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FOREARM SHAFT FRACTURES: RESULTS OF TEN-YEAR FOLLOW-UP

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SUMMARY – Fractures of the forearm present a unique management problem for years. Major improvements in the results of management of this injury awaited the development of advanced techniques. The introduction of AO implants and AO principles has markedly improved functional results for the patient, depending on the degree of soft tissue injury. Presentation is made of a ten-year follow-up of forearm fractures operatively treated at the Department of Surgery, Sestre milosrdnice University Hospital in Zagreb. The follow-up included 354 forearm fractures in 331 patients. Complete forearm shaft fractures were recorded in 121 (34%), fracture of the ulna alone in 130 (37%) and of the radius alone in 102 (29%) patients. Compound fractures occurred in 67 (19%) patients. All patients underwent operative treatment. Compound fracture was the indication for early operation in 85 (24%) patients. Internal fixation was performed by use of a narrow dynamic compression plate (DCP), mostly small DCP, and occasionally semitubular plate. Second and third degree open fractures were treated with external fixation. Postoperative plaster immobilization was employed in 39 patients for three to four weeks. Complications included infection (2.8%), nonunion (3.9%), refracture (1.4%), and synostosis (2.8%). Results of surgical treatment were considered excellent in 62%, good in 16%, satisfactory in 12%, and poor in 10% of patients.

Key words: *Fractures, surgery; Fracture fixation, methods; Forearm injuries, surgery; Osteosynthesis*

Introduction

A forearm fracture involving either one or both bones, more than any other diaphyseal fracture in the body, requires open anatomical reduction with stable fixation, preferably with plates, for optimal functional results. Anatomical reduction allows for restoration or normal radial and ulnar length to prevent subluxation of proximal or distal radioulnar joint, and restoration of rotational alignment essential for normal pronation – supination function of the forearm. Stable internal fixation with plates will reduce pain and allow for early soft tissue rehabilitation without the use of external splints or casts. Restoration of forearm and hand function is ensured by the use of plates, either as a tension band axially compressing the fracture, or as a neutralization plate with prior interfragmental compression.

Shortcomings of the closed treatment method have long been recognized as malunion, nonunion, and poor functional results[1-3]. Early attempts at functional result improvement by open reduction and internal fixation did little because of unstable fixation and long-term plaster immobilization[4,5]. The introduction of AO implants and principles has changed the outlook dramatically. Stable internal fixation has eliminated most external casts and splints. The lack of recognition of important biological and biomechanical principles of modern techniques of internal fixation is the most common cause of failure[6,7].

The natural history of forearm fracture, under almost all circumstances, is so uncertain when treated by means of other than anatomical open reduction, stable fixation with plates, and early motion of the extremity, that this

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treatment alone can be recommended in almost all cases of fractures of both bones, fractures of the shaft of the radius or ulna with radioulnar subluxation (Galleazzi or Monteggia), isolated fracture of the ulna, and open fracture of the forearm[8-14].

On surgery timing, early operation is desirable but not essential. Since the operation is usually indicated for all displaced forearm fractures, we prefer to proceed with it as soon as possible following the injury. The operation may be delayed by general or local factors. Under these circumstances, the operation should be performed at the earliest appropriate time.

In surgical technique, we prefer the use of tourniquet in closed fracture to ensure bloodless field, thus reducing the time of operation. Surgical approach to the ulna is relatively simple. The ulna is a subcutaneous bone and is easily exposed throughout its length. For the radius, there are several standard approaches, i.e. anterior according to Henry, posterior Thompson's approach to the proximal middle third of the posterior surface of the radius, and Boyd's approach to the proximal third of the ulna and proximal third of the radius.

The principle of stable internal fixation can be achieved by internal splinting with intramedullary devices or by compression. In the forearm, intramedullary devices do not control rotational stability, therefore compression with intrafragmental screws or plates under tension is the method of choice. In the forearm where exposure is limited, a dynamic compression plate (DCP) should be used wherever possible for transverse or short oblique fractures. In all cases where the obliquity of the fracture allows, a lag screw should be inserted across the fracture to increase rotational stability. For spiral or comminuted fractures, interfragmental compression with lag screw is the keystone of treatment. Once the interfragmental compression has been achieved, a neutralization plate must be applied to protect the stability of the fracture. Wherever possible, lag screw should be used through the plate and across any of the fracture lines, to increase the stability of the system.

