

Hook-plate fixation of unstable lateral clavicle fractures

A report on 63 patients

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Background Hook-plate fixation of unstable lateral clavicle fractures has given promising results in previous reports, but numbers of patients have been small. We assessed the results of this technique in 63 patients.

Patients and methods 63 patients with unstable lateral clavicle fractures were operated on at Oulu University Hospital during 1997–2004, using a clavicle hook-plate. Fracture union and complications were assessed retrospectively from case records and radiographs. The subjective part of the Constant score, Oxford shoulder questionnaire data and subjective shoulder value (SSV) were assessed after an average of 3.6 years in 58 patients. 31 patients were reviewed at the outpatient clinic, using complete Constant scores and radiographs of both acromioclavicular joints.

Results 59 fractures united uneventfully. There was 1 case of delayed union and 3 nonunions, but only 1 of these required surgery. Additional complications involved 1 case of infection, 1 frozen shoulder and 3 cases of late fracture medial to the plate. The mean Oxford score was 15, the mean for the subjective part of the Constant score was 32, and the SSV was 86%.

Interpretation Clavicle hook-plate fixation of unstable lateral clavicle fractures results in a good union rate and good shoulder function.

such as transarticular Kirschner wire or Knowles pin fixation, tension band, coracoclavicular screw, and Dacron band fixation, with good results (Neer 1963, Eskola et al. 1987, Ballmer and Gerber 1991, Chen et al. 2002, Fann et al. 2004). Many of the studies have involved small case series reported by surgeons who described a new operative technique for this relatively rare fracture (Ballmer and Gerber 1991, Goldberg et al. 1997, Mall et al. 2002, Levy 2003, Bezer et al. 2005, Scadden and Richards 2005). Other authors have reported the results of several different operative methods carried out at a single center over a long period of time (Hessmann et al. 1996, Kruger-Franke et al. 2000). Patient numbers in published papers on surgical treatment of Neer type 2 unstable lateral clavicle fractures have ranged from 3 to 41 only, and it is difficult to draw reliable conclusions from these (Table 1). We have reported good outcome of clavicle hook-plate fixation in 17 patients (Flinkkilä et al. 2002). Other studies on this technique have involved up to 23 cases (Schmittinger and Sikorski 1983, Eberle et al. 1992, Hakenbruch et al. 1994, Mizue et al. 2000, Meda et al. 2006). Starting in 1997, we have used hook-plate fixation in 63 patients with unstable lateral clavicle fractures. The purpose of this paper is to report our experiences and results with these patients, and to describe the complications associated with this technique.

The treatment of unstable lateral clavicle fractures (Neer type 2), although controversial, is often operative (Anderson 2003, Ritchie and McCarty 2004). Several surgical techniques have been described,

