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Original Article

Comparison of percutaneous pinning with Kirschner wires and internal fixation with anatomical proximal humeral plates for proximal humeral fractures

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Abstract

Aim: The treatment of proximal humeral fractures is a controversial issue. The aim of this study was to compare clinically and radiologically the results of two surgical treatment methods for proximal humeral fractures.

Material and Methods: Between January 2010 and January 2016, 32 consecutive patients with a diagnosis of displaced proximal humeral fracture who underwent surgical treatment were evaluated retrospectively. The fractures were classified as two-, three-, and four-part fractures according to the Neer system. Sixteen patients were treated with closed-reduction percutaneous pinning and 16 patients were treated with open-reduction internal fixation with proximal humerus anatomical plates. The results were compared clinically using the Constant-Murley shoulder outcome score (CS) and radiologically with direct roentgenograms.

Results: The CSs of the Kirschner wire (K-wire) and plate groups did not differ significantly (P = 0.696). The mean CS values were 76.56 ± 19.11 for the K-wire group and 73.56 ± 15.91 for the plate group. No case of avascular necrosis (AVN) and three cases of partial loss of reduction occurred in the K-wire group. In the plate group, two cases of AVN and no case of loss of reduction occurred. All fractures in both groups healed, with no need for revision surgery in either group.

Conclusion: The clinical and radiological results of the plate and K-wire groups were similar. Percutaneous fixation has the advantage of minimal invasiveness, which lowers the rate of complications. Closed reduction with K-wire application is a good alternative, especially for two- and three-part fractures of the proximal humeral surgical neck.

Keywords: Proximal Humeral Fracture; Kirschner Wire; Anatomical Plate; Percutaneous Fixation; Nonunion.

INTRODUCTION

Proximal humeral fractures account for 5–6% of all adult fractures (1), and an estimated 706,000 cases occurred worldwide in 2000 (2). A fall from standing height is the most common trauma mechanism (89% of cases) (3). The type of trauma mechanism is related to age: high-energy trauma in younger patients and low-energy trauma in elderly patients are observed (3).

Neer defined a classification system for proximal humeral fractures, he described two-, three-, and four-part fractures and fracture dislocations of the proximal humerus (4). The degree of separation of the fracture fragments has prognostic implications and is thus taken into account to adjust the treatment regimen.

Several ideas concerning the treatment of complex and displaced proximal humeral fractures have been expressed. A wide range of treatment options for proximal humeral fractures is available. Soft tissue protection and fracture stabilization are important factors for union (5). Treatment decisions range from conservative to various surgical options. Surgical treatment (reconstruction or arthroplasty) is increasingly being used (6), contributing to increased treatment costs for upper limb fractures (7).

Conservative treatment of displaced two- and three-part fractures can result in non-union or malunion and give rise to poor functional results (8). Open reduction (OR) with internal fixation (IF) is a good method for fine reduction, but extensive soft tissue exposure during OR impairs the vasculature and doubles the risk of humeral head avascular necrosis (AVN) (8). Closed reduction (CR) and IF with Kirschner wires (K-wires) or screw is another

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method for the treatment of proximal humeral fractures. CR with percutaneous fixation preserves the soft tissues and prevents further soft tissue damage. Four-part fractures have the worst prognosis because bone/soft tissue connections are extremely weak or completely separated and the periosteum is damaged (9).

A wide range of treatment options for proximal humeral fractures is available. Soft tissue protection and fracture stabilization are important factors for union. With the application of K-wires, minimal soft tissue damage and fracture stabilization are possible. Our aim was to compare the results of K-wire application with those of anatomical plate application and provide further information to enhance the literature.