The choice of implant will depend on the size of the bone. For large bone, a 4.5-mm DCP can be used, while in short individuals a 3.5-mm DCP or small DCP is the implant of choice. It is important for at least five cortices to be fixed on either side of the fracture; however, the length of the plate will ultimately depend on the degree of comminution.

The site of ulnar plate application is medial border. The site of radial plate application depends on the surgeon's choice of incision.

Bone grafts are indicated when the anatomical reduction has not been achieved due to comminution, or when the bone loss is a decisive factor.

Material and Methods

Patients with forearm fractures operatively treated at the Department of Surgery, Sestre milosrdnice University Hospital in Zagreb during a ten-year period (1988 – 1998) are presented. During the study period, there were 354 forearm fractures operatively treated in 331 patients. The distribution of fractures according to localization, age and sex was analyzed. The mode of treatment and complications are also presented.

Closed fractures predominated, while compound fractures were recorded in 67 of 354 cases (19%).

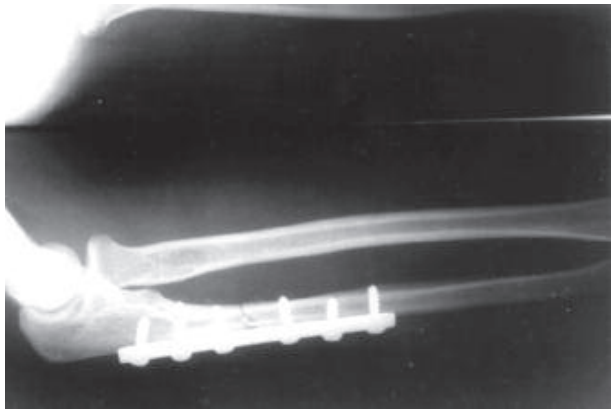
Forearm fractures are basically divided into fractures of the proximal and distal part, and diaphyseal fractures, while luxational fractures (Galleazzi, Monteggia, and Essex-Lopresty fracture) make a separate entity.

Monteggia fracture is a diaphyseal fracture of the ulna with proximal radioulnar luxation. The four types according to the position of subluxation of the radius head are as follows: type I or extension type denoting forward position of the radial head; type II or flexion type denotes a backward position of the radial head; type III means that the head is laterally luxated; and tpye IV denotes diaphyseal fracture of the ulna and radius with radial head luxation.

As these fractures are followed by disruption of the annular ligament, joint membrane and interosseous membrane, they are considered to be extremely unstable, manifesting as a pronounced inclination to subsequent dislocation and subluxation, thus we used surgical treatment in such cases (Fig. 1).

Galleazzi fracture is fracture of the shaft of the radius (from tuberositas radii to 5 cm above the level of radiocarpal joint) with distal radioulnar subluxation. The Essex-Lopresti fracture is described as a subdivision of this bone injury, i.e. subcapital radial fracture with proximal and distal radioulnar joint instability. In 30% of Galleazzi injuries, an associated fracture of ulnar styloid was found. The most severe form of Galleazzi fracture includes fracture of the shaft of the ulna and radius with distal radioulnar dislocation. These fractures are also unstable, i.e. upon repositioning and immobilization they show a tendency of reluxation and redislocation. Therefore, they were surgically treated. In young patients aged ≤ 15, this frac-

Fig.1. Left panel: Fracture of the ulna with associated redioulnar dislocation (Monteggia fracture).



Right panel: Fracture of the ulna with associated radioulnar dislocation (Monteggia fracture) after surgical tretment).

