Osteosynthesis in Long Oblique and Spiral Metacarpal Fractures: Comparison Between Interfragmentary Screws and Plating

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ABSTRACT

Objective: To compare open reduction and internal fixation with interfragmentary screws and with plates and screws for the treatment of long oblique or spiral metacarpal fractures. **Materials and Methods:** A comparative retrospective study was carried out between 2 groups of patients treated surgically. In the first group, 24 patients were treated with interfragmentary screws and in the second group, 17 patients were treated with plate and screw osteosynthesis. A dorsal longitudinal approach was used. Postoperatively, immobilization was performed using a plaster splint; both groups followed rehabilitation with same occupational therapist team. After a minimum follow-up of 12 months, they were evaluated with the DASH score, total active motion (TAM), pulp-to-palm distance, and comparative contralateral dynamometry. A p value < 0.05 was considered significant. **Results:** The average follow-up was 24.5 months (range 12-43 months). There were no statistically significant differences in DASH, TAM, pulp-to-palm distance, and strength. The group treated with plate and screw fixation returned to work earlier, although there were two cases of implant removal, in addition to tendon adherence (tenolysis) in one of them. **Conclusions:** The treatment of patients with long oblique or spiral metacarpal fractures with interfragmentary screws or plates and screws showed similar outcomes; the treatment with plate and screws allowed an earlier return to work but had a greater number of complications.

Keywords: Fracture; metacarpal; osteosynthesis; plate; screws.
Level of Evidence: III

Osteosíntesis en fracturas oblicuas o espiroideas largas de metacarpianos: comparación entre tratamiento con tornillos interfragmentarios solos y placa con tornillos

RESUMEN

Objetivos: Comparar el tratamiento de pacientes con fracturas oblicuas o espiroideas largas de metacarpianos, mediante reducción abierta y fijación interna con tornillos interfragmentarios solos o placas y tornillos. **Materiales y Métodos:** Se realizó un estudio retrospectivo comparativo entre 2 grupos de pacientes: uno con 24 pacientes tratados con tornillos interfragmentarios solos y otro con 17 pacientes tratados mediante osteosíntesis con placas y tornillos. En ambos, se utilizó un abordaje longitudinal dorsal, y se les indicó inmovilización posoperatoria con valva de yeso y rehabilitación con el mismo equipo de terapistas ocupacionales. Tras un seguimiento mínimo de 12 meses, se evaluaron los resultados con el puntaje DASH, la movilidad activa total, la distancia pulpejo-palma y la fuerza con dinamometría comparativa. Se consideró significativo un valor p <0,05. **Resultados:** El tiempo promedio de seguimiento fue de 24.5 meses (rango 12-43). No se hallaron diferencias estadísticamente significativas en el puntaje DASH, la movilidad activa total, la distancia pulpejo-palma y la fuerza. El tiempo hasta el reingreso laboral fue inferior en el grupo tratado con placas y tornillos, aunque, se registraron dos casos de retiro de material, sumado, en uno de ellos, a adherencia tendinosa (tenólisis). **Conclusión:** El tratamiento de pacientes con fracturas oblicuas o espiroideas largas de metacarpianos, mediante tornillos interfragmentarios solos o placas y tornillos logró resultados similares, se destaca el menor tiempo hasta la reincorporación laboral y la mayor cantidad de complicaciones con placas y tornillos.

Palabras clave: Fractura; metacarpiano; osteosíntesis; placa; tornillos solos.
Nivel de Evidencia: III

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INTRODUCTION

Fractures of the metacarpal bones represent one of the most frequent injuries of the hand and cause a temporary or definitive functional limitation.[1,2] Most of these fractures can be successfully treated in a non-invasive way, but if there is an unacceptable displacement, or they are irreducible or unstable, we should opt for surgery.[3-5] There are multiple fixation systems designed for this purpose: external fixators, percutaneous pins placed with different mounts, intramedullary screws, wire cerclage, single screws, plates and screws, among others.[6-8,12]

Metacarpal shaft fractures are typically classified into three groups: transverse, oblique (or spiral), and comminuted.[12] The arrangement of the line, added to other characteristics of the injury, such as associated soft tissue injuries, the presence of multiple fractures, bone exposure, the age of the patient, the involvement of the dominant hand, the functional requirements and, to a great extent, the preferences and experience of the surgeon, make it possible to identify the best treatment method for each lesion.[4,7]

Long oblique or spiral fractures (with a simple line, whose length reaches or exceeds twice the diameter of the diaphysis of the affected metacarpal),[4] usually require surgical treatment, due to the thrust or rotation that they usually present.[5,6,8,11,12]

This study aimed to compare the treatment of patients with long oblique or spiral metacarpal fractures by open reduction and internal fixation with interfragmentary screws alone or with plates and screws.

