Acta Orthop Scand 1990;61(1):50–53

Acute compartment syndrome in forearm fractures

Lars-Åke Broström[1], André Stark and Gunnar Svartengren[2]

Sixteen patients were reexamined 2 to 5 years after surgical treatment of acute compartment syndrome in forearm fractures. High-energy trauma was the casual factor in 11 cases, in 5 of which there was an open fracture with skin defect. Fracture stabilization and fasciotomy of forearm and carpal compartments were performed as emergency procedures. The time for fracture healing averaged 8 weeks. Median nerve function was impaired in all the patients, and the ulnar nerve function in 8. The median nerve recovered completely in 15 patients, but ulnar nerve function was still impaired in 2 patients, 1 of whom had a nerve tissue defect. Eight patients could resume their occupation within a year.

Prompt recognition of acute compartment syndrome and early decompression are essential to minimize damage to nerve and muscle tissue and prevent development of a Volkman ischemic contracture (Mubarak et al. 1978, Matson et al. 1980). Elevation of the common interstitial fluid pressure is accepted as the denominator of compartment syndrome; and fasciotomy has been recommended if this pressure exceeds 40 mmHg (Whitesides et al. 1975, Gelberman et al. 1975, Mubarak et al. 1978). Most cases can be diagnosed from the clinical manifestations pain, swelling, paralysis, and pain on passive extension of the fingers (Mubarak et al. 1978, Matson et al., 1980, Rowland 1982); and measurement of tissue pressure is rarely important in the acute situation (Holden 1979, Rowland 1982).

The aim of our study was to analyze the late results of decompressive fasciotomy in a series of patients with forearm fracture and acute compartment syndrome.

Department of Orthopedics[1], Karolinska Hospital, and Hand Surgery[2], Sabbatsberg Hospital, Stockholm, Sweden.

Correspondence: Dr. André Stark, Department of Orthopedics, Karolinska Hospital, S-104 01 Stockholm, Sweden

Patients and methods

In the period 1978–1983, 16 patients (9 men, 7 women), with a mean age of 39 (18–65) years, were treated at Karolinska Hospital for forearm fracture with acute compartment syndrome. Eleven of the injuries were of high-energy type (traffic accidents), six of them with extensive soft-tissue damage. Thirteen fractures were located distally in the radius (one of Galeazzi type), and one was in the distal part of the ulna. Two patients had a dislocation of the radiocarpal joint and fractures of metacarpal bone. Five fractures were intraarticular.

The acute compartment syndrome was in all cases diagnosed clinically from pain and swelling of the forearm, palpable tenderness, impaired nerve function, and severe pain on passive extention of the fingers. In 1 patient the tissue pressure was measured preoperatively in the volar compartment, 5 cm distal to the elbow and 5 cm proximal to the wrist and compared with the contralateral, intact arm. The ipsilateral values were 41 mmHg distally and 25 mmHg proximally, compared with 11 and 9 mmHg, respectively. After fasciotomy the pressure normalized to 12 mmHg.

In all the cases a curved volar skin incision was used for decompressive fasciotomy. The incision was extended distally to open the carpal tunnel and the canal of Guyon. The operation was performed within 3 hours of admission in 9 cases and within 3

Table 1. Sensibility measured as two-point discrimination capacity in 16 patients with acute compartment syndrome following forearm fracture

	Two-point discrimination capacity (mm)		
Time of examination	< 5	5–15	> 15
At diagnosis			
median nerve	0	2	14
ulnar nerve	8	3	5
1 month postoperatively			
median nerve	7	7	2
ulnar nerve	13	1	2
1 year postoperatively			
median nerve	15	0	1
ulnar nerve	14	0	2

days, but promptly after clinical manifestation of compartment syndrome, in 6 cases. One patient underwent fasciotomy 7 days after the trauma. All the patients had an impaired two-point discrimination test in median nerve-innervated fingers (Table 1). Dorsal fasciotomy of the hand was performed on the patients with metacarpal fractures.

External fixation with a Hoffman frame was used for 10 fractures and internal fixation with an AO plate for four. Carpal dislocation with metacarpal fractures was treated with K-wires and plaster fixation. The Hoffman frame was removed after 5 weeks and replaced with plaster fixation for 3 more weeks. Fracture healing was observed after 8 weeks in 14 cases. Delayed union necessitated bone grafting in the other 2 patients. Autogenous split-thickness skin grafting was performed within 3 days to cover the defect after volar fasciotomy in 15 cases. Repeat skin grafting was necessary in 3 of them. Superficial wound infection occurred in 2 cases.

All 16 patients were recalled for clinical and radiographic examination 2–5 years postoperatively. Subjective assessment regarding pain (severe/moderate/slight/none), stiffness (yes/no), and weakness (yes/no) was performed. Range of motion was measured with a goniometer and grip strength with a Martin vigorimeter. A decrease was expressed in percentage of values in the healthy arm. Nerve function was analyzed, and the two-point discrimination capacity measured. Fracture healing, displacement and development of arthrosis were radiographically analyzed. Details of sick listing and return to work were recorded.

