The Reconstruction Twisted Wire-screws for Internal Fixation of Two- and Three-Part Fractures of the Proximal Humerus

THOSSART HARNROONGROJ, M.D.*,
VICHAI VANADURONGWAN, M.D.*

Abstract

Using the implants for internal fixation of the proximal humeral fractures has several problems which lead to complications and poor results of the fracture treatment. Because there is no suitable implant for internal fixation of the fracture. Therefore, the reconstruction twisted wire was developed in 1990 to improve the results of the fracture treatment. Between 1990 and 1994, the reconstruction twisted wire was used in 31 patients whose ages ranged from 18 to 90 years. Sixteen patients had displaced two-part surgical neck fractures. Fifteen patients had displaced three-part fractures. Postoperative follow-up ranged from two and a half years to five years and one month. All fractures healed. No avascular necrosis of the humeral head was observed at the follow-up. There was temporary subluxation of the shoulder joint in three patients and loosening of the screws in two patients with marked osteoporosis. One had a rupture of wire between the greater tuberosity and the shaft and loosening of the screw at the greater tuberosity and united with 10 degrees varus deformity. According to the functional scale proposed by Hawkins, 28 of the 31 patients achieved a "good" result and 3 patients had a "fair" result.

The treatment of displaced proximal humeral fractures is problematic and has a high incidence of complications especially in comminuted three - and four-part fractures[1-6]. The operative treatment of these fractures involve a variety of fixation techniques[3,5]. In addition to the severity of the fracture[3,6], some methods of fixation provide inadequate or poor stability by failure of the implant. Others involve a large implant or an extensive surgical exposure with damage to the soft tissues and disruption of the blood supply all leading to unsatisfactoy results[1,3,6]. The most suitable implant for fracture fixation depends on anatomical factors, the fracture confi-

* Department of Orthopaedic Surgery, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

gurations, surgical exposure and biomechanics of the implants. So, the reconstruction twisted wire was developed in 1990 for internal fixation of proximal humeral fractures.

MATERIAL AND METHOD

The reconstruction twisted wire-screws was used as an implant for internal fixation of the proximal humeral fractures between 1990 and 1994 in 31 patients with displaced fractures of the proximal humerus. Fifteen were males and sixteen were females. They ranged in age from 18 to 90 years (average 43 years). Sixteen patients had two-part surgical neck fractures. Fifteen had three-part fractures as classified by Neer. There was no associated shoulder joint dislocation. There were 12 left sides and 19 right sides. Seven patients had associated injuries : two intertrochanteric fractures of the femurs, a compression fracture of the first lumbar vertebra with incomplete neurological deficits, an intercondylar fracture of the right femur, an intercondylar fracture of the right humerus, a fracture distal right radius and a non-displaced pelvic fracture (Table 1). Radiographs of the proximal humerus were taken in anteroposterior, axillary/lateral scapular views to assess accurately the fracture type and its displacement. The indication for operation was at least 1 cm of displacement or 45 degrees of angulation. All operations were performed within 7 days of injuries. Follow-up ranged from two and a half years to five years and one month (average 3 years and 7 months).

Preparation of the reconstruction twisted wire

The reconstruction twisted wire was constructed by the first author. Double linear stainless steel wires (Biomed Southmorgan UK) are twisted together under approximately 5 kilogram tension and have several holes available for screw insertion. There are two different sizes. The large size is prepared from double 1.25 millimeter diameter wires with 3.5 millimeter diameter of the holes for a 4.5 millimeter cortical screw or a 6.5 millimeter cancellous screw. The distance between the adjacent screw holes of the wire is 3 centimeter and contains 12 twists and is used mainly for two-part fracture of the large humerus. The small size is prepared from 0.9 millimeter diameter wires with 2.7 millimeter diameter holes for a 3.5 millimeter cortical screw or 4.0 millimeter cancellous screw. The distance between the screw holes is 2.5 centimeter and contain 12 twists (Fig. 1) and is used for three part fractures or two-part fracture of the small humerus. The reconstruction twisted wire is used as a small implant and can be adapted to the shape of the proximal humerus and fracture configurations (Fig. 2). Each major bone fragment is secured and held to the other by insertion of a