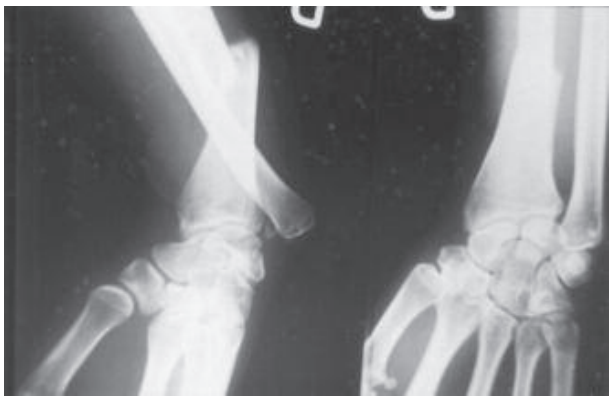
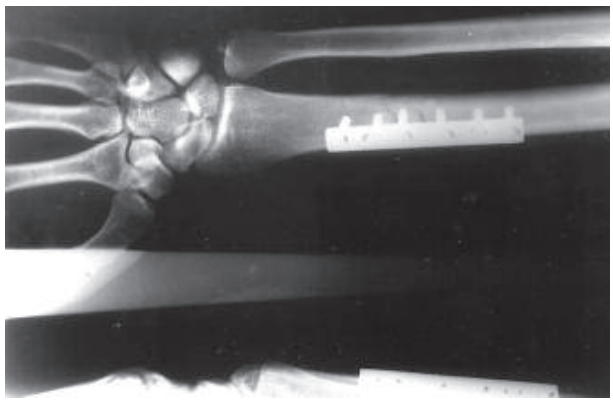


Fig. 2. Left panel: Fracture of the radius with distal radioulnar subluxation (Galleazzi fracture).



Right panel: Fracture of the radius with distal radioulnar subluxation (Galleazzi fracture) after surgical treatment.

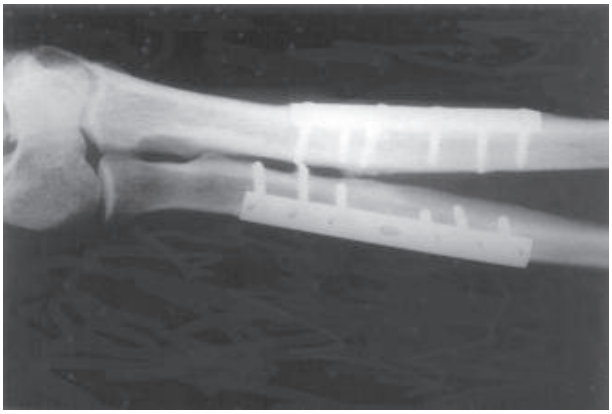
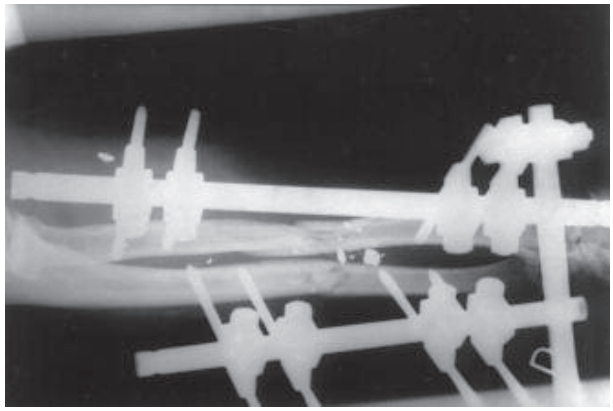


Fig. 3. Left panel: Internal fixation of forearm shaft fracture.



Right panel: External fixation of forearm shaft fracture.

ture is usually subperiosteal, with a high degree of fracture stability. At this age, the therapeutic approach was primarily conservative (Fig. 2).

Indications for operative treatment and stable fixation of fragments were diaphyseal fracture with dislocation of fragments or comminution; fracture of the shaft of the

radius or ulna with radioulnar subluxation (Galleazzi, Monteggia and Essex-Lopresti injuries), and open fracture of the second and third degree when external fixation of the bone was indicated. Open fractures of the first degree were treated with internal fixation.

Radial head fractures were operatively managed in case of dislocation of fragments exceeding 2 mm; major fragment avulsion; or impression fracture involving more than one third of the radial head circumference. In case of olecranon fracture, surgical treatment was used when dislocation of the fragment exceeded 2 mm, because of the brachial triceps tension. This fracture is also unstable. Coronoid process fractures were surgically treated when the fracture involved more than one sixth of the semilunar incisure of the ulna.

In surgical technique, we preferred the use of tourniquet in closed fractures to ensure bloodless operative field if there was no sign of compartmental syndrome. For internal fixation, we used DCP and 3.5-mm cortical screws.