Results

Five patients had no complaints; 3 reported pain in the arm at rest and 8 had slight pain during exercise. Stiffness of the arm was experienced by 7 patients, and 3 had problems of arm weakness.

Flexion and extension of the elbow were normal in all 16 patients. The range of wrist motion, expressed as mean decrease, was 42 (range 1–64) percent for volar flexion, 38 (20–75) percent for dorsal extension, and 30 (0–47) percent for both pronation and supination. A finger flexion defect of at least 1 cm was observed in 5 patients. The range of wrist motion did not differ between the cases with high energy and those with low-energy trauma.

The mean decrease in grip strength was 54 (10–95) percent. High-energy crush injury was associated with major impairment of grip strength.

Fifteen patients regained normal motor and sensory median nerve function; 14 showed normal ulnar nerve function; 1 patient with a crush injury still had impaired two-point discrimination capacity (> 15 mm) in median nerve-innervated fingers, and also had reduced ulnar nerve function (Table 1).

Eight patients resumed their previous occupations within a year of the injury. Six, including 5 with a crush injury, were still stick listed after 2 years. The other 2 patients were of retirement age.

At follow-up, all the fractures had healed. In three of the 13 radius fractures, there was dorsal angulation of more than 20°, and in six, there was also radial compression (> 0.5 cm). Radiocarpal arthrosis was found in eight wrists, classified as moderate in three and slight in five joints (Table 2).

Discussion

Anatomic and functional studies of the forearm have shown no firm fascial divisions between the dorsal, volar, and mobile wad regions, and also have found the pressures in these compartments to be independent (Gelberman et al. 1978). Volar fasciotomy as performed in our study appears to be sufficient for effective decompression of all the compartments. Both the median and the ulnar nerve can be explored through a volar forearm incision, and can be easily visualized in the carpal tunnel and the canal of Guyon, respectively. Involvement of the interosseous muscles of the hand can occur if the hand has been injured, possibly in high-energy trauma. In such situations the interosseous fascial compartments should be released by dorsal incisions (Rowland 1982, Halpern and Mochizuki 1980), as was done in 2 of our cases.

Table 2. Observation in 16 patients with acute compartment syndrome and forearm fractures

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI
1	20	1	1	1	2	2	1	1	3	3	1	3	1	–	–	2	3	2	2	2	2	1	3	3	3	3	3	3	3	3	3	2	3	2
2	16	2	2	2	2	1	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	3	1	2	1	2	1	2	1	1	1	1
3	41	1	1	1	1	1	1	1	1	2	1	2	1	2	2	3	1	1	1	2	2	2	1	3	1	2	1	2	1	2	1	1	1	1
4	41	1	1	1	2	2	1	1	2	2	2	2	1	–	–	1	1	1	1	1	1	1	2	3	3	2	1	1	1	1	1	1	1	2
5	25	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	2	1	1	1	1	1	2	3	1	3	1	2	1	1	1	1	1	1
6	53	1	2	2	2	2	2	1	3	3	1	3	2	–	–	1	2	2	1	2	2	2	3	3	1	2	1	2	1	2	1	1	1	2
7	45	2	2	2	2	2	1	2	4	1	1	2	1	1	2	1	2	2	1	2	2	2	3	3	1	2	1	2	1	1	1	1	1	2
8	39	1	2	2	2	1	1	2	1	1	1	2	1	1	1	2	2	2	1	2	2	2	2	3	1	3	1	3	1	2	1	1	1	1
9	23	2	1	1	2	2	2	1	4	1	1	3	2	1	1	1	3	2	2	2	2	2	3	2	3	1	3	1	3	1	3	1	3	2
10	58	2	1	1	1	1	1	2	1	1	1	2	1	2	2	2	2	2	1	2	2	2	2	3	2	2	2	2	2	1	1	1	1	3
11	65	1	1	1	2	2	2	2	4	1	1	2	1	1	2	3	2	2	1	3	3	2	3	3	3	3	3	2	2	2	2	1	1	3
12	39	2	1	1	1	1	2	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1	1	1	1
13	40	1	2	2	2	1	2	1	1	1	2	2	1	1	2	2	3	1	2	2	2	2	3	3	2	–	–	2	2	1	1	1	1	2
14	38	2	2	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	3	1	2	1	1	1	1	1	1	1	1
15	24	1	2	2	2	1	1	2	4	1	1	2	1	2	1	1	2	1	1	2	2	1	2	3	3	–	–	2	1	1	1	1	1	1
16	57	2	2	2	1	1	1	1	4	1	1	2	1	1	1	3	2	1	1	1	1	1	2	3	2	3	2	2	1	2	1	1	1	1

