External fixation of proximal humerus fracture

Clinical and cadaver study of pinning technique

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The risk of injuring important anatomic structures or interfering with motion of the glenohumeral joint by transcutaneous pinning of the proximal end of the humerus was investigated in 12 cadaver shoulders and in 23 patients with displaced fractures of the proximal humerus. In the cadavers, pinning of the proximal humeral shaft from laterally more than 20 mm below the surgical neck did not injure the neurovascular structures in any case. Pin insertions into the humeral head medial to the intertubercular groove endangered the cephalic vein and interfered with shoulder function by transfixing the subacromial bursa and by restricting internal rotation. Lateral pinning did not carry such risk.

In the patients closed reduction and external fixation confirmed the low risk of neurovascular injuries. Lateral pinning of the humeral head resulted in an unrestricted passive mobility of the glenohumeral joint of the anesthetized patient, whereas anterior pinning carried the risk of mechanical restriction of the internal rotation.

The present study was designed to evaluate the risk of damaging important anatomic structures and interfering with motion of the glenohumeral joint by pinning of the proximal humerus. The technique and preliminary results following transcutaneous reduction and external fixation of displaced surgical neck fractures have been presented in a study of the first 12 cases (Kristiansen and Kofoed 1987).

Material and methods

Cadaver experiments. The experimental part of the study was carried out on 12 shoulders in 6 fresh cadavers. The cadaver was placed supine with the humerus in neutral rotation and the forearm supinated. In each shoulder, seven 3.0 mm half-pins with continuous threads were drilled into the proximal humerus using fluoroscopy. Because no jig was available, a distance of 10 mm between the pins was used. Complete dissection of the region was performed to expose the following anatomic structures: the cephalic vein, the circumflex humeral arteries and the axillary nerve, the medial neurovascular bundle, the tendon of the long head of the biceps, the fibrous capsule of the glenohumeral joint, and the bursae protruding through apertures in the capsule. The shortest distance from inserted pin to neurovascular structure or tendon was measured. It was noted if the pins in the humeral head entered the joint cavity through the capsule or a bursa. As described by Dempster (1965) and Sarrafian (1983), an osteoligamentous preparation of the shoulder joint was made by severing all the muscles involved in active motion of the joint. Passive motions were performed with the arm as close to the body as feasible and the epicondyles horizontal in the starting position. The scapula and clavicle were allowed to move freely. Glenohumeral flexion was measured in the sagittal plane and abduction in the frontal plane, whereas rotation was measured in 45° of flexion with the elbow flexed 90° to use the forearm as a landmark. The amount of motion was determined by using a universal goniometer. Measurements were made with all the pins in place, after removal

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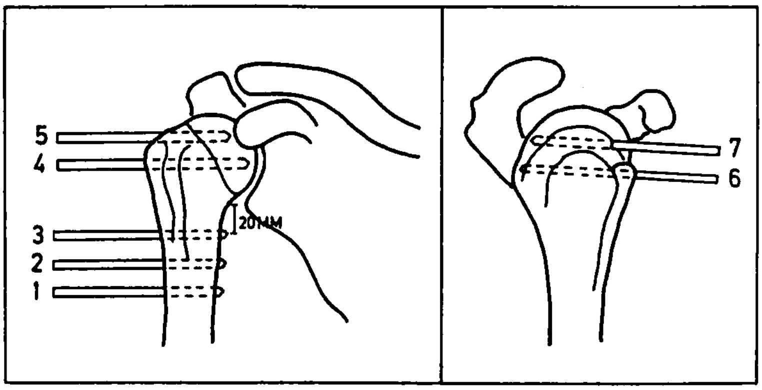

Figure 1. Pin number in relation to intended positions in the proximal end of the humerus.

of the anteriorly inserted pins, and after removal of the remaining pins. Individual measurements were ranked and statistical differences were tested by the Mann-Whitney rank sum test.

Clinical study. In 23 cases of displaced fracture of the proximal humerus, external fixation was performed as follows: with the patient supine under general anesthesia and using fluoroscopy, the fracture was reduced by manipulation of a Steinmann pin, transcutaneously inserted in the major proximal fragment. Following the reduction, two half-pins were drilled into the humeral head. The insertion was determined by the number, size, and stability of fragments, but was done in most cases lateral to the intertubercular groove. In the shaft, three pins were positioned laterally (Figure 2). An external bar was applied and the range of movement of the glenohumeral joint was tested on the still anesthetized patient. A neurovascular examination was performed preoperatively and postoperatively.

