus and acromiohumeral part simultaneously by applying both intra-articular and extra-articular fixation. At follow-up examination, we evaluated radiological bony union, pain after surgery and complications and assessed the benefits and clinical outcomes of shoulder arthrodesis with a reconstruction plate.

Surgical procedure and postoperative care

Each patient was placed in the lateral decubitus position under general anaesthesia. A skin incision was made along the spine of the scapula, acromion, deltopectoral groove and down to the deltoid tuberosity. The rotator cuff was excised and the entire area, including the glenoid fossa and proximal humerus, was exposed. The subsequent surgery involved decortication of the glenoid fossa, head of the humerus and undersurface of the acromion. The positions for glenohumeral and acromiohumeral fixation were then determined, and 2–3 Steinmann pins were used for temporary fixation such that the hand of the affected side could reach the patient's mouth and groin. Fixation was performed using a 4.5-mm ten-hole pelvic reconstruction plate with screws; the plate was bent to suit the curve of the scapular spine, acromion and proximal humerus and then fixed after refixing the head of the humerus and glenoid with 1–2 cancellous bone screws. When an autologous bone graft was possible, we grafted cancellous bone to the glenohumeral and acromiohumeral surfaces. After the operation, the shoulder was immobilised in an abduction brace in all of the cases for at least six weeks.

Results

We confirmed clinical and radiological shoulder fusion during the follow-up in all of the cases. Although determining the accurate period of joint fusion was difficult, we were easily able to confirm radiological bony fusion at the shoulder joint within 4–12 months after the operation in seven cases. One case was unavailable for follow-up during this period. However, radiological bony fusion in this case was confirmed at 14 months after the operation (Table 2).

When there was radiological bony union, the shoulder pain was completely abolished. Six patients, including the representative patient (case 1) who was revised for failed

Table 1 Summary of cases

Case No.	Sex/age	Underlying disease	Affected side	Follow-up period (months)	Bone graft
1	M/17	Tuberculosis	Right	92	Autograft
2	F/48	Brachial plexus injury	Left	49	
3	M/19	Osteosarcoma	Right	50	Autograft & allograft
4	F/14	Osteosarcoma	Right	62	Autograft & allograft
5	M/57	Tuberculosis	Left	17	
6	M/68	Septic arthritis sequelae	Left	47	
7	M/60	Failed fusion	Right	22	
8	M/84	Septic arthritis sequelae	Right	17	

Table 2 Results of treatment

Case No.	Radiographically determined time to fusion (postoperative period, months)	Pain ^a	Removal of implants (postoperative period, months)	Complications
1	7	None	17	
2	5	None	13	
3	5	None	14	Peri-arthrodesis fracture
4	8	None	30 ^b	Plate loosening Peri-arthrodesis fracture
5	12	None		
6	10	None	.	
7	6	None	22	
8	14 ^c	None		

^a Refers to radiographic fusion^b In this case, removal of implants was followed by resection arthroplasty^c This case was temporarily lost to follow-up

shoulder arthrodesis, exhibited progressive radiological arthrodesis and functional improvement at the follow-up examinations.

The implants were removed after an average of approximately 16 months (range: 13–22 months) in four cases. A fracture in the distal part of the arthrodesed shoulder occurred at 40 months after the surgery in one of the two cases of osteosarcoma (case 2). In the other osteosarcoma case, shoulder arthrodesis was repeated following a fracture in a part of the homologous bone graft and loosening of the plate at 12 months after the surgery; subsequently, resection arthroplasty was performed after the removal of the implants, which led to continuous disappearance of bone.

With the exception of the two patients who underwent arthrodesis after malignant bone tumour resection, none of

the patients complained of severe pain or other complications (Table 2).