A Case
B Age: years
C Sex: 1 male, 2 female
D Side: 1 left, 2 right
E Side: 1 dominant, 2 nondominant
F Energy type: 1 low, 2 high
G Crush injury: 1 no, 2 yes
H Open fracture; 1 no, 2 yes
I Intraarticular fracture: 1 no, 2 yes
J Fracture location: 1 distal radius/ulna,
2 diaphys radius/ulna
3 metacarpal bones
4 multiple
K Fixation: 1 external, 2 plaster, 3 pins and plaster
L Delayed fracture union: 1 no, 2 yes
M Skin grafting: 1 none, 2 once, 3 repeated
N Infection: 1 no, 2 yes
O Dorsal angulation: 1 < 20°, 2 > 20°
P Compression: 1 < 0.5 cm, 2 > 0.5 cm
Q Osteoarthrosis: 1 no, 2 slight, 3 moderate, 4 severe
R Pain: 1 no, 2 at exercise, 3 at rest
S Stiffness: 1 no, 2 yes
T Weakness: 1 no, 2 yes
Range of wrist motion. Decrease in percent of the healthy side: 1 < 25%, 2 25–50%, 3 > 50%
U Volar flexion
V Dorsal extension
W Rotation (pronation and supination)
X Grip strength. Decrease in percent of the healthy side: 1 < 25%, 2 25–50%, 3 > 50%
Two-point discrimination:
1 < 5mm, 2 5–10 mm, 3 >15 mm
Y Preop. n. medianus
Z Preop. n. ulnaris
AA Postop. n. medianus
AB Postop. n. ulnaris
AC 2 weeks postop. n. medianus
AD 2 weeks postop. n. ulnaris
AE 1 month postop. n. medianus
AF 1 month postop. n. ulnaris
AG 12 months postop. n. medianus
AH 12 months postop. n. ulnaris
AI Sick listed more than 2 years: 1 no, 2 yes, 3 retired

In all 16 patients the compartment syndrome was clinically obvious. Complementary tissue-pressure measurements were performed to establish the diagnosis in 1 unconscious patient. The preoperatively-high pressures normalized after volar fasciotomy, the levels then agreeing with those reported in the literature (Gelberman et al. 1978, Murabak et al. 1978). In our view, measurement of tissue pressure can be reserved for high-risk or unconscious patients.

The median nerve, probably due to its exposed position, is more often, and in most cases more severely affected than the ulnar nerve (Seddon 1956). In our study, all the patients had impaired function of the median nerve, whereas the ulnar nerve was affected in only 8. Fasciotomy was followed by complete recovery of nerve function in all but the 2 patients who had sustained a high-energy crush injury with damage to the nerves.

There were no major problems in fracture treatment. All the fractures healed, two of them after bone grafting. The time required for bone healing (mean 8 weeks) was short in consideration of the extensive soft-tissue damage, and was comparable with results elsewhere (Cooney 1983). The Hoffman frame proved to be valuable both for fracture stabilization and for optimal management of soft tissues. It facilitated revisional surgery and permitted repeated skin grafting, as well as early active and passive training of elbows and finger joints.

Weakness and stiffness of the arm were common complaints at follow-up. These symptoms were related to the amount of soft-tissue damage. Three patients who had pain at rest had sustained high-energy trauma. The poorer results following high-energy trauma were also reflected in protracted sick listing. To restore adequate blood supply for maintenance of nerve and muscle function, fasciotomy should be performed with a minimum of delay. The prompt treatment of compartment syndrome in our cases probably explains the near complete restoration of nerve function.

References

Cooney W P. External fixation of distal radial fractures. Clin Orth 1983; (180): 44–9.

Gelberman R H, Zakaib G S, Mubarak S J, Hargens A R, Akeson W H. Decompression of forearm compartment syndromes. Clin Orthop 1978; (134): 225–9.

Halpern A, Mochizuki R M. Compartment syndrome of the interosseous muscles of the hand. Orthop Rev 1980; 9: 121–7.

Holden C E. The pathology and prevention of Volkmann's ischaemic contracture. J Bone Joint Surg (Br) 1979; 61(3): 296–300.

Matsen F A 3rd, Winquist R A, Krugmire R B Jr. Diagnosis and management of compartmental syndromes. J Bone Joint Surg (Am) 1980; 62(2): 286–91.

Mubarak S J, Owen C A, Hargens A R, Garetto L P, Akeson W H. Acute compartment syndrome: diagnosis and treatment with the aid of the wick catheter. J Bone Joint Surg (Am) 1978; 60(8): 1091–5.

Rowland S. Fasciotomy. In: Operative Hand Surgery (Ed. Green D P). Churchill Livingstone, New York 1982: 565–81.

Seddon H J. Volkmann's contracture. Treatment by excision of the infarct. J Bone Joint Surg (Br) 1956; 38: 152–74.

Whitesides T E, Haney T C, Morimoto K, Harada H. Tissue pressure measurements as a determinant for the need of fasciotomy. Clin Orthop 1975; (113): 43–51.