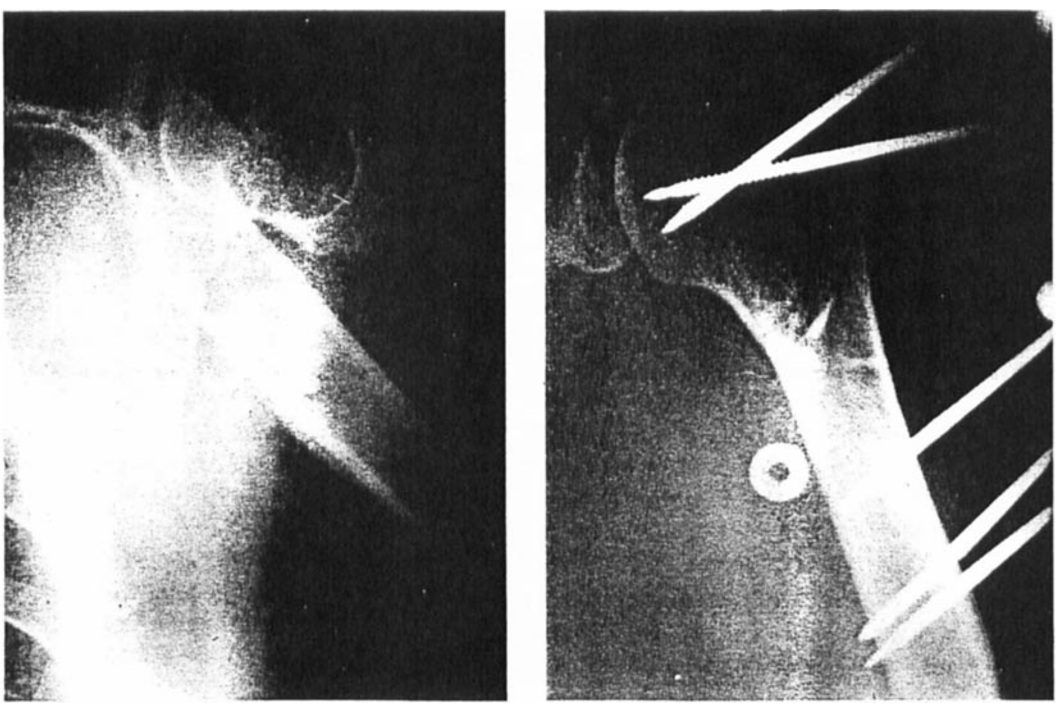

Figure 2. Case 15. A 70-year-old women with a 2-part displaced proximal humeral fracture. Preoperatively and after reduction and fixation with pins.

Table 1. Transcutaneous pinning of 12 cadaver shoulders. Distance values are median (range) mm. Distances > 50 mm were not recorded

Pin[a]	Distance to			Number of pins penetrating	
	Cephalic vein	Circumflex arteries and axillary nerve	Biceps tendon	Fibrous capsule	Bursa
1			12 (8–18)	0	0
2		24 (9–38)	15 (5–19)	0	0
3		15 (6–26)	8 (4–15)	0	0
4		12 (5–35)	6 (2–12)	0	3
5		32 (10–51)	8 (5–15)	0	4
6	7 (0–34)	11 (5–24)	4 (0–14)	5	10
7	10 (0–26)	18 (10–31)	4 (3–16)	8	11

[a] For definition of pin number, see Figure 1.

Table 2. Passive motion of 12 glenohumeral joints in cadavers following transcutaneous pinning of the humeral head. Values are median (range) degrees

Position of pins in the humeral head	Maximal motion			
	Flexion	Abduction	Internal rotation	External rotation
0 degrees anterior	55 (45–70)	60 (40–75)	5 (0–30)	45 (10–60)
90 degrees lateral	65 (50–75)	50 (30–80)	80 (55–100)	50 (5–60)
No pins	65 (60–70)	60 (30–90)	75 (60–100)	45 (10–65)

Table 3. Neurovascular injuries and restriction of motion of the glenohumeral joint following transcutaneous pinning of the proximal humeral end in 23 cases of reduced displaced proximal humeral fractures