MATERIAL and METHODS

Between January 2010 and January 2016, data from 32 patients (19 men [59.3%] and 13 women [40.6%]) who underwent surgery due to displaced surgical neck fractures of the humerus were evaluated retrospectively at our institute. The mean patient age was 75.06 ± 17.36 (range, 16–91) years. The minimum follow-up period was 12 (mean, 35.4; range, 12–68) months. Radiographic examinations were performed with antero–posterior and scapular lateral views and 2D-3D computed tomography. Subsequently, fractures were classified as two-, three-, and four-part fractures according to the Neer system. Fracture classification identified 10 (31.2%) two-part fractures, 17 (53.1%) three-part fractures, and 5 (15.6%) four-part fractures.

Two fractures were sports related, eight were high-energy fractures sustained in traffic accidents, and the remainder were low-energy fractures sustained in simple falls. Sixteen (50%) patients were treated by CR and fixation with K-wires, and 16 (50%) patients underwent OR and fixation with proximal humeral plates. Two surgeons with similar skills and experience performed the surgeries.

Patients were evaluated clinically using the Constant-Murley shoulder outcome scoring system (CS). Radiologically standard antero-posterior and scapular lateral X-rays were reviewed to evaluate reduction continuity, union/non-union, and AVN.

The study exclusion criteria comprised the following: a history of ipsilateral shoulder surgery, pre-existing neurological or systemic condition affecting shoulder function (e.g. hemiplegia), pathological fracture, fracture dislocation, and head cleavage fracture.

Surgical technique

The operations were performed under general anesthesia with the patients placed in the beach chair position. A standard deltopectoral approach was used for OR and proximal humeral plate application. Following reduction, the fracture was stabilized with temporary K-wires. After the application of an anatomical proximal humerus plate, the K-wires were removed (Figure 1 a,b,c).

We applied CR by manual traction and mobilisation of the arm, then confirmed the reduction using an image intensifier. An assistant maintained the reduction, and percutaneous pinning was performed using the technique described by Jaberg et al. (10) (Figure 2 a,b,c,d). We advanced three to five 2–2.5-mm K-wires, depending on the stability of the fixation. The K-wires were left protruding from the skin. For each of the above-described techniques, the joint was imaged multi-directionally to avoid joint penetration.

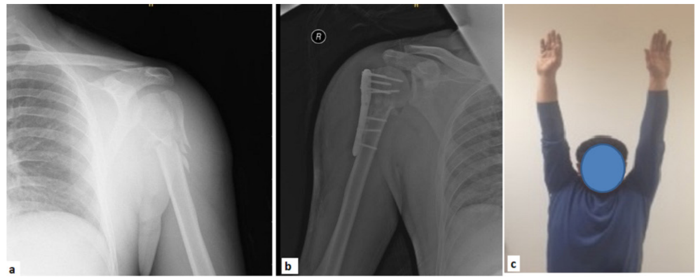

Figure 1. 29 years old patient, a) Three part proximal humeral fracture. b)Postoperative first year, treated with OR+IF with plate. c) ROM is full

