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Internal fixation of valgus-impacted humeral head fractures using the screw-wiring technique

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Abstract Between February 1996 and July 2000 eight patients (ages 35–74 years) with nine severely impacted humeral head fractures were operated on with the aim of preserving the humeral heads. Patients were treated surgically with open reduction, autologous bone grafting, and internal fixation with a screw-wiring technique. There were no complications and all patients were satisfied with the results. After 10–63 months there was no evidence of nonunion, arthritis, avascular necrosis, or loosening of implants. The mean Constant score was 83 (66–97) points. Results of this study support the observation that four-part valgus-impacted humeral head fractures without significant lateral displacement have a low incidence of avascular necrosis.

Résumé Entre février 1996 et juillet 2000, 8 patients (âge 35–74 ans) avec 9 fractures impactées de la tête humérale ont été opérés avec le but de conserver la tête humérale. Ils ont été traités avec réduction ouverte, greffe osseuse autologue et fixation interne avec une technique de vissage – cablage. Il n’y avait pas de complications. Tous les patients ont été satisfaits. Après un délai de 10 à 63 mois il n’y avait pas de défaut de consolidation, ni d’arthrose, de nécrose avasculaire ou de démontage d’implant. Le score de Constant moyen était 83 (66–97)

points. Les résultats de cette étude confirment que les fractures de la tête humérale à quatre fragments avec impaction valgusée et sans déplacement latéral notable ont un taux faible de nécrose de avasculaire.

Introduction

Management of displaced four-part proximal humeral fractures is difficult, especially in the elderly [2, 6, 10, 12, 13, 15, 20]. The valgus-impacted humeral head fracture is a specific type that is not mentioned in the Neer’s classification [16, 17]. This type of fracture consists of four fragments with variable degrees of displacement of the greater and lesser tuberosities and usually a severe degree of valgus impaction of the humeral head [11, 19]. Despite few reports having been published on this subject, recent literatures shows that reconstruction rather than replacement yields good results [5, 11, 18]. There is no consensus about fixation methods: AO screws, and Kirschner wires with or without circlage wires, were utilized in the Jakob series [11]; multiple transosseous sutures crossing the fracture line were utilized in the Resch series [18]. In this review we present results following the screw-wiring technique and autologous bone grafting.

Patients and methods

Between February 1996 and July 2000 a total of eight patients (Table 1) presenting with valgus-impacted humeral head fractures were operated on at either Tuen Mun Hospital or North District Hospital with the aim of achieving anatomic reconstruction. One patient had bilateral fractures. Average age at time of injury was 56 years, and average period of follow-up was 26.1 (10–63) months.

Severity of lesions was expressed in terms of degree of impaction angle. Initial anteroposterior radiographs were used to measure the angle between the fracture plane of the articular segment and the axis of the humeral shaft (Fig. 1). The average impaction angle was 93.7° (80–120°) and no patient had lateral displacement of more than 1 mm (Table 1).

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Fig. 1 Anteroposterior radiograph of shoulder showing impaction angle formed by the fracture plane of the articular segment and the axis of the humeral shaft

All cases were treated operatively by open reduction and were stabilized by utilizing a screw-wiring technique. Chips of autologous cancellous bone graft were employed to fill the void created by raising the impacted humeral head in all but one case. In this case the impaction angle was 120° and a carefully shaped cortical cancellous graft was used.

For the surgical procedure patients were placed in a supine, semireclining position on the operating table with a soft support beneath the scapula on the affected side. A standard anterior incision measuring 10 cm in length was made. The arm was then abducted to facilitate retraction of the deltoid in the posterior direction, with lysis of adhesions between the muscle belly and the underlying tissues. The deltoid origin and soft tissue attached to the tuberosity fragments were preserved. The fracture line between the two tuberosity fragments was identified and separated gently to allow insertion of the tip of a curved elevator, and the articular

Fig. 2 Position of humeral head fragment was confirmed under intraoperative X-ray control

fragment was raised far enough to permit opposition of the tuberosities. Position of the humeral head fragment was confirmed under intraoperative X-ray control (Fig. 2). The void created by raising the impacted humeral head was filled with chips of autologous cancellous bone graft. The tuberosities were then relocated in correct anatomic position, secured to each other, and anchored to the shaft with a 20-gauge stainless wire – similar to the method described by Hawkins [9, 8, 7]. A 14-gauge large-bore colpotomy needle was passed through the subscapularis tendon and its attached lesser tuberosity, and out through the reduced greater tuberosity and supraspinatus tendon. (Predrilling with a 2 mm K-wire might be required in cases involving strong cortical bone.) The stainless wire was passed through the needle and the needle was removed, leaving the wire in place. The wire was crossed over the site of the fracture and tied. One to two cortical screws were inserted to fix the greater tuberosity to the medial cortical bone of the shaft. A washer was employed in osteoporotic bone. The rent between the supraspinatus and the subscapularis tendons was then repaired, and the shoulder was carefully moved through a limited range of motion to confirm the stability of fixation.