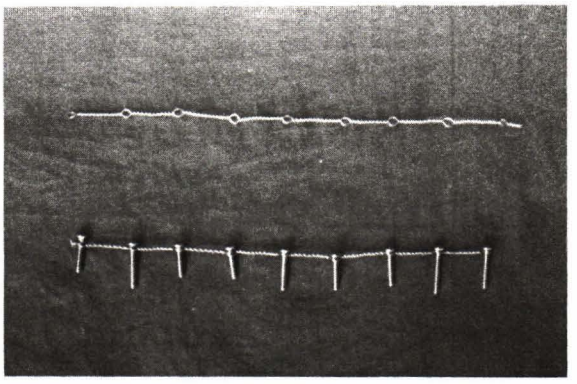

Fig. 1. The reconstruction twisted wire has several pre-made holes avialable for screw insertion.

Fig. 2. The reconstruction twisted wire can be adapted to the shape of proximal humerus and different fracture configurations.

Table 1. Data on the thirty-one patients who had a reconstruction twisted wire fixation.

Case	Sex, Age (yrs)	Side	Type of accident	Type of fracture	Associated injuries	Follow-up (yrs + Mos)	Postoperative complication	Hawkins' rating scale of shoulder function
1	F, 64	L	Falling	Three-part	-	5+1	Temporary subluxation of the glenohumoral joint, loosening of the screw, wire rupture and mild varus deformity	4
2	F, 66	L	Falling	Three-part	-	4+11	-	4
3	F, 20	L	Motorcycle	Two-part surgical neck	-	4+9	-	4
4	F, 19	R	Bus	Two-part surgical neck	-	4+8	-	4
5	M, 20	R	Motorcycle	Two-part surgicak neck	-	4+8	-	4
6	M, 25	L	Motorcycle	Two-part surgical neck	-	4+7	-	4
7	F, 66	L	Falling	Three-part	-	4+3	-	3.3
8	F, 73	L	Falling	Three-part	Intertrochanteric fracture left femur	4+2	-	3.5
9	M, 26	R	Motorcycle	Two-part surgical neck	-	4+2	-	4
10	F, 84	L	Falling	Two-part surgical neck	-	3+11	loosening of the screws	3.8
11	M, 25	R	Motorcycle	Two-part surgical neck	-	3+8	-	4
12	F, 36	R	Jumping from the height	Three-part	Compression fracture L1 with partial neurological deficits	3+7	-	4
13	M, 18	R	Motorcycle	Three-part	-	3+6	-	4
14	M, 40	R	Car	Three-part	-	3+5	-	3.3
15	F, 90	R	Falling	Three-part	Intertrochanteric fracture right femur	3+4	loosening of the screws	3.5
16	F, 58	R	Falling	Three-part	-	3+1	-	4
17	M, 31	L	Car	Three-part	-	3+1	-	4
18	M, 25	R	Car	Two-part surgical neck	-	3+1	-	4
19	M, 42	R	Car	Three-part	-	2+11	-	4
20	F, 72	R	Falling	Two-part surgical neck	-	2+11	Temporary subluxation of the shoulder joint	3.5
21	F, 67	L	Falling	Three-part	-	2+10	-	4
22*	F, 24	R	Jumping from the height	Two-part surgical neck with malunion	Intercondylar fracture of the right humerus	2+9	-	4
23	M, 32	L	Car	Three-part	-	2+9	-	4
24	M, 30	R	Motorcycle	Two-part surgical neck	-	2+9	-	4
25	M, 21	L	Motorcycle	Two-part surgical neck	-	2+8	-	4
26	F, 54	R	Falling	Three-part	Fracture distal right radius	2+8	-	4
27	F, 64	L	Falling	Three-part	-	2+8	-	3.4
28	M, 67	R	Car	Two-part surgical neck	-	2+7	Temporary subluxation of the shoulder joint	4
29	F, 18	R	Motorcycle	Two-part surgical neck	Pelvic fracture	2+7	-	4
30	M, 18	R	Motorcycle	Two-part surgical neck	-	2+7	-	4
31	M, 24	R	Car	Two-part surgical neck	Intercondylar fracture right femur	2+6	-	4

* The case had two-part surgical neck fracture with malunion. The valgus correction osteotomy and fixation with a reconstruction twisted wire was performed.

screw through a pre-made hole in the wire. The wire should be placed on an anterolateral aspect of the proximal humerus. The fracture is stabilized by not only the combined wire tension and screw holding power but also using the natural effect of a posterior hinge at the fracture site.