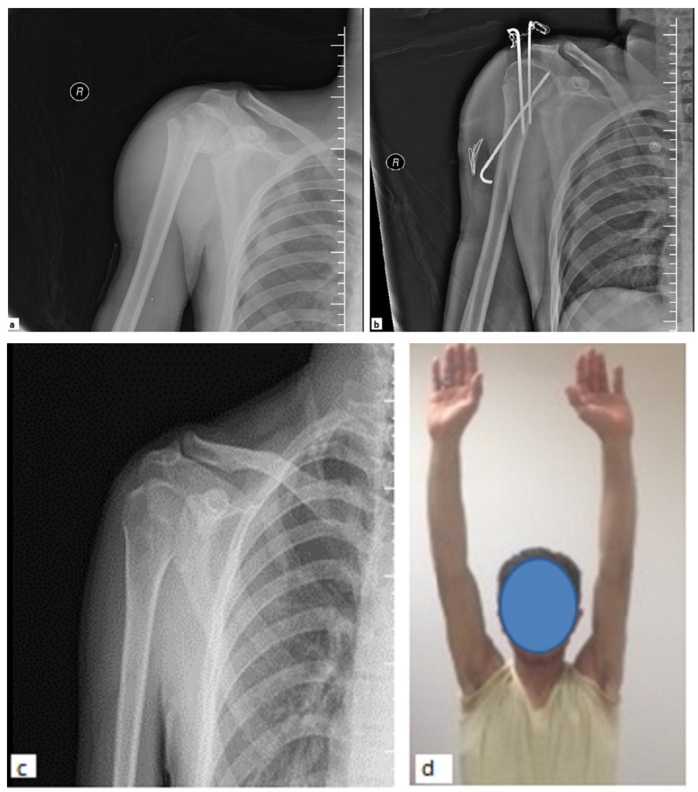

Figure 2. 19 years old patient, a) Two part proximal humeral fracture b) Postoperative first day treated with CR+IF with K-wire. c) Postoperative first year. d) ROM is full

Postoperative period and functional analysis

At follow-up visits, Velpeau bandages were applied to both sets of patients. Patients in the K-wire group were advised to perform passive shoulder exercises for the first 2 weeks, active assisted exercises at 2–4 weeks, and active exercises after 4 weeks. K-wires were removed after 6 weeks under local anesthesia. The plate group began passive exercises from the first postoperative day until the third day. Active assisted exercises were encouraged between 3 days and 2 weeks, and active exercises had begun by the end of 2 weeks. All patients were evaluated in the second, fourth, and sixth weeks, third, sixth, and twelfth months, and then once per year during outpatient visits.

Statistical method

The normality of numerical variables was checked by using the Shapiro–Wilk test. Student's t test (for normally distributed variables) and the Mann–Whitney U test (for non-normally distributed variables) were used to compare the two independent groups. Spearman's rank correlation test was used to show relationships between numerical variables, and the chi-squared test was used for categorical variables. A generalized linear model was built to adjust P values for possible confounding factors. All analyses were performed in SPSS for Windows (version 24.0). Two-sided P values < 0.05 was defined as statistically significant.

RESULTS

Sixteen patients were treated by CR and IF with K-wires, and 16 patients were treated by OR and plating. The mean operation times were 34.8 (range, 22–58) min for the K-wire group and 81.4 (range, 59–122) min for the plate group. Nineteen men and thirteen women underwent surgery. The sample contained 10 two-part, 17 three-part, and 5 four-part fractures.

CS values did not differ significantly between the K-wire and plate groups (P = 0.696). The mean CS values were 76.56 ± 19.11 for the K-wire group and 73.56 ± 15.91 for the plate group. Age and CS showed a reverse correlation (Spearman's rank correlation coefficient[r] = –0.515; P = 0.002; Table 1).

Table 1. Demographic data and CSs for the two treatment groups. The CS did not differ significantly between groups (P = 0.696)

		Group		
Variable		**KW (n = 16)**	**Plate (n = 16)**	**P value**
Age* (years)		43.31 ± 20.84	48.81± 19.95	0.452
Sex†	**Male**	9 (56.2)	10 (62.5)	0.303
	Female	7 (43.8)	6 (37.5)	
Fracture Type†	2	6 (37.5)	4 (25.0)	0.719
	3	9 (56.2)	8 (50.0)	
	4	1 (6.2)	4 (25.0)	
CS*		76.56 ± 19.11	73.56± 15.91	0.696

*Continuous variables (mean ± SD), Student's t test or Mann–Whitney U test; †Categorical variables (%), chi-squared test.
KW: Kirschnerwire; CS: Constant-Murley shoulder outcome score

CS values were significantly higher in males than in females (P = 0.020, Mann–Whitney U test). The mean CS values were 81.26 ± 18.20 for men and 66.00 ± 11.48 for women (Table 2).

