

# INTRAMEDULLARY FIXATION OF FOREARM FRACTURES IN ADULTS

J. MOERMAN<sup>1</sup>, A. LENAERT<sup>2</sup>, D. DE CONINCK<sup>2</sup>, L. HAECK<sup>2</sup>,  
S. VERBEKE<sup>3</sup>, D. UYTENDAELE<sup>1</sup>, R. VERDONK<sup>1</sup>

**The authors present a retrospective study of acute fractures of the diaphysis of the radius or ulna, or both, in adults treated by intramedullary nailing.**

**Seventy diaphyseal fractures in 38 patients (30 men and 8 women) were treated by intramedullary fixation. The mean age of the patients was 31.5 years.**

**Union occurred in 66 fractures (94%). The average union-time was 73 days.**

**Compared with the results published by other authors, using the same evaluation criteria, union-time with the intramedullary technique was shorter than with other techniques. Union-rates and functional results were similar to those in comparable studies.**

**Closed nailing does have many advantages, including early union, low incidence of infection, small scars, less blood loss, and short operating time with minimal surgical trauma.**

**Keywords :** fracture ; forearm ; radius ; ulna ; medullary fixation ; adult.

**Mots-clés :** fracture ; avant-bras ; radius ; cubitus ; em-brochage centro-médullaire ; adulte.

---

## INTRODUCTION

Since 1986 the authors have used an intramedullary fixation technique to treat fresh forearm fractures in adults. In the ensuing years they have refined the indications to optimize the results.

This fixation technique was used already by Sage in 1959 (9). Like all intramedullary fixations this technique is less traumatic than plate and screw fixation. The primary fracture haematoma is not opened and the bone is not devitalised.

The idea of primary bone healing was one of the reasons why intramedullary techniques became disregarded in favor of plate and screw fixation

as advocated by the A.O.-group. As success with intramedullary devices in the treatment of fractures in the lower limb increases, this method is again gaining interest in upper limb surgery.

## MATERIAL AND METHODS

### Patients

We reviewed the patients who had undergone intramedullary nailing of the radius, ulna or both, for an acute fracture between 1986 and 1992. From this study were excluded : (1) all undisplaced fractures treated conservatively ; (2) all fractures in patients under 18 years of age ; (3) all metaphyseal fractures ; (4) all fractures treated with plates and screws ; (5) all fractures treated with external fixation. Our indications for nailing are : the open and closed fractures of the forearm with their localisation between the 2nd and 5th sixths according to Hackethal.

Thirty-eight patients, 30 men and 8 women, had 70 diaphyseal fractures which were treated by intramedullary fixation (table I). The mean age of the patients was 31.5 years (range 18-62 years). All patients were reviewed by one of the authors and radiographs of both arms were performed. The mean follow-up was 61 months with a minimum follow-up of 2 months (table II).

Both ulna and radius were fractured in 32 patients. Five patients had an isolated radius fracture and one patient had an isolated ulna fracture (Monteggia). Three patients had a segmental fracture of the radius and a displaced fracture of the ulna diaphysis and three

---

<sup>1</sup> Department of orthopaedic surgery, University Hospital, 9000 Ghent, Belgium.

<sup>2</sup> O.L.V. Hospital, 8790 Waregem, Belgium.

<sup>3</sup> University Hospital, 3000 Leuven, Belgium.

Correspondence and reprints : J. Moerman, Burgemeesterstraat 11, B-9830 St-Martens-Latem.

Table I. — Localisation of fractures

	Ulna #			Radius #			(7) total #
	(1) uln	(2) uln/rad	(3) tot uln	(4) rad	(5) rad/uln	(6) tot rad	
number of #	1	32	33	5	32	37	70
aver. union-time	35d	73d	71d	61d	77d	74d	73d
unions (n° #)	1	30	31	5	30	35	66
delayed unions	0	0	0	0	0	0	0
non-unions	0	2	2	0	2	2	4
overall rate of union (%)	100	93.8	93.9	100	93.8	94.6	94.3

- (1) Number of ulna fractures in patients without radius fracture.
- (2) Number of ulna fractures in patients with radius fracture.
- (3) Total number of ulnar fractures.
- (4) Number of radius fractures in patients without ulna fracture.
- (5) Number of radius fractures in patients with ulna fracture.
- (6) Total number of radius fractures.
- (7) Total number of forearm fractures.

Table II.