Case 1

A 60-year-old man underwent shoulder arthrodesis with Knowles pins in another hospital due to injury of the right brachial plexus after a motorcycle accident. He visited our hospital because of continuous pain and bony nonunion after the surgery (Fig. 1a). Removal of the Knowles pin and shoulder arthrodesis with a reconstruction plate were performed (Fig. 1b). We observed that nonunion had occurred because insufficient cortical bone had been removed from the glenohumeral joint. Radiological bony arthrodesis was confirmed at the six-month follow-up (Fig. 1c), and implants were removed 22 months after our

Fig. 1 **a** Radiograph of a 60-year-old man obtained after arthrodesis with Knowles pins shows bone nonunion. Postoperative radiographs showing shoulder arthrodesis with a reconstruction plate (**b**) and bony

fusion after 6 months (**c**). **d** Radiograph obtained 22 months after implant removal shows bony union

operation (Fig. 1d). Pain and other complications did not develop after the operation.

Case 2

A 19-year-old man with an osteosarcoma in the right proximal humeral head was under follow-up after the excision of the osteosarcoma and limb salvage with a fibula graft. However, joint destruction with severe osteolysis was observed after three years (Fig. 2a). Allogeneous and autogenous bone grafting were performed concomitantly with shoulder arthrodesis using a reconstruction plate (Fig. 2b), and radiological fusion was confirmed at five months after the surgery. Removal of implants was performed at 14 months, and a linear fracture was observed in the distal part of the arthrodesed shoulder at 38 months post-operatively (Fig. 2c); a complete fracture was observed after more than 40 months post-operatively (Fig. 2d).

Discussion

The objectives of shoulder arthrodesis are limited [6, 21]. The primary objectives are to provide pain relief and a stable platform for elbow and hand function as well as allowing active elevation of the shoulder to a certain extent through scapulothoracic motion [21].

This operative procedure should only rarely be indicated as a salvage option for selected cases in which other reconstructive methods would probably provide little benefit. In our study, we only selected and operated on patients who were unable to carry out activities of daily

living, whose pain had persisted for more than three months and who were strongly in favour of surgery.

According to Rowe, an upper limb should have the following functional parameters after shoulder arthrodesis. First, the hand should be able to reach the face, head and midline of the body anteriorly and posteriorly. Second, the arm should be in the position of maximum strength for lifting, pushing and pulling. Third, the shoulder should be comfortable when the arm is at the side of the body, and the scapula should not be prominent in this position [17]. Hawkins and Neer recommended 25–40° abduction, 20–30° flexion and 25–30° internal rotation of the shoulder [11]; Richards et al. recommended abduction, flexion and internal rotation of approximately 30° [15], while Matsen et al. proposed 15° abduction, 15° flexion and 40° internal rotation as the appropriate position [13]. Many researchers have emphasised the importance of a fixed angle of the shoulder joint. However, Barton asserted that a direct correlation does not exist between a fixed angle of the shoulder joint and pain of the muscles supporting the shoulder, and that excessive abduction and internal rotation should be avoided, but some variation in the position of arthrodesis appears to be permissible [2]. The optimal position for shoulder joint fixation remains controversial; however, many researchers agree that some degree of abduction and flexion and a greater internal rotation are necessary [5]. In our study, the shoulder was fixed in a standard position at which the hand could reach the mouth and groin; this position was mainly 15° abduction, 15° flexion and 40° internal rotation.

Various types of shoulder arthrodeses have been proposed, of which the combination of intra-articular and

Fig. 2 **a** Radiograph of a 19-year-old man obtained after wide excision of the osteosarcoma shows a severe bony defect and articular destruction. **b** Shoulder arthrodesis with a reconstruction plate was performed along with simultaneous autologous and homologous bone

grafting. **c** Implant removal was performed. Radiograph obtained 38 months post-operatively demonstrates a linear fracture of the proximal humerus. **d** Radiograph obtained at 40 months post-operatively shows a complete fracture

extra-articular fixation is considered the most effective method. Richards et al. reported the achievement of adequate stability and bony fusion after intra-articular fixation with 4.5-mm ten-hole pelvic reconstruction plate [15]; this method was later recommended by Groh et al. [10]. A reconstruction plate can be bent to suit the anatomy of the region more easily and accurately than a DCP. Further, the former reduces skin irritation since there are relatively few protrusions of the implant [15]. Clare et al. recommended the use of a reconstruction plate in routine cases, but preferred the use of a DCP in obese patients weighing more than 100 kg [5] (Table 3).