Table 1. Results of Neer type 2 unstable lateral clavicle fractures

Study	n	Method	Union	Outcome measures ^a	Complications
Ballmer and Gerber (1991)	5	Coracoclavicular screw	5/5	ROM, strength	–
Bezer et al. (2005)	10	Suture anchor, K-wire	10/10		
Chen et al. (2002)	13	Coracoclavicular band	10/11	ROM, strength, own scoring	1 infection
Eberle et al. (1992)	12	Hook-plate, coracoclavicular srew		ROM	1 infection, 1 RSD
Edwards et al. (1992)	23	Various operative	23/23	ROM, local pain	3 screw or pin pull-outs,
	20	Nonoperative	14/20		
Eskola et al. (1987)	23	K-wire, plate	22/23	ROM, local pain	3 infections, 2 wire pull-outs
Fann et al. (2004)	32	Knowles pin	32/32	UCLA score	–
Flinkkilä et al. (2002)	17	Hook-plate	15/17	Constant score, L'Insalata score	1 diaphyseal fracture
	22	K-wire/tension band	20/22		12 wire migrations, 4 infections
Goldberg et al. (1997)	9	Coracoclavicular sling	8/9	ROM, strength	–
Hakenbruch et al. (1994)	21	Hook-plate	21/21	ROM, local pain	1 screw loosening
Hessman et al. (1996)	30	PDS banding, plate	30/30	ROM, local pain	4 infections, 3 hematomas
Kao et al. (2001)	12	K-wire, tension band	11/12	ROM, local pain	1 iatrogenic comminution
Kona et al. (1990)	19	Various	13/19	Own scoring	6 infections, 1 pin break-age, nerve injury
Kruger-Franke et al. (2000)	41	Various	38/41	Boenisch score	–
Levy (2003)	12	Interfragmentary wire	12/12	ROM, Constant score, strength	–
Macheras et al. (2005)	15	Coracoclavicular screw	15/15		
Mall et al. 2002	12	PDS tension band	12/12	Constant score	–
Meda et al. (2006)	23	Hook-plate	23/23	Constant score, ASES score	
Mizue et al. (2000)	16	Hook-plate	15/15	Strength, pain	–
Neer (1963)	23	Various	4/23	Local symptoms	–
Nordqvist et al. (1993)	23	Nonoperative	18/23	Shoulder symptoms	
Robinson and Cairns (2004)	86	Nonoperative	54/86	Constant score, SF-36	
Rokito et al. 2002	14	Coracoclavicular sling	14/14	UCLA score, ASES score	–
	16	Nonoperative	7/14	Constant score	
Scadden and Richards (2005)	10	Malleolar screw	10/10		
Schmittinger and Sikorski (1983)	3	Hook-plate	3/3	ROM	–
Tambe et al. (2005)	18	Hook-plate	16/18	Constant score	2 nonunion, 1 infection
Webber and Haines (2000)	15	Dacron sling, screw	15/15		
Yamaguchi et al. (1998)	11	Coracoclavicular screw	15/15	"Shoulder function"	–

^a Additional outcome measures besides subjective result and pain.

Patients and methods

All our patients with unstable Neer type 2 lateral clavicle fractures were operated on at Oulu University Hospital during 1997–2004. There were 63 patients (51 male) with a mean age of 39 (17–71) years. The 17 patients from our previous study (Flinkkilä et al. 2002) are also included in this study. The cause of injury was a bicycle accident in 21 cases, a simple fall in 19, a sports injury in 13, a fall from a height in 2, a motor vehicle accident

in 3 and various other causes in 5 cases. The right clavicle was involved in 30 cases and the left in 33 cases. The patients were operated on within 7 days of the injury using a clavicle hook-plate (Stratec Medical, Oberdorf, Switzerland). The operation was carried out by the surgeon on duty and there were 23 operating surgeons. The mean number of operations per surgeon was 4 (1–24). 12 surgeons carried out only 1 operation and only 2 surgeons carried out more than 4 operations. Postoperative treatment was early mobilization after pain had

Table 2. Shoulder pain and subjective part of the Constant score in 58 patients

	Affected side, mean (SD)	Control side, mean (SD)	Mean difference	95% CI for the difference	P-value ^a
Pain	13 (3.2)	14 (2.0)	-1.3	-2.1 to -0.4	0.004
Constant ^b	32 (5.7)	34 (4.3)	-2.1	-3.5 to -0.7	0.003

^a P-values refer to differences between affected and control side (paired t-tests).
^b Subjective part.

subsided, but heavy manual work was not allowed until the plate had been removed after 5(1–16) months. We evaluated the case records and radiographs of these 63 patients retrospectively to assess fracture union and complications.