Operative technique

Under general anesthesia, a deltopectoral incision is made and the cephalic vein is mobilized laterally. The subdeltoid fascial plane is gently dissected. The arm is abducted to facilitate retraction of the deltoid. The exposure is enhanced by four Hohmann retractors, one each just below and above the greater tuberosity and two others at the upper and the lower borders of the subscapularis tendon. Damage to the axillary nerve at the lower border of subscapularis is avoided. The bicep tendon is identified and preserved. The fracture site is identified and the interposed soft tissues are separated from the bone ends. However, extensive exposure is not necessary. In two-part fractures the humeral shaft is reduced onto the humeral head anatomically. In three-part fractures the greater tuberosity is first reduced onto the head and held with pointed bone forceps before internally rotating the arm and the upper fragment through 30 degrees to obtain a good view of the lateral aspect of the greater tuberosity. The greater tuberosity is fixed to the head by a 3.5 millimeter screw through a "proper" hole in the reconstruction twisted wire. The proximal part is now composed of the head fragment and the greater tuberosity which are externally rotated through 30 degrees to return the greater tuberosity to its position. Then, the proximal part and the shaft are reduced. With the arm held in 45 degree abduction, the medial end of the reconstruction twisted wire is turned around the front of the head and placed just below the capsular attachment. The wire is pulled under moderate tension with the wire holder. The adjacent hole is secured to the head with an appropriate 3.5 millimeter screw to obtain at least two screws of the reconstruction twisted wire fixing at the humoral head. Moreover, the additional fixation of the fracture of the greater tuberosity to the head is obtained by the tension of the wire. (Fig.3, Fig.6-B, Fig.8-B) Then both free ends of the wire are pulled down to the shaft. By applying moderate tension with the wire holder and fixing the shaft to the head with 3.5 millimeter screw through the "proper" holes of the wire, the fracture is stabilized. When there are other large bone pieces which need to be fixed to the head through additional holes in the wire, the length between adjacent holes can be adjusted by twisting some of the wire between the holes

Fig. 3. In the two-part fracture, two holes of the reconstruction twisted wire is fixed to the head for securing the wire onto the proximal part before fixing both free ends of the wire onto the shaft.

Fig. 4. The large bone pieces are secured onto the head with the reconstruction twisted wire.

Fig. 5-A and 5-B The left shoulder radiographs of a 64-year old female patient.

Fig. 5-A A rupture of the reconstruction twisted wire between the screws at the greater tuberosity and at the shaft of the three-part fractures.

Fig. 5-B The healing with mild varus deformity.

Fig. 6A, 6B, 6C Radiographs of two-part surgical neck fracture of the right proximal humerus of a 26-year old male patient.

Fig. 6A The displaced two-part surgical neck fracture with marked anterior angulation.

Fig. 6B The fracture was fixed by a large size reconstruction twisted wire.

Fig. 6C The appearance of the fracture healing after removing the implant one year post-operation.

Fig. 7A, 7B, 7C Radiographs of right shoulder of a 24-year old female patient.

Fig. 7A The malunion of two-part surgical neck fracture of the proximal humerus.

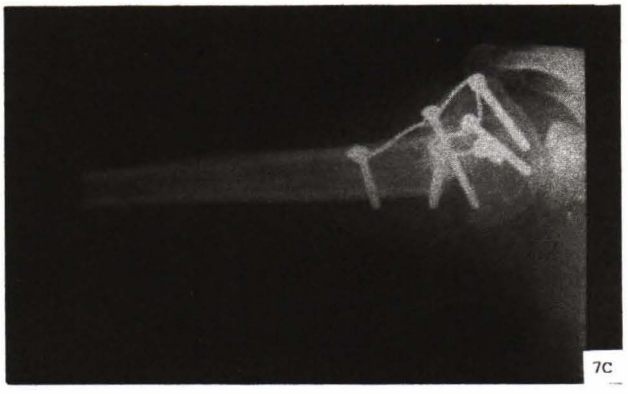

Fig. 7B, 7C The six months healing after performing correction osteotomy and fixation with a small size reconstruction twisted wire.