Complications of shoulder arthrodesis include bony nonunion, malposition of the joint, fracture around the arthrodesis, infection, continuous pain and irritation of soft tissues by projections of the implant. Such complications are largely controlled by bone quality, bone quantity and soft tissue conditions in the arthrodesed area [20].

The incidence of nonunion has been reported to be approximately 0–20% [7, 8, 11, 15, 24], and in the event of such a nonunion, arthrodesis can be easily accomplished mainly by bone graft and refixation [20]. In our series, achieved a firm arthrodesis by performing a second arthrodesis using a reconstruction plate in a patient in whom failure of the first arthrodesis had led to bony nonunion and pain.

With regard to malpositioning of the fusion, the optimum position for fixation is debatable and therefore cannot be established. However, Groh et al. reported that in cases with severe pain in the shoulder joint or discomfort in routine activities, a remarkable relief in pain and improvement in function can be achieved by corrective osteotomy and plate fixation [10].

Postoperative infections have been reported in 0–14% of shoulder arthrodeses [7, 9, 15, 19]. In our cases, we routinely used prophylactic antibiotics and did not experience any infections.

When there is concurrent osteopaenia, loss of movement at the glenohumeral joint after arthrodesis can cause a

fracture around the bony fusion even after relatively minor trauma; such a fracture was typically found in the distal part of the arthrodesed shoulder in our study.

The implant used in shoulder arthrodesis can often cause topical skin irritation when it is placed in a relatively superficial layer; therefore, removal of the implant is required after a firm bony fusion is achieved in the majority of cases. Richards et al. reported a lower rate of complications with a reconstruction plate than with a DCP [15]. On the other hand, Diaz et al. reported that five of eight cases treated with a reconstruction plate required implant removal [8]. In our study, the implants were removed in four cases because the patients were relatively young (average: 36 years, range: 17–60 years) and they requested removal of the implants.

After tumour resection, shoulder arthrodesis can be a more appropriate alternative than amputation from the viewpoint of aesthetics and function in cases where arthroplasty is not feasible due to the bone deficit in the proximal humerus and severely damaged surrounding soft tissue [4, 5, 22]. Cheng and Gebhardt reported a high patient satisfaction rate in all patients undergoing shoulder arthrodesis after malignant bone tumour resection. Stability and functional recovery were better when autologous or homologous bone grafting was performed simultaneously in the proximal part of the humerus [4, 22]. Cofield and Briggs reported that a bone graft from the iliac crest as well as fibular strut grafts could be considered in cases of bone deficit [4, 7]. We performed simultaneous autologous and homologous bone grafting in two patients who underwent arthrodesis after malignant bone tumour resection, and both patients showed bony fusion and satisfactory function after arthrodesis during the early follow-up period. However, during the long-term follow-up, we noted a fracture in the distal part of the fusion; the fracture had been induced by continuous bone loss and osteolysis. Therefore, it is recommended that therapeutic alternatives other than bone grafting will be required while performing shoulder arthrodesis after malignant bone tumour resection.

Table 3 Selected reports of arthrodesis with a plate

Authors	Year	<i>n</i>	Fixation method	Follow-up (months)
Hawkins and Neer [11]	1987	17	Plate or screws	40
Leffert and Pess [12]	1988	21	Plate	-
Arntz et al. [1]	1991	11	Plate	38
Stark et al. [23]	1991	15	DC plate	18
Richards et al. [14]	1993	57	Reconstruction plate or DC plate	43
Groh et al. [10]	1997	28	Reconstruction plate or DC plate	74
Ruhmann et al. [18]	1999	14	Reconstruction plate or DC plate	14
Dimmen and Madsen [9]	2007	18	Plate	90

Conclusion

In cases without severe bone deficit, shoulder arthrodesis with a reconstruction plate can be considered a useful method for end-stage salvage. Further, additional therapeutic measures should be considered to prevent a fracture that may occur consequent to severe bone deficit.