A closely monitored three-phase rehabilitation program was given to all patients, including immediate postoperative mobilization exercise. The first phase lasted 3 weeks and consisted of passive-assistive mobilization exercise. The second phase was started 3 weeks later and consisted of active-assisted mobilization exercise. In the third phase active-resisted exercise was given after radiological evidence of healing – usually 8 weeks after surgery.

Anteroposterior radiographs were taken to assess fracture position, loosening of implants, osteoarthritis, avascular necrosis, and

Table 1 Overview of clinical data. *M* male, *F* female, *na* not applicable

Patient no	Sex/age (years)	Mechanism of injury	Injured limb	Lateral displacement (mm)	Injury impaction angle ($^\circ$)	Final impaction angle ($^\circ$)	Duration of follow-up (months)	Constant score (injured side)	Constant score (normal side)	Functional score (%)
1	M/35	Sport	Left	1	82	50	63	97 (Left)	97 (Right)	100
2	M/40	Fall	Left	0	80	48	27	93 (Left)	97 (Right)	96
3	F/56	Fall	Left	0	91	68	27	76 (Left)	81 (Right)	94
4	F/63	Fall	Right	0	81	58	26	80 (Right)	87 (Left)	92
5a	M/41	Motorcycle	Right	1	103	62	18	93 (Right)	na	(93)
5b			Left	0	88	62	18	93 (Left)	na	(93)
6	F/74	Fall	Right	0	99	64	23	66 (Right)	75 (Left)	88
7	F/74	Fall	Left	0	100	62	15	75 (Left)	85 (Right)	88
8	F/66	Fall	Right	0	120	59	10	74 (Right)	83 (Left)	89

Fig. 3 Anteroposterior radiograph of the same patient 10 months after the injury showing absence of avascular necrosis, arthritis and loosening of implants, and maintenance of reduced impaction angle

nonunion (Fig. 3). Functional outcomes were assessed on the basis of Constant and Murley scoring system at final follow-up [3]. Patients' satisfaction, occupational life, and sporting activities were also reviewed.

Results

All patients were available for final assessment. Accuracy of surgical reduction was assessed by postoperative anteroposterior radiographs. The average impaction angle was 59.2° (48 – 68°). There were no wound complications and no radiological evidence of loss of reduction. At final assessment there was no radiological evidence of avascular necrosis, arthritis, nonunion, or loosening of implants.

With the patients in a sitting position, the average active total elevation was 148° (125 – 170°). Upon assessment of internal rotation with respect to the posterior segment reached by the thumb, all patients could reach at least the T8 segment. With the patients in a supine position, the average passive total elevation was 168° (150 – 180°).

Three male patients had an occupation before injury, and all could resume their occupation without difficulty. All patients could resume previous levels of daily and recreational activities.

All patients were well satisfied with the results. They reported either no pain, or mild pain after heavy physical

activity. None required analgesics for pain control. The Constant score was fully evaluated for all patients and the mean was 83 (66 – 97) points. As a departure from the original method, results were compared with the contralateral glenohumeral joint [18]. The average functional score in comparison with the nontraumatized side was 92.5% (88 – 100%).

Discussion

Valgus-impacted fracture of the proximal humerus is not specifically mentioned in Neer's classification [16, 17], and clinical behavior differs from that of other displaced four-part fractures with a much lower chance of avascular necrosis of humeral heads. Rates of avascular necrosis were five out of 19 cases in the Jakob series [11] and two out of 22 cases in the Resch and Bayley series [18].

Two circumflex arteries surround the surgical neck: the anterior circumflex artery provides a constant antero-lateral "arcuate" artery formed by the ascending branch which enters the humeral head at the upper end of the bicipital groove, or by penetrating the tuberosities with multiple branches [14]. Valgus-impacted humeral head fracture universally involves fractures of the greater and lesser tuberosities that could disrupt this blood supply to the humeral head. The articular fragment is maintained only via the periosteum extending to the medial part of the anatomical neck. Resch proposed that, in cases with only slight or zero lateral displacement between the humeral head fragment and the humeral shaft, vascularity to the humeral head fragment was either not, or only rarely, compromised [18]. This accounts for the low rate of osteonecrosis of the humeral head fragment.

We strictly selected our cases, with only two cases having a 1-mm lateral displacement. In addition, there were no complications of avascular necrosis of the humeral head fragments. While based on a relatively small number of cases (eight patients and nine fractures), our findings support other reports in the literature that the incidence of avascular necrosis is much lower than in other displaced four-part fractures, and proceeding to arthroplasty is apparently not indicated [11].

Like Jakob, we object to nonoperative treatment [11]. Joint incongruity will be present if the valgus-impacted humeral head is left in situ. The disturbed joint mechanics may lead to osteoarthritis, and malunited tuberosities can lead to impingement. Bigliani recommended open reduction and internal fixation for any greater tuberosity displacement of more than a 5 mm in order to obtain optimum results [1]. All our cases showed significant displacement of the greater tuberosity.