Fig. 8A, 8B, 8C Radiographs of right shoulder of a 58-year old female patient.
Fig. 8A The displaced three-part fracture of the proximal humerus.

Fig. 8B The fracture was fixed by a small size reconstruction twisted wire.

Fig. 8C The appearace of fracture healing after removing the implant one year postoperation.

(Fig. 4). The stability of the fixation is tested immediately after completing the fixation by full passive movement of the shoulder in abduction-adduction, internal-external rotation and foreward flexion-extension. The wound is closed over a suction drain. The patient is allowed to begin movement of the shoulder on the third postoperative day. Gentle passive forward flexion and pendular exercise are conducted for 4 weeks. Then, active movement and strengthening is begun. The postoperative rehabilitation program continues until maximum movement of the shoulder is achieved and maintained. Radiographs are repeated immediately postoperatively, 3 weeks, 3 months and every 6 months for 2 years. At final follow-up all patients were evaluated clinically and radiographically. Clinical evaluation using the Hawkins' scale of shoulder function (Table 2) which evaluated the performance of the shoulder in 11 activities of daily living and the pain experienced during these activities was used. For each activity the patient rates his or her performance on a scale of one to four and an average score is determined for the 11 activities. A score of 3.5 points or greater is classified as "good", 2.5-3.4 points as "fair" and less than 2.5 points as "poor". Postoperative radiographs include an anteroposterior and an axillary

Table 2. Hawkins' rating scale of shoulder function.

Function	Rating
1. Use back pocket (if male) Fasten brassiere (if female)	
2. Care for perineum	
3. Wash opposite axilla	
4. Eat with utensils	
5. Comb hair	
6. Use hand with arm at shoulder level	
7. Carry 10-15 lbs (4.5-8 kg) with arm at side	
8. Dress self	
9. Sleep on affected side	
10. Pull with involved shoulder	
11. Use hand over hand	

0, unable to perform; 1, can perform with aid; 2, can perform with difficulty;
3, mild compromise; 4, normal. The average of the 11 scores is determined for an overall score.

views of the proximal humerus. Fractures were considered to be healed when either bridging callus or obliteration of the fracture lines were evident.

RESULTS

In twenty-eight fractures, secure fixation was achieved but three cases resulted in dubious fixation (Table 1). Because two cases (patient #10 and #15) with severe osteoporosis had loosening of the screw fixation at the head and one (patient #1) had a wire rupture and one screw loosening at the greater tuberosity. The fractures healed within two and a half months. There were no post-operative infection nor axillary nerve injuries. One of the three-part fractures (patient #1) and two of the two-part fractures (patient #20 and #28) in the elderly had inferior subluxation of the glenohumeral joints which recovered eight to ten weeks after surgery. Two patients suffered loosening of the screw fixation at the greater tuberosity and at the anterior aspect of the humeral head (patient #10 and #15) at week three with resultant impingement upon the acromium during abduction. This impingement problem disappeared after removal of the implants. However, in these two patients there was no displacement of the wires from the fixation point because the lower part of the screw was retained in the bone, no secondary displacement of the fractures and healing was not affected. Patient #1 had a wire rupture between the screw fixation at the greater tuberosity and at the shaft, healing occurred in 10 degrees of varus deformity (Table 1, Fig. 5). There were no roentgenographic signs of avascular necrosis of the humeral head or degenerative arthrosis among the patients at follow-up. Most reported no pain and no limitation of daily activities. At follow-up in two and a half years and five years and one month the functional outcome was evaluated. All sixteen two-part surgical neck fractures had "good" scores (Table 1, Fig. 6 and Fig. 7). For three-part fractures, twelve patients had "good" scores (Table 1, Fig. 8) and three elderly patients (patient #7, #14 and #27) had "fair" scores (Table 1).