References

1. Arntz CT, Matsen FA 3rd, Jackins S (1991) Surgical management of complex irreparable rotator cuff deficiency. *J Arthroplasty* 6:363–370
2. Barton NJ (1972) Arthrodesis of the shoulder for degenerative conditions. *J Bone Joint Surg Am* 54:1759–1764
3. Beltran JE, Trilla JC, Barjau R (1975) A simplified compression arthrodesis of the shoulder. *J Bone Joint Surg Am* 57:538–541
4. Cheng EY, Gebhardt MC (1991) Allograft reconstructions of the shoulder after bone tumor resections. *Orthop Clin North Am* 22:37–48
5. Clare DJ, Wirth MA, Groh GI, Rockwood CA Jr (2001) Shoulder arthrodesis. *J Bone Joint Surg Am* 83-A:593–600
6. Cofield RH (1985) Shoulder arthrodesis and resection arthroplasty. *Instr Course Lect* 34:268–277
7. Cofield RH, Briggs BT (1979) Glenohumeral arthrodesis. Operative and long-term functional results. *J Bone Joint Surg Am* 61:668–677
8. Diaz JA, Cohen SB, Warren RF, Craig EV, Allen AA (2003) Arthrodesis as a salvage procedure for recurrent instability of the shoulder. *J Shoulder Elbow Surg* 12:237–241
9. Dimmen S, Madsen JE (2007) Long-term outcome of shoulder arthrodesis performed with plate fixation: 18 patients examined after 3–15 years. *Acta Orthop* 78:827–833
10. Groh GI, Williams GR, Jarman RN, Rockwood CA Jr (1997) Treatment of complications of shoulder arthrodesis. *J Bone Joint Surg Am* 79:881–887
11. Hawkins RJ, Neer CS 2nd (1987) A functional analysis of shoulder fusions. *Clin Orthop Relat Res* 223:65–76
12. Leffert RD, Pess GM (1988) Tendon transfers for brachial plexus injury. *Hand Clin* 4:273–288
13. Matsen FA, Rockwood CA Jr, Wirth MA, Lippitt SB, Parsons M (2004) Glenohumeral arthritis and its management. In: Rockwood CA Jr, Matsen FA, Wirth MA, Lippitt SB (eds) *The shoulder*, 3 edn. Saunders, Philadelphia, pp 879–1008
14. Richards RR, Beaton D, Hudson AR (1993) Shoulder arthrodesis with plate fixation: functional outcome analysis. *J Shoulder Elbow Surg* 2:225–239
15. Richards RR, Sherman RM, Hudson AR, Waddell JP (1988) Shoulder arthrodesis using a pelvic-reconstruction plate. A report of eleven cases. *J Bone Joint Surg Am* 70:416–421
16. Riggins RS (1976) Shoulder fusion without external fixation. A preliminary report. *J Bone Joint Surg Am* 58:1007–1008
17. Rowe CR (1974) Re-evaluation of the position of the arm in arthrodesis of the shoulder in the adult. *J Bone Joint Surg Am* 56:913–922
18. Ruhmann O, Gosse F, Wirth CJ, Schmolke S (1999) Reconstructive operations for the paralyzed shoulder in brachial plexus palsy: concept of treatment. *Injury* 30:609–618
19. Ruhmann O, Schmolke S, Bohnsack M, Flamme C, Wirth CJ (2005) Shoulder arthrodesis: indications, technique, results, and complications. *J Shoulder Elbow Surg* 14:38–50
20. Safran O, Iannotti JP (2006) Arthrodesis of the shoulder. *J Am Acad Orthop Surg* 14:145–153
21. Scalise JJ, Iannotti JP (2008) Glenohumeral arthrodesis after failed prosthetic shoulder arthroplasty. *J Bone Joint Surg Am* 90:70–77
22. Scarborough MT, Helmstedter CS (1997) Arthrodesis after resection of bone tumors. *Semin Surg Oncol* 13:25–33
23. Stark DM, Bennett JB, Tullos HS (1991) Rigid internal fixation for shoulder arthrodesis. *Orthopedics* 14:849–855
24. Wick M, Muller EJ, Ambacher T, Hebler U, Muhr G, Kutschal-Lissberg F (2003) Arthrodesis of the shoulder after septic arthritis. Long-term results. *J Bone Joint Surg Br* 85:666–670