	Age years	cast weeks	follow-up months	union-time days	material-out days
Average	31.5	7.97	61.4	73.0	148
Median	25.0	6.00	33.5	47.0	114
Mode	18.0	6.00	28.0	43.0	114
Geomet. mean	28.9	7.32	34.5	60.4	127
Stand. dev.	14.0	3.97	85.4	61.5	96.8
Stand. error	2.30	0.692	14.2	7.81	12.5
Minimum	18.0	4.00	2.00	34.0	52.0
Maximum	62.0	24.0	440	312	450
Low. quartile	19.0	6.00	18.0	43.0	82.0
Upp. quartile	40.0	8.00	51.0	81.0	150

patients had a segmental fracture of the ulna and a diaphyseal radial fracture. A segmental fracture is considered in all statistics as one fracture. Nine (13%) of the fractures were open. A double fracture with penetration of one of the bones through the skin is considered as one closed fracture and one open fracture. Sixty-one fractures were closed. Eleven patients (29%) were polytraumatised (at least 3 fractures, including one of a large bone). Two patients had temporary neurological damage and two patients had permanent neurological damage (C5-C6 brachial plexus paralysis which did not show recovery on the date of follow up).

All fractures have been classified using the fracture-classification system of the Orthopedic Trauma Asso-

ciation (4). Twenty-six (37%) of the fractures were comminuted (categories IV through VII). The open fractures have been further classified according to the system of Gustilo (5).

### Surgical Technique

A modification of the Rush pin technique was used. Nails in different diameters were inserted in the fractured bones. For very small shafts, Kirchner-wires were used.

For anesthesia a brachial plexus block was used. The use of a pneumatic tourniquet was not necessary. With the arm either on a side table, or across the chest, the

ulnar distal border was located. The tip of the nail or wire was slightly prebent to ease the reduction. A small skin incision less than one centimeter long was made just proximal to the ulno-carpal joint line. Next the wire or nail was inserted manually in the ulnar shaft from distal to proximal. An image intensifier was used to pick up the proximal fragment(s). The radiocarpal joint was then palpated, a small skin incision was made over the distal radius and the same procedure as for the ulna was used. The nails were bent against the outer cortex at the place of insertion and cut off. The extremity of the nails was smoothed using a rasp. The skin was closed. A splint extending from the metacarpal joints to the upper half of the humeral shaft was applied. Immobilisation in the cast was continued until radiographic union was found to be progressing satisfactorily.

The nails remained in situ until there was a bridging periosteal callus.

Cefazolin 1 gram was administered intravenously preoperatively and after the intervention.

### Evaluation

The criteria described by Anderson (1, 2) have been used. A fracture was considered to be united if it had healed within six months. Those that healed after six months without an additional surgical intervention were designated as delayed unions. Fractures that failed to unite within six months and required a second operative procedure were referred to as "non-unions".

The presence of periosteal callus bridging the fracture site or trabeculation crossing it, was considered as the roentgenographic criterion for union.

Time to union was defined as the time between the first surgical intervention and the date of radiographic union.

A positive culture with or without local signs of infection was considered as an infection, as were systemic signs of infection with or without a positive culture. If union did not occur, and if a second intervention revealed positive bone-fragment cultures, the case was designated as chronic osteomyelitis.

To evaluate the functional results, the definitions of Anderson were used (1, 2). By excellent result is meant a union of the fracture, a loss of flexion and extension at the wrist or elbow of less than 10 degrees, and a loss of pronation and supination of less than 25 percent. The result is satisfactory if the fracture is united with loss of flexion and extension at the wrist or elbow of less than 20 degrees, and loss of pronation and supination of less than 50 percent. A result is considered

unsatisfactory when there is union of the fracture and either loss of flexion and extension at the wrist or elbow of more than 20 degrees or loss of supination and pronation of more than 50 percent. A non-union or unresolved chronic osteomyelitis is considered a failure.

The grip force of both hands was measured using a dynamometer. The patient was asked to squeeze three times with each hand and the highest value obtained was noted. The force was expressed in percentage of the contralateral side.

## RESULTS

Union occurred in 66 fractures (94%); non-union in 4 fractures (6%). There were no delayed unions. The average time to union was 73 days (range 34 - 312 days) or 10.4 weeks (range 4.9 - 44.6 weeks). The modus of the union time was 43 days or 6.1 weeks. The upper quartile was 81 days or 11.6 weeks. Thus 75% of the fractures had united in less than 11.7 weeks (table II).