DISCUSSION

There are various implants for internal fixation of the proximal humeral fracture including T-plates, pins, wires, tension band wires and screws[2,5]. Plating requires an extensive surgical exposure with soft tissue damage and is too "rigid". In three-part fractures, internal fixation with a plate is rather difficult and is associated with more complications. With pin, screw and tension band,[3,6] the implant is small and requires less surgical exprosure but the implant can be used for only one interfragmentary fixation. For the reconstruction twisted wire is one of the small implants but can be adapted the contour as the fracture configuration and shape of the proximal humerus including can be used for several inter-fragmentary fixations. The mechanics of fracture stabilization is the combination of forces from

screw holding power and wire tension including the combination effect of wire tension at the anterior aspect and of a natural posterior hinge from the soft tissue at the fracture site gives more stability of the fracture fixation. These make the reconstruction twisted wire have more advantages than pins, wires, screws and plates. In this report, there was loosening of srews, however, there was no displacement of the wire from the fixation point because the lower part of the screw remained in the bone. So, the fracture can be held by the wire tension of the reconstruction twisted wire. One patient (case #1) had a wire rupture with healing in mild varus deformity because in the beginning of the study, the wire used for making the reconstruction twisted wire being too small in diameter. As a result of this study, the authors feel that the reconstruction twist wire-screws make the operation at the proximal humerus a simple procedure and well suited to internal fixation of two- and three part fractures. However, in severe osteoporosis there is a problem of screw fixation, the reconstruction twisted wire-screws is not recommended.

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การประดิษฐ์ reconstruction twisted wire-screws เพื่อใช้ในการยึดตรึงกระดูก humerus ส่วนต้นหัก

ทศศาสตร์ หาญรุ่งโรจน์, พ.บ., วิชัย วนดุรงค์วรรณ, พ.บ.**

การทำผ่าตัดดามโลหะเพื่อยึดตรึงกระดูก humerus ส่วนต้นหัก มักมีปัญหาเรื่องการใช้โลหะดาม ที่มีขนาดใหญ่เกินไป และบาดแผลแผลผ่าตัดมีขนาดกว้าง หรือไม่สามารถยึดตรึงกระดูกที่หักได้มั่นคงแข็งแรงเพียงพอ ส่งให้มีผลแทรกซ้อนตามมา ฉะนั้นในปี 1990 ผู้รายงานได้ประดิษฐ์และพัฒนา reconstruction twisted wire-screws เพื่อใช้ในการผ่าตัดยึดตรึง กระดูกหักชนิดนี้และได้นำมาใช้ระหว่างปี 1990-1994 กับผู้ป่วยทั้งหมด 31 ราย แบ่งเป็นการหักแบบ 2-part surgical neck ของกระดูก humerus 16 ราย และการหักแบบ 3-part 15 ราย จากการติดตามผลการรักษาตั้งแต่ 2 ปี 6 เดือน ถึง 5 ปี 1 เดือน พบว่า ไม่จำเป็นต้องใช้บาดแผลผ่าตัดขนาดใหญ่แต่สามารถยึดตรึงกระดูกที่แตกหักหลาย ๆ ชิ้นเข้าหากันได้และความมั่นคงต่อการยึดตรึงกระดูกหัก กระดูกที่หักเชื่อมติดกันภายในระยะเวลา ระหว่าง 2 เดือน ถึง 2 เดือนครึ่ง ไม่พบมีการตายของหัวกระดูก humerus จากการขาดเลือด ผู้ป่วย 3 ราย มี inferior subluxation ของหัวกระดูก humerus ชั่วคราวผู้ป่วย 2 ราย ซึ่งมีภาวะกระดูกพรุนมาก พบการหลวมของสกูรที่ยึด ผู้ป่วย 1 ราย พบการขาดของลวดที่ยึด ระหว่าง greater tuberosity และแกนกระดูก humerus ร่วมกับการหลวมของสกูรที่ยึดที่ greater tubuosity ผู้ป่วยรายนี้มีการเชื่อมติดของกระดูกหักในท่า varus 10 องศา การประเมินการทำงานของข้อหัวไหล่โดยการใช้ functional scale ของ Hawkins พบว่าผู้ป่วย 28 ราย จาก 31 ราย ให้ผลอยู่ในขั้นดี และ 3 รายอยู่ในขั้นพอใช้ ไม่พบผู้ป่วยรายใดอยู่ในขั้นเลว

* ภาควิชาศัลยศาสตร์ออร์โธปิดิคส์, คณะแพทยศาสตร์ศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กรุงเทพ ฯ 10700