A	B	C	D	E	F	G
1	F	79	3	A	IR	1
2*	M	31	3	AL	–	–
3*	F	82	2	L	–	–
4*	M	65	4	L	–	–
5*	M	57	4	A	IR	–
6*	M	62	3	L	–	–
7*	M	51	3	L	–	–
8*	F	36	3	L	–	–
9*	F	66	3	L	–	–
10*	F	66	2	L	–	–
11	F	70	3	L	–	–
12*	F	79	4	L	–	–
13	F	67	3	L	–	–
14	F	47	3	L	–	–
15	F	70	2	L	–	–
16	M	69	2	L	–	–
17*	M	30	2	AL	IR	–
18	M	21	4	AL	–	–
19	F	84	4d	L	–	2
20	F	76	2	L	–	3
21*	F	60	3	A	–	–
22	M	76	3	L	–	–
23	F	80	2	L	–	–

A Case number
B Sex
C Age
D Number of fragments according to the Neer classification. d fracture-dislocation
E Position of head pins: A both pins anteriorly, L both pins laterally.
F More than 45° of restriction measured on the anesthetized patient: – no; IR restriction of internal rotation.
G 1 Primarily diagnosed as a trigger finger. Later complaints of dysesthesia of the 4th and 5th fingers. Objective examination 6-month postinjury normal.
2 Three-day-old dislocation fracture with affection of the brachial plexus and the axillary artery. Following closed reduction and external fixation, a surgical exploration disclosed lesion of the artery. Endarterectomy was unsuccessful and gangrene developed. A forearm amputation was performed.
3 Temporary paresthesia of the sensory distribution of the median nerve.
* Cases included in a study on the early functional results (Kristiansen & Kofoed 1987).

Results

In the cadavers, none of the pins in the shaft injured neurovascular structures (Table 1). The pinning of the humeral head through the greater tuberosity was lateral to the biceps tendon and the attachment of the fibrous capsule in all the cases. In 7 of 24 cases, transfixation of the synovial membrane of a subdeltoid bursa was seen. In 24 anterior pinnings of the head, the cephalic vein was injured in 3 cases, and the pin touched the biceps tendon in 1 case. In 13 cases, intracapsular pinning was seen, and in 21 cases the subacromial bursa was transfixed.

Pinning of the humeral head had no effect on the passive flexion, abduction, or external rotation of the glenohumeral joint, but maximal internal rotation was diminished following anterior pinning, compared with lateral pinning, as well as no pinning at all ($P < 0.01$, Table 2), due to collision between the pins and the coracoid or glenoid rim.

In 3 of 5 cases where an anterior position of one or both head pins was necessary, internal rotation became restricted by more than 45° (Table 3). Temporary distal dysesthesia, as a sign of affection of the brachial plexus, was seen in 2 cases. In no case was the axillary nerve affected by the injury or operation.

Discussion

External fixation has gained acceptance as the preferred method of stabilization for severe open fractures and as an alternative method for some closed ones (Hierholzer et al. 1978, Behrens and Searls 1986); and an atlas showing safe pin placement positions in all the anatomic regions of the extremities has been published (Green 1981). In the shoulder region, pinning of the clavicle or the scapular spine proximally and the humeral shaft distally has been advocated for arthrodesis, open comminuted fractures, and infected nonunions (Mears 1979, Marti and Besselaar 1984, Burny 1985), whereas no clinical experience with pinning of the humeral head in cases of displaced proximal humeral fractures has been reported.

The present cadaver study largely confirms the anatomic considerations made by Green (1981). The main neurovascular bundle containing the brachial artery and vein and the radial nerve is separated from the medial cortex by a distance of more than 10 millimeters. Half-pin placement in the proximal humeral shaft from the lateral side can be accomplished, with caution not to drill more than just through the medial cortex. In the 2 fracture cases with affection of the brachial plexus, the pins were in correct positions as judged radiographically, and the sensory disturbances were only temporary. The anterior and posterior circumflex arteries followed by the axillary nerve wind around the surgical neck of the humerus. Pinning of the shaft more than 20 millimeters below the surgical neck did not endanger these structures in the cadavers. In the clinical cases, injuries of the circumflex arteries with a risk of humeral head necrosis cannot be excluded in this short-time follow-up study, but no injuries to the axillary nerve were seen.

In cadavers with intact humeral bones, pinning of the humeral head from the lateral side did not carry the risk of damaging the neurovascular structures or the long head of the biceps; it was extraarticular and did not restrict the passive motions of the glenohumeral joint. Anterior pinning, however, may endanger the cephalic vein and restrict internal rotation by impaling the biceps tendon or by transfixing the subacromial bursa.

After fracture reduction, motion, as tested on the anesthetized patient, was unrestricted after lateral pinning, while anterior pinning carried the risk of restricted internal rotation. In disagreement with Green (1981), the zero degrees anterior insertion into the humeral head thus cannot be recommended as a routine.

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