The average time before removing the material was 148 days (4.95 months) with a minimum of 52.0 days (1.73 months) and a maximum of 450 days (15.0 months).

The average time in cast was 7.9 weeks (range 4 - 24 weeks).

No early postoperative infections were noticed. An infection occurred 10 weeks after surgery in one case; enterobacter cloacae was identified. The fracture was an open IIIB (Gustilo) VII (OTA) severely comminuted segmental fracture with bone loss.

The functional and radiological results have been recorded for 38 patients with 70 fractures of the diaphysis of the forearm. Table III shows that the overall success rate is 83% (an excellent or satisfactory result).

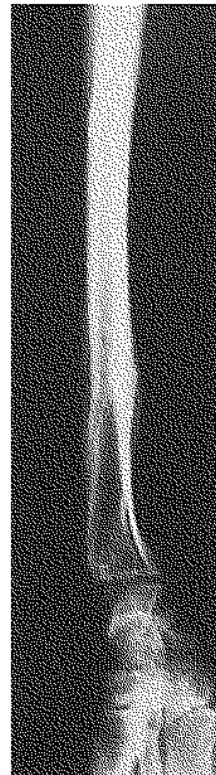
Two cases (5.6%) were considered as failures: in one patient, there was an open fracture of the ulna and a comminuted fracture of the radius; the union-time for the ulna was 228 days (7.6 months) and a second intervention was necessary. One patient developed a non-union of the radius following an OTA type VI segmental fracture; a reoperation was necessary. Cortico-cancellous iliac bone grafts were implanted. The union time was 312 days for the radius. The median nerve had to be released.



*Fig. 1.* — Forearm X-ray at date of injury.



*Fig. 2.* — Forearm X-ray one day postop.



*Fig. 3.* — 147 days postop.

Table III. — Functional results

	Excellent	Satisf	Unsatisf	Failure
ulna only (1 pt)	100%	—	—	—
radius only (5 pt)	60%	40%	—	—
radius + ulna (32 pt)	63%	17%	13.3%	6.7%
total (38 pt)	63.9%	19.4%	11.1%	5.6%
	83.3%			

Table IV.

union-time	Cast-time S : 0.7176 (0.0008) K : 0.6339 (0.00001)	union-time 1 1
fract-type	S : 0.4295 (0.001) K : 0.3317 (0.0001)	S : 0.4320 (0.001) K : 0.3211 (0.0001)
union-time	squeeze-force S : -0.6775 (0.0015) K : -0.4906 (0.0004)	functional result not significant
fract-type	S : -0.4736 (0.0263) K : -0.3715 (0.0089)	not significant
cast-time	S : -0.8142 (0.0001) K : -0.6762 (0.00001)	S : -0.4747 (0.0260) K : -0.4303 (0.00001)

S = Spearman rank correlation coefficient

K = Kendall's tau

between brackets : significance level

This patient ended with a shortened radius, a limited supination (20°) and a grip force of 67.7%. He resumed his previous occupation fourteen months after his accident.

Four patients (11.1%) had an unsatisfactory score at the functional evaluation. Three of these patients had at least three other fractures in the same limb and two had a seriously jeopardized rehabilitation program due to a traumatic brachial plexus paralysis. One other patient also had fractures of the clavicle, scapula, several ribs, nose, acetabulum and a hemarthrosis of the shoulder on the ipsilateral limb.

In the group of 70 fractures there were no concomitant vascular injuries. There was one radial nerve palsy which recovered spontaneously. Two patients had loss of sensation and paresthesias in respectively the ulnar and median nerve areas. One patient needed a release of the median nerve. As mentioned before, two traumatic brachial plexus lesions were noted.

No failures of fixation or material breakage have been observed.

### STATISTICAL ANALYSIS

The relative degree of agreement or disagreement of the variables (fracture type, union time, age, squeeze-force, functional result and casting time) is measured by Kendall's tau and the Spearman rank correlation coefficient. As appears from the examination of the group under study there is positive correlation between : union time and the duration of cast immobilisation, fracture type (O.T.A.) and casting time, fracture type (O.T.A.) and union time. There is a negative correlation between : squeeze force and fracture type, squeeze force and union time, squeeze force and casting time, functional result and casting time (table IV).