The type of fracture also affected the CS values, with a significant difference among fracture types (P = 0.036, Kruskal–Wallis test). The highest values were for two-part fractures (mean, 84.60 ± 19.09), and the lowest values were for four-part fractures (mean, 59.80 ± 14.06; Table 3).

Age, sex, and fracture type also affected CS values. To more clearly compare the K-wire and plate groups, we established a new model that included age, sex, and fracture type. We found that comparison of the two groups with this model was more suitable after first determining the effects of these factors on CS values. The new model showed no significant difference between the K-wire and plate groups (P = 0.953), but a clear difference between two-part and four-part fractures (P = 0.045). In addition, a significant difference was noted between males and females (P = 0.023; Table 4).

Table 2. CSs according to sex. This value differed significantly between groups (P = 0.020)

Variable	Sex	N	Mean	SD	P value
CS	Male	19	81.26	18.205	0.020
	Female	13	66.00	11.482	

CS: Constant-Murley shoulder outcome score; SD: standard deviation

Table 3. CSs according to fracture types. A significant difference was observed between two-part and four-part fractures (P = 0.036). No significant difference was found between the other groups

Fracture type	N	Mean	SD	P value
2	10	84.60	19.092	0.036
3	17	73.94	14.096	
4	5	59.80	14.061	
Total	32	75.06	17.363	

CS: Constant-Murley shoulder outcome score; SD: standard deviation

Table 4. Generalised linear model for estimation of the effects of particular factors on CSs

				Hypothesis test		
Variable	**Parameter**	**B**	**SE**	**Wald chisquared**	**DF**	**Padjusted**
Group	**KW**	−0.28	4.78	0.003	1	0.953
	Plate	**Reference category**				
Fracture type	**2**	17.20	8.58	4.011	1	0.045*
	3	11.58	7.24	2.553	1	0.110
	4	**Reference category**				
Sex	**Male**	11.56	5.09	5.138	1	0.023*
	Female	**Reference category**				
Age (years)		−0.206	0.14	1.991	1	0.158

*Significant vs. reference category.
CS:Constant-Murley shoulder outcome score; DF: degrees of freedom; KW: Kirschner wire; SE: standard error

According to the radiological evaluation, all fractures healed, with no case of non-union. After plating, partial AVN of the humeral head occurred in two patients, one of whom had a four-part fracture and the other of whom had a three-part fracture. Non-union was not observed. Following K-wire application, partial loss of reduction was seen in three patients, two of whom had three part-fractures and one of whom had a four-part fracture, but no secondary surgery was required; all of these fractures healed. Pin migration and AVN were not observed.

In the K-wire group, two superficial infections were seen and were treated with oral antibiotics. Deep infection occurred in one patient in the plate group and was treated by debridement and intravenous antibiotics. Neurovascular injury did not occur in any patient in either group.

DISCUSSION

The treatment of multi-part proximal humeral fractures is controversial, and no consensus on this subject has been reached. Although surgery rates have increased in recent years, some authors recommend non-surgical treatment. The Proximal Fracture of the Humerus Evaluation by Randomization (PROFHER) trials present good clinical results of non-surgical treatment (11,12). In addition, various surgical treatment options (reconstruction with plates, percutaneous fixation, arthroplasty) are available. However, no optimal method has been detailed in the literature, and few studies have compared plate reconstruction with K-wire application. In general, only the results of reconstruction with plates and arthroplasty have been compared in the literature. In this study, we compared the results of surgeries using K-wires and plates.

In our clinic, proximal humeral fractures are primarily treated conservatively with slings. Operative treatment is offered in cases of instability and unsatisfactory reduction. In the past, we performed CR and IF with K-wires. However, our operative rates have increased in recent years, in line with other reports, and we started to use plates more often than K-wires. We compared our previous K-wire results with plate results clinically (using CS values) and radiologically (based on union and AVN). The CS values did not differ significantly between methods. These results are displayed in the tables summarizing patient demographics (Table 1) and the generalized linear model results (Table 4).