The patients were reviewed after an average of 3.6 (0.6–6.9) years. 2 patients had died owing to causes unrelated to their clavicle fracture and 3 patients were lost to follow-up. All other 58 patients returned a self-administered Oxford shoulder questionnaire (Dawson et al. 1996), a subjective shoulder value (SSV) questionnaire (Jost et al. 2003) and the subjective part of the Constant score questionnaire (Constant and Murley 1987). In the Oxford shoulder questionnaire, a normal shoulder scores 12 points and severe disability scores 60 points. In the subjective part of the Constant score, a normal shoulder scores 35 points and severe disability scores 0 points. For the SSV, a completely normal shoulder scores 100%. The unaffected shoulder was used as a control where appropriate. The patients were invited to the outpatient clinic, but only 31 patients participated in follow-up examination, which was carried out by an independent physiotherapist (shoulder range-of-motion (ROM), acromioclavicular (AC) joint tenderness, Constant score, and radiographs of both AC joints). Most of those patients who did not pay a follow-up visit were contacted by phone, but most of them were not interested in a follow-up visit because they felt that they had recovered sufficiently.

Statistics

We used paired t-tests when comparison against the unaffected side was possible. Analysis of covariance (ANCOVA) was used to test the significance of age, sex and the length of follow-up to pain and subjective part of the Constant score. Because of the small number of patients, we constructed two

different ANCOVA models: (1) age and sex, and (2) length of follow-up and sex, both of which were adjusted using control-side values. We used SPSS version 12.0.1 software. A p-value of less than 0.05 was considered statistically significant. Summary data is presented as mean (range) where appropriate.

Results

59 fractures united uneventfully. There was 1 case of delayed union (union after 6 months) and 3 cases of nonunion. 2 of these were probably the result of premature plate removal (at 2 and 3 months) and 1 patient had early plate loosening. Subsequent K-wire fixation failed, leading to nonunion. 1 patient with nonunion was operated on using a new hook-plate and bone grafting from the iliac crest, and union occurred uneventfully. The other 2 patients had only mild symptoms and no operation was needed. Additional complications involved 1 case of superficial infection, which was resolved with antibiotics, and 1 frozen shoulder, which needed manipulation under anesthesia with a good result eventually. There were 3 cases of late diaphyseal fractures medial to the plate after new falls. 1 patient was an epileptic who had recurrent seizures and the 2 other patients abused alcohol. 2 of these patients were treated nonoperatively; 1 needed plate fixation and eventually all 3 fractures united.

The mean Oxford shoulder score was 16 (12–43), indicating good shoulder function and minimal symptoms. Mild shoulder pain during exercise was the most common complaint. The subjective part of the Constant score (mean) was 32 (10–35) and the control side score was 34 (14–35), the difference being statistically significant (Table 2). Mean SSV was 86% (20–100). 41 patients

regarded their shoulder value as being 90–100%, 8 patients as 80–90%, 3 patients as 70–80% and 6 patients regarded it as being below 70%. Pain, as assessed by means of a 15-cm visual analog scale, had a mean value of 13 (3–15) and the control side 14 (1–15), the difference being statistically significant (Table 2). Among those 31 patients who could be assessed completely, the mean Constant score was 80 (30–94), while the control shoulder scored 82 (23–93). 10 patients showed pain on AC joint palpation. 10 shoulders showed mild AC osteoarthritis (irregularities of the clavicle joint surface/mild osteophytes). The number of patients was too small to allow statistical analysis regarding symptoms and osteoarthritis.

According to ANCOVA, age and sex (model 1, $p = 0.9$ and 0.1 , respectively) and length of follow-up and sex (model 2, $p = 0.5$ and 0.2 , respectively) were not significant covariates for the subjective part of the Constant score and the difference relative to the control side remained significant ($p < 0.001$ in both models).

Discussion

The hook-plate fixation resulted in a good union rate, good shoulder function and patient satisfaction, and the overall complication rate (14%) was acceptable. Although statistically significant, the difference between the affected and control sides in pain and the subjective part of the Constant score was very small, and probably not relevant clinically. A fracture medial to the plate was a typical late complication, usually caused by a new fall. Our results support previous reports with smaller patient material (Schmittinger and Sikorski 1983, Eberle et al. 1992, Hakenbruch et al. 1994, Flinkkilä et al. 2002).