The Essex-Lopresti luxation fracture is characterized by instability of distal and proximal radioulnar joints. In surgical treatment, we used internal fixation of the radius with radioulnar transfixation of the distal part of the forearm.

Simple olecranon fractures were treated with spongiosal screws of 3.5 mm in diameter, and multifragmental olecranon fractures with plates and screws.

Compartmental syndrome, encountered in one case, was successfully managed with forearm fascia incision.

All fractures were surgically treated. Eighty-five (24%) fractures were operatively managed within 8 hours from the accident, 79% of them open fractures.

Results

During a ten-year period (1988 – 1998), the method of internal fixation was used in 331 injured persons with 354 forearm shaft fractures combined with joint injuries. Data on these patients were statistically analyzed according to age and sex, fracture anatomical localization, mode of treatment, and complications, with special reference to diaphyseal fractures associated with injuries of adjacent joints, i.e. Monteggia and Galleazzi fractures.

Of the total of 354 forearm shaft fractures, 196 (55%) were found in males and 158 (45%) in females. The mean age of the patients was 43 years. There were 67 (19%) open forearm shaft fractures. Out of 354 forearm shaft fractures, there were 121 (34%) bilateral diaphyseal fractures, 102 (29%) radial fractures, and 130 (37%) ulnar fractures (Tables 1 and 2).

Table 1. Forearm fracture

Localization	No. of cases	%
Bilateral diaphyseal fracture	121	34
Radial fracture	103	29
Ulnar fracture	130	37
Total	354	

Table 2. Forearm fracture according to localization

Localization	No. of cases
Diaphyseal	121
Radius	43
Ulna	20
Monteggia	30
Galleazzi	30
Olecranon	78
Radial head	30
Coronoid process	2
Total	354

In the management of forearm shaft fractures, surgical method is preferred because it allows anatomical repositioning of the fragments and provides a high degree of stability. This method enables early rehabilitation and functional convalescence of the arm.

Bone consolidation of the fracture occurred within 8-10 weeks after the operation, as shown by x-ray examination. However, surgical treatment may also be associated with some specific complications (Table 3).

Table 3. Complications of osteosynthesis

Complication	%
Pseudoarthrosis	3.9
Refracture	1.4
Synostosis	2.8
Compartmental syndrome	0.2
Infection	2.8

The outcome of the surgical treatment of forearm shaft injuries was evaluated on the basis of functional re-

Table 4. Results of surgical treatment of forearm shaft fractures according to restriction of movements, function and arm discomforts[15]

Judgement	Restriction of movement	Function	Discomfort
Excellent	Flex 0/Ext to 15 Pron/Supin to 15 Dors/Palmflex to 15 Rad/Ulnar abd to 5	OK	No
Good	Flex to 15/Ext to 30 Pron/Supin to 25 Dors/Plamflex to 25 Rad/Ulnar abd to 10	Minor loss	Yes
Satisfactory	Flex to 20/Ext to 45 Pron/Supin to 45 Dors/Plamflex to 35 Rad/Ulnar abd to 10	Medium loss of arm strength Neurologic dysfunction	Considerable
Poor	More than above	Considerable loss of arm strength Neurologic dysfunction	Severe

sults achieved by the treatment and degree of restriction of the elbow and wrist joint movement, as proposed by the AO group[15]. Assessment of therapeutic results based on restriction of movement, hand function, and discomforts is illustrated in Table 4.

Results achieved by the forearm surgery were judged as excellent in 62%, good in 16%, satisfactory in 12%, and poor in 10% of cases (Table 5).

Table 5. Results of forearm surgery treatment

Result	%
Excellent	62
Good	16
Satisfactory	12
Poor	10

The satisfactory and poor results were recorded in cases where postoperative plaster immobilization was used for three weeks due to insufficient stability of internal fixation.

Monteggia and Galleazzi fractures were analyzed in separate. Results of operative treatment are presented in Table 6. In this group, the satisfactory and poor results were observed in 40% of patients, as differentiated from the total number of patients where this figure was as low as 20%.