In our K-wire group, the mean CS value was 76.56. All fractures united, but three cases of malunion were noted; none of the patients required revision. AVN did not occur in any patient. Superficial infection was seen in two patients and was treated with oral antibiotics. In comparison, Keener et al.(13) applied CR with percutaneous fixation in 35 patients with two-, three-, and four-part fractures. The mean CS value was 73.9, and four cases of malunion were seen (13). Fenichel et al. (14) applied CR and K-wires to 50 two- and three-part fractures. The mean CS value was 81, and seven malunions were seen (three required revision). Yu et al. (15) reported a study of 87 two-, three-, and four-part fractures. The mean CS value was 77.2. Two cases of malunion, one case of non-union, and two cases of AVN were seen (15). Francesco et al. reported results from 41 patients with two-, three-, and four-part fractures. The mean CS value was 87.6. One case of non-union was seen, and malunion and AVN were not reported (16). Neurovascular complication was not reported in any of these studies, and AVN was reported only in Yu et al.'s study. In our study, the results were parallel with the literature and we did not perform any surgery for revision or infection.

In our plate group, the mean CS value was 73.56. Two partial AVNs of the humeral head and one deep infection were seen. Neurovascular complication, non-union, and malunion were absent. Nho et al. (17) reported results of OR and IF with plates in eight patients; the CS value was 70.4 and no non-union or AVN was seen. Fattoretto et al. (17) reported a study of 45 patients with three- and four-part fractures, in which the mean CS value was 61.93. Two cases of AVN and one case of pseudarthrosis were seen (18). After plate application, AVN, non-union, and malunion may occur, and revision with another plate or arthroplasty is performed. In our study, we did not undertake any revision surgery, but debridement was performed for deep infection at one fracture site.

Extensive soft tissue exposure during OR doubles the AVN risk in the proximal humerus (8). Percutaneous fixation has the advantage of minimal invasiveness and reduced exposure and stripping of the soft tissues, and thus reduces the risk of AVN. This technique has not been compared thoroughly with others (i.e. plate use, arthroplasty). For K-wire application in particular, malunion and non-union may occur due to the decreased strength of the fixation (16) and the removal of the K-wires at an average of 6 weeks. This situation may increase the revision rate, but we saw no need for revision in our study. In addition, weused to smooth K-wires; the literature recommends the usage of threaded K-wires for increased stability (16). A prospective study with threaded K-wires should also be undertaken.

Boons et al suggested that no differences in Constant-Murley and Simple Shoulder Test scores were detected between surgical and conservative groups (19). But patients with surgical treatment suffered more complications postoperatively (20). After K-wire application superficial infection were seen in two patients and partial reduction loss in three patients. With K-wire application deep infection and AVN rates decreased compared to plate application and the fracture is internally fixated as it's not the case for the conservative management. Also costs were lower in K-wire application compared to plate osteosynthesis.

CR and K-wire application was easier and more frequent in cases of two- and three-part fractures. CR of four-part fractures was more difficult; only one patient with such a fracture underwent this technique with the application of K-wires. The CS value for four-part fractures was significantly lower, particularly compared with that for two-part fractures (Table 3). Application of CR plus K-wires was easier and more feasible for two- and three-part fractures and can be applied instead of plate.

Treatment of proximal humeral fractures differs between age groups and fracture types. Trials like PROFHER investigate conservative versus surgical treatment of fractures of proximal humerus. In the future studies well designed study groups and subgroup analysis according to age and fracture type will give more information about treatment of proximal humeral fractures.

CONCLUSION

The clinical and radiological results of plate and K-wire use are similar. Percutaneous fixation has the advantage of minimal invasiveness and soft tissue stripping, which reduce the risk of complications such as AVN and deep infection. CR with K-wire application is a good alternative, particularly for two- and three-part fractures of the proximal humeral surgical neck.

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