There are more unsatisfactory results and failures in the OTA < III group than in the comminuted fracture groups (OTA > III). In the OTA III

group there are no failures nor unsatisfactory results. In groups III, IV, VI, and VII no failures occur. In the OTA groups I, III, IV, and V the union time does not exceed 150 days. In group VI a great majority of the fractures united within 100 days. In group II the maximum union time is 300 days. Those results are therefore not attributable to the incidence of fractures with a "simple" configuration (OTA < III). All the failures or unsatisfactory results were found in the young adult group. There is a good distribution of the different fracture-types in all age groups.

Summary statistics concerning age, casting-time, follow-up, and union-time are shown in table II.

### DISCUSSION

The same classification criteria for fracture configuration (O.T.A.), open fracture classification (Gustilo), and functional result have been used by Chapman *et al.* (4) and by Anderson *et al.* (1, 2). The distribution of fracture-configuration in the present study is comparable with that of Chapman (cfr. Pie Chart). Chapman reported a 98.4% overall rate of union. Children, who heal very quickly, are included in his study, whereas the present study deals with adults only. The average union-rate is 12 weeks in the study of Chapman, 10 weeks only in the present study.

Anderson (1) and Anderson *et al.* (2) reported 97.9% union. They reported 58.7% excellent results, 30.9% satisfactory results, 7.2% unsatisfactory results and 3.1% failures.

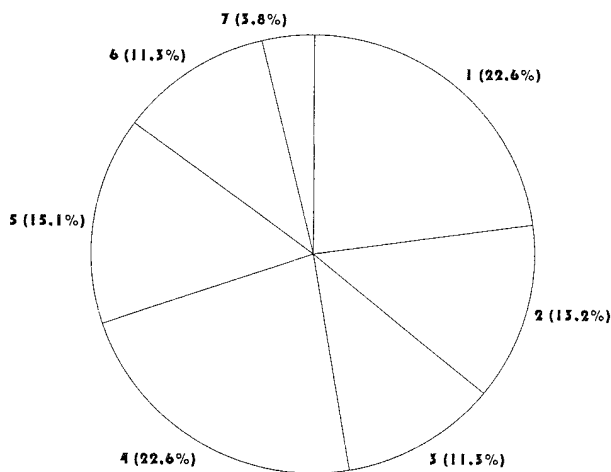
Moed *et al.* (9) reported 91% of union. This is 3.3% less than in the present study. The average union-time was 13.2 weeks. An excellent or good result was found in 85% of the patients.

Langkamer et Ackroyd (8) reported 89.7% union. An excellent or good result was found in 73.2% of the patients. A failure was found in 10% of the cases.

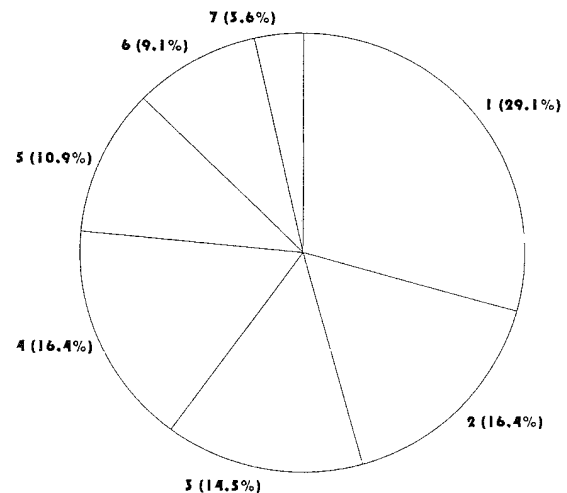
Winckler *et al.* (12) used a bundle-nailing technique ; 71.5% of their patients obtained an excellent or satisfactory functional result. The average time for removal of the material was 11.5 months (4.9 months in our study). They do not mention the overall union rate. The average union-time was 10.4 weeks. They emphasized that intramedullary techniques shortens the union-time.

Street (11) used an intramedullary technique with reaming of the bones. He reported a 93% union-rate. An excellent or satisfactory result was obtained in 83.5% of the cases using the classification of Anderson. He noted 8.5% failures, which is 3.1% higher than in our series (5.6%).

Interpretation of these figures is difficult, because of the lack of an identical control group, as is the case in most retrospective studies. However



O.T.A. Class. Chapman.



O.T.A. Class. Present series.

it can be noted that the union-time in intramedullary techniques is low. The figures concerning union-rate and functional results in the present study are compatible with those of Chapman *et al.* (4), Anderson *et al.* (1, 2) and Moed *et al.* (9).

The technique of intramedullary pinning of fractures of the forearm implies closed reduction. Therefore it has its limitations. In the case of polytraumatised patients this technique can prove its success by being very fast.