Table 6. Results of surgical treatment for Monteggia and Galleazzi fractures

Result	Monteggia (n=30) n (%)	Galleazzi (n=30) n (%)
Excellent	14 (46)	15 (50)
Good	4 (13.3)	6 (16.6)
Satisfactory	3 (10)	4 (13.3)
Poor	9 (30.1)	6 (20.1)

Discussion

The issue of forearm shaft fractures has been addressed in a great number of studies, and it is common to all of them that the authors prefer operative treatment of fractures in this region. Good treatment results can only be achieved with appropriate internal fixation allowing for early physical therapy of soft tissues of the forearm and hand.

However, the achievement of good operative results requires proper knowledge of traumatology, high surgi-

cal skill, and appropriate implants and instrumentarium. It should be borne in mind that each fracture is unique and lacking similarity to any other, thus the treatment of each fracture is an entirely new procedure, not just repeating another one. Accordingly, complications are by no means unexpected. The most important complications are wound infection and pseudoarthrosis. Statistical analysis of the results obtained in the present study yielded values that were quite consistent with those recently reported elsewhere. Pseudoarthrosis developed in 3.9% and was treated by reosteosynthesis with spongiosaplasty. Early infection occurred in 2.8% of cases, manifesting as osteitis, which was treated with antiobiotic therapy along with surgical treatment. Chronic osteomyelitis was not recorded. Synostosis was observed in 2.8% of cases, however, it did not require surgical intervention. Refracture occurred in 1.4% of cases after plate removal from both forearm bones. Therapy consisted of reosteoynthesis with spongiosaplasty. The operative treatment results were excellent and good in 78% of patients, as indicated by the parameters of movement restriction, function of the arm, and discomforts. Poor results were recorded in 10% of patients.

Conclusion

The aim of the study was to assess the efficiency of the operative treatment of forearm shaft fractures, with special reference to cases with associated luxation of adjacent joints, according to possible complications and end results of the treatment. Comparison of the results achieved in the overall series of forearm shaft fractures and in cases of these fractures combined with adjacent joint lesions, such as Monteggia and Galleazzi fractures, yielded a twofold rate of poor outcome in the latter, as expected. The results of the study clearly point to the justifiability of the choice of operative treatment for forearm fractures, especially when associated with adjacent joint injuries. The crucial role of stable internal fixation for good functional result cannot be overemphasized.

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Sažetak

PRIJELOM PODLAKTICE: REZULTATI DESETGODIŠNJEG PRAĆENJA

A. Matejčić, M. Ivica, M. Tomljenović i I. Krolo

Svrha istraživanja bila je ispitati opravdanost operacijskog pristupa liječenju prijeloma podlaktice udruženih s ozljedama susjednih zglobova u odnosu na moguće komplikacije i konačan rezultat liječenja, kroz 10-godišnje praćenje bolesnika u vlastitoj kazuistici. U 10-godišnjem razdoblju od 1988. do 1998. godine metodom osteosinteze je liječen 331 bolesnik s ukupno 354 prijeloma podlaktičnih kostiju udruženih s ozljedama zglobova. Prikazani su statistički podaci o lokalizaciji prijeloma, raspodjeli prema dobi i spolu, načinu liječenja i komplikacijama. Posebna je pozornost poklonjena dijafiznim prijelomima podlaktičnih kostiju udruženim s ozljedama susjednih zglobova, kojih je bilo 162 (48%). Ocjena uspješnosti kirurškog liječenja navedenih ozljeda temeljena je na funkcionalnom rezultatu po završetku liječenja, prema stupnju ograničenja pokretljivosti lakatnog i ručnog zgloba. Rezultat kirurškog liječenja ovih ozljeda ocijenjen je kao odličan u 60%, dobar u 15%, zadovoljavajući u 13% i loš u 12% slučajeva. Zadovoljavajući i loši rezultati zabilježeni su u slučajevima gdje je dodatna sadrena imobilizacija primijenjena u poslijeoperacijskom tijeku kroz razdoblje duže od tri tjedna, a zbog nedovoljne stabilnosti osteosinteze. Rezultati ovoga ispitivanja nedvojbeno govore u prilog ispravnosti operacijskog liječenja prijeloma podlaktice udruženih sa zglobnim ozljedama, pričem se ne može dovoljno naglasiti potreba postizanja stabilne osteosinteze za dobar konačan funkcionalni rezultat ovakog načina liječenja.

Ključne riječi: *lom podlaktice, osteosinteza DCP*