However, there is no consensus about fixation methods for this type of fracture. Various methods were used in the Jakob series [11], and a large number of transosseous sutures were employed in the Resch and Bayley series [18]. It is important to provide enough postoperative stability to allow early mobilization exercise essential for optimum function [1]. Operative stabilization re-

quires an understanding of the relative merits of various implant techniques. While the mean age of our patients was 56.3 years, the mean age of the five women patients was 66.6 years, and the bone was osteoporotic. Wiring was chosen as it allows incorporation of the intact musculotendinous insertions with the fracture fragment – rotator cuff tissue is stronger than the osteoporotic proximal humerus [4, 9, 8, 7]. The greater tuberosity fragment was usually intact. We added one to two 3.5-mm cortical screws, with washer, to fix these relatively intact fragments to the opposite medial cortex at the proximal humeral shaft, a technique that improves purchase [8]. There was no loosening of implant at follow-up in any of our cases. Jakob recommended that bone grafting was not usually necessary [11]. However, we found that the void created was quite significant. Like Resch and Bayley we filled the void with autologous bone graft in all cases [18] except one, in which case a cortical cancellous graft was placed to ensure adequate support.

Rehabilitation is essential because adequate motion is needed for optimum functional results [1]. Resch and Bayley immobilized the arm at 90° of abduction during the immediate postoperative period; after 10 days the shoulder was mobilized [18]. We found that, with the screw-wiring technique supplemented with adequate autologous bone graft, the fracture-implant construct was stable enough to withstand physiologic forces. Hence, we allowed immediate mobilization exercise similar to the three-phase system by Hughes and Neer [1]. This may explain our superior results of a functional score of 92.5% compared to the functional score of 84% in the Resch and Bayley series [18]. A well-defined program of rehabilitation is necessary [9] and active participation by patient, physiotherapist, and occupational therapist is important. Furthermore, the patient must not be discharged before maximum results are obtained.

In conclusion, good functional and radiological results can be achieved after reconstruction with adequate bone grafting and the screw-wiring technique. The procedure should be considered for the four-part valgus-impacted fracture without significant lateral displacement.

References

1. Bigliani LU, Flatow EL, Pollock RG (1998) Fractures of the proximal humerus. In: Rockwood CA, Matsen FA (Eds) *The shoulder*, 2nd edn. Saunders, Philadelphia
2. Cofield RH (1988) Comminuted fractures of the proximal humerus. *Clin Orthop* 230:49–57
3. Constant CR, Murley AHG (1987) A clinical method of functional assessment of the shoulder. *Clin Orthop* 214:160–164
4. Cornell CN, Levine D, Pagnani MJ (1994) Internal fixation of proximal humerus fractures using the screw-tension band technique. *J Orthop Trauma* 8:23–27
5. Cuomo F (1996) Fractures about the shoulder. *Curr Opin Orthop* 7:77–82
6. Esser RD (1994) Treatment of three- and four-part fractures of the proximal humerus with a modified cloverleaf plate. *J Orthop Trauma* 8:15–22
7. Hawkins RJ, Angelo RL (1987) Displaced proximal humeral fractures – selecting treatment, avoiding pitfalls. *Orthop Clin North Am* 18:421–431
8. Hawkins RJ, Kiefer GN (1987) Internal fixation techniques for proximal humeral fractures. *Clin Orthop* 223:77–85
9. Hawkins RJ, Bell RH, Gurr K (1986) The three-part fracture of the proximal part of the humerus. *J Bone Joint Surg [Am]* 68:1410–1414
10. Henrik SH (1974) Displaced proximal humeral fractures. *Acta Orthop Scand* 45:359–364
11. Jakob RP, Miniaci A, Anson PS, Jaberg H, Osterwalder A, Ganz R (1991) Four-part valgus impacted fractures of the proximal humerus. *J Bone Joint Surg [Br]* 73:295–298
12. Knight RA, Mayne JA (1957) Comminuted fractures and fracture-dislocations involving the articular surface of the humeral head. *J Bone Joint Surg [Am]* 39:1343–1355
13. Kristiansen BK, Christensen SW (1986) Plate fixation of proximal humeral fractures. *Acta Orthop Scand* 57:320–323
14. Laing PG (1956) The arterial supply of the adult humerus. *J Bone Joint Surg [Am]* 38:1105–1116
15. Mills HJ, Horne G (1985) Fractures of the proximal humerus in adults. *J Trauma* 25:801–805
16. Neer CS (1970) Displaced proximal humeral fractures – Part I. Classification and evaluation. *J Bone Joint Surg [Am]* 52:1077–1089
17. Neer CS (1970) Displaced proximal humeral fractures – Part II. Treatment of the three-part and four-part displacement. *J Bone Joint Surg [Am]* 52:1090–1103
18. Resch H, Beck E, Bayley I (1995) Reconstruction of the valgus-impacted humeral head fracture. *J Shoulder Elbow Surg* 4:73–80
19. Stableforth PG (1984) Four-part fractures of the neck of the humerus. *J Bone Joint Surg [Br]* 66:104–108
20. Zyto K, Ahrengart L, Sperber A, Tornkvist H (1997) Treatment of displaced humeral fractures in elderly patients. *J Bone Joint Surg [Br]* 79:412–417