Comparison of the hook-plate technique with other operative methods of fixation of unstable lateral clavicle fractures is difficult. Previous studies on fixation by means of K-wire, tension band wiring, coracoclavicular screws and Knowles pins have indicated good results, but patient numbers have been small (Table 1). The complication rate after K-wire fixation is also controversial, and high rates of wire migration have been reported (Kona et al. 1990, Flinkkilä et al. 2002). Migration after

Knowles pin fixation is less common, but the pin violates the AC joint and may cause osteoarthritis (Fann et al. 2004). In our previous study, we compared hook-plate and K-wire fixation and found that the functional result was similar, but the complication rate was much higher with K-wire fixation (Flinkkilä et al. 2002). Eberle et al. (1992) compared the hook-plate technique with coracoclavicular screw fixation, and concluded that both methods resulted in good shoulder function—but mobilization could be started earlier after hook-plate fixation. A disadvantage of hook-plate fixation is greater soft tissue dissection, and removal of the plate requires general anesthesia.

Despite using several operating surgeons with only a little experience of hook-plate fixation, we obtained good results, and this indicates that successful hook-plate fixation requires experience of basic plating techniques only. Unstable lateral clavicle fractures are not common injuries, and the hook-plate technique is especially suitable for small centers and for surgeons who treat these fractures only rarely.

Because the hook is inserted in the subacromial space behind the AC joint, the posterior part of the supraspinatus tendon and the musculotendinous junction may be at risk of abrasion by the metal. Hackenberger et al. (2004) studied 28 shoulders after hook-plate fixation (Breithaler plate), using MRI and ultrasonography, and they found no high-grade rotator cuff lesions or signs of impingement. Our good clinical results support the idea that the hook does not harm the rotator cuff. If the plate is not removed, the hook can erode the acromion and even a low energy injury can break the clavicle medial to the plate (Nadarajah et al. 2005). Patients who cooperate poorly or who are likely to have recurrent falls are not suitable for clavicle hook-plate fixation. The clavicle hook-plate does not violate the AC joint, but as seen in our series, osteoarthritis is common and the effect of the initial trauma may play a major role in the development of osteoarthritis.

Although several authors have reported a high rate of nonunion, pain and shoulder dysfunction in nonoperative treatment (Table 1), the need for operative treatment of Neer type 2 fractures is still controversial. Robinson and Cairns (2004) and Nordqvist et al. (1993) reported a nonunion in 32/86

and 5/23 patients, respectively, but only a small proportion had symptoms sufficient to lead to late operative treatment. Robinson and Cairns (2004) recommended nonoperative treatment of patients older than 35 years. In a retrospective comparative study, Edwards et al. (1992) suggested that nonoperative treatment leads to nonunion in one-third of cases and delayed union in half of all cases. Local complications such as shoulder dysfunction were more common after nonoperative treatment than after operative treatment, and they recommended operative treatment. In contrast, Rokito et al. (2003), in their retrospective study of 30 patients, came to the opposite conclusion and suggested that operative treatment is unnecessary. One explanation for this may be the degree of displacement of the fragments, and soft tissue injury, which Neer fracture classification does not take into account. Nonoperative treatment is unlikely to be successful if there is skin tenting as a result of gross displacement. Prospective randomized studies are required in order to determine which unstable fractures eventually need operative treatment.

We feel that the results of our study are reliable, although clinical examination and complete scoring could be done for only half of the patients. The questionnaires concerning subjective results were valid and the number of patients lost to follow-up was small. Subjective shoulder values and the Oxford questionnaire in particular measure shoulder-specific quality of life, and they are probably more sensitive in revealing problems related to the shoulder girdle than the Constant score or ROM measurements. The assessment of osteoarthritis could be carried out in only half of the patients and the relationship between clinical symptoms and radiographic changes could not be assessed reliably.

Contributions of authors

TF reviewed the case records and radiographs and wrote the draft manuscript. All authors contributed equally to evaluation and revision of this manuscript.

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