In several long bones we see a come-back to intramedullary techniques supported by the principle that unopened fracture hematoma favors early union. The present series shows a shorter union time. The low incidence of infection, the small scars and the shorter operating time with minimal surgical trauma are other windfalls in forearm nailing. Closed nailing of forearm fractures should therefore not be banished to history but be considered as a valid alternative with its own indications.

## REFERENCES

1. Anderson L. D. Compression plate fixation and the effect of different types of internal fixation on fracture healing. *J. Bone Joint Surg.*, 1965, 47-A, 191-208.
2. Anderson L. D., Sisk D., Tooms R. D., Park W. I. Compression-plate fixation in acute diaphyseal fractures of the radius and ulna. *J. Bone Joint Surg.*, 1975, 57-A, 287-297.
3. Bauer G., Arand M., Mutschler W. Post-traumatic radio-ulnar synostosis after forearm fracture osteosynthesis. *Arch. Orthop. Trauma Surg.*, 1991, 110, 142-145.
4. Chapman M. W., Gordon J. E., Zissimos A. G. S. Compression-plate fixation of acute fractures of the diaphyses of the radius and ulna. *J. Bone Joint Surg.*, 1989, 71-A, 159-169.
5. Gustilo R. The multiple trauma patient. *Minn. Med.*, 1975, 88, 552-556.
6. Hackethal K. H. *Die Bündelnagelung*. Springer Verlag, Berlin, Gottingen, Heidelberg, 1961.
7. Hughston J. C. Fracture of the distal radial shaft. *J. Bone Joint Surg.*, 1957, 39-A, 249-264.
8. Langkamer V. G., Ackroyd C. E. Internal fixation of forearm fractures in the 1980s: lessons to be learnt. *Injury*, 1991, 22, 97-102.
9. Moed B. R., Kellam J. F., Foster R. J., Tile M., Hansen S. T. Immediate internal fixation of open fractures of the diaphysis of the forearm. *J. Bone Joint Surg.*, 1986, 68-A, 1008-1017.
10. Sage F. P. Medullary fixation of fractures of the forearm. *J. Bone Joint Surg.*, 1959, 41-A, 1489-1525.
11. Street D. M. Intramedullary forearm nailing. *Clin. Ortop.*, 1986, 212, 219-230.
12. Winckler S., Brug E., Baranowski D. Bündelnagelung bei Unterarmfrakturen. *Unfall Chirug.*, 1991, 94, 335-341.

## SAMENVATTING

*J. MOERMAN, A. LENAERT, D. DE CONINCK, L. HAECK, S. VERBEKE, D. UYTTENDAELE, R. VERDONK. Intramedullaire verpenning van voorarm fracturen bij volwassenen.*

De auteurs stellen een retrospectieve studie voor over de intramedullaire behandeling van diafysaire voorarm fracturen bij volwassenen.

Zeventig diafysaire fracturen in 38 patiënten (30 mannen en 8 vrouwen) werden intramedullair behandeld. De gemiddelde leeftijd van de patiënten was 31.5 jaar. Heling van de fractuur werd in 66 fracturen bereikt (94%). De gemiddelde tijd tot de heling van de breuk bedroeg 73 dagen.

De helingstijd der fracturen in deze serie was korter dan deze bereikt met andere dan intramedullaire technieken. De functionele resultaten waren vergelijkbaar met de resultaten van gelijkaardige studies.

Gesloten intramedullaire fixatie heeft voordelen zoals: snelle botheling, laag infectierisico, kleine littekens, weinig bloedverlies en korte operatietijd met minimaal chirurgisch trauma.

## RÉSUMÉ

*J. MOERMAN, A. LENAERT, D. DE CONINCK, L. HAECK, S. VERBEKE, D. UYTTENDAELE, R. VERDONK. Embrochage centro-médullaire des fractures de l'avant-bras chez l'adulte.*

Etude rétrospective portant sur 38 patients qui présentaient 70 fractures du radius et/ou du cubitus, traitées par embrochage centro-médullaire.

La consolidation osseuse a été obtenue dans 66 fractures (94%). Le temps moyen de consolidation était de 73 jours.

En comparant aux résultats d'autres études, on constate un délai de consolidation plus court, avec des résultats fonctionnels similaires.

Dans les indications opératoires citées, l'ostéosynthèse centro-médullaire à foyer fermé constitue un traitement à faible risque, non traumatisant, qui assure une consolidation osseuse rapide.