MATERIALS AND METHODS

We conducted a retrospective study that evaluated patients between August 2009 and December 2015. In our Service, 288 metacarpal fractures were treated with surgery in 255 patients. The inclusion criteria were: patients >18 years old, with closed simple long spiral or oblique fractures of a single metacarpal, with >3 mm shortening, malrotation with distal finger overlap or an angle >20º, no surgical history, and a minimum follow-up of 12 months. Patients with associated fractures of more than one metacarpal or other hand bone, exposed fracture, associated soft tissue injury, or inadequate follow-up were excluded.

We obtained a final sample of 41 patients, divided into two groups, according to whether they had been treated with interfragmentary screws alone (group 1) or osteosynthesis with plates and screws (group 2), respectively. The choice of technique and implant depended on the decision of the treating team.

Group 1 consisted of 24 patients (5 women and 19 men), with an average age of 41 years (range 17-58) and involvement of the right (15 cases) and left (9 cases) hands. The dominant hand was affected in 17 cases and the non-dominant hand was affected in seven. Surgery was carried out, on average, eight days after the fracture (range 3-19). In these patients, two or three screws of 1.5, 1.7, 2.0, or 2.3 mm in diameter were used with an interfragmentary compression technique (Table 1, Figure 1).

Group 2 consisted of 17 patients (3 women and 14 men), with an average age of 41.8 years (range 17-71) and involvement of the right (12 cases) and left (5 cases) hands. Thirteen patients had compromise of the dominant hand and four of the non-dominant. Surgery was performed, on average, seven days after the fracture (range 4-14). Unlocked plates and 2.0 and 2.3 mm screws were used (Table 2, Figure 2).

Surgical technique

In all cases, a dorsal longitudinal approach was performed in the intermetacarpal space adjacent to the affected metacarpal under ultrasound-guided brachial plexus block and hemostatic cuff. The intrinsic muscles and the periosteum were longitudinally opened, elevating them and separating them from the bone in a single plane. Subsequently, the metacarpal reduction and osteosynthesis were carried out with interfragmentary screws (to place them, the length of the fracture line must be at least twice the diameter of the metacarpal and the location of the screw hole must be perpendicular to the line) or with plate and screws, according to the AO technique. The implant was covered with the closure of soft tissue, creating a plane between it and the extensor tendons; then, and a sterile bandage was placed.

Table 1. Series of patients treated with interfragmentary screws alone.

N°	Age	Sex	Injured hand	Dominant hand	Metacarpal affected	Pre-surgical days	Days of immobilization	% strength	Pulp-to-palm distance	DASH score	Days until return to work	Total active motion	Screws
1	31	M	L	No	3	6	12	100	0	1.2	68	260	2
2	22	M	R	Yes	3	3	10	120.32	0	0	76	272	2
3	29	M	R	Yes	4	9	14	97.14	0.5	2.16	52	265	2
4	37	M	L	No	5	10	15	94.87	0	0	75	258	2
5	58	M	R	Yes	2	12	17	78.5	1	4.51	83	240	2
6	48	M	L	No	4	11	14	97.5	0	1.2	105	267	2
7	32	F	R	Yes	4	8	16	90	0	0	72	247	2
8	39	M	R	Yes	3	5	15	94.74	0	0	77	263	2
9	43	M	L	Yes	4	6	18	92.96	0	0.83	70	260	3
10	32	M	R	Yes	4	7	15	97.3	0.8	1.76	84	230	3
11	27	M	R	Yes	2	4	17	107.05	0	1.75	69	270	2
12	29	F	R	Yes	3	5	16	134.58	0	0	73	270	2
13	54	M	R	Yes	4	7	16	104.28	0	0	71	280	2
14	21	M	R	Yes	4	6	18	109.37	0.8	7.5	83	265	2
15	42	M	L	No	4	5	14	45.31	0.5	4.85	68	264	3
16	40	M	L	No	5	8	15	114.28	0	4.6	79	260	2
17	24	M	R	Yes	4	8	17	89.52	0	3.29	81	258	2
18	22	M	R	Yes	4	10	17	95.06	0	0.66	107	265	3
19	49	M	L	No	5	16	16	75.63	0	0	67	273	2
20	54	F	R	Yes	4	3	18	106.82	0	4.05	61	269	2
21	34	F	L	No	4	19	14	100	0	0.83	74	263	2
22	19	M	R	Yes	4	7	19	100	0	0	65	265	3
23	43	M	R	Yes	4	6	19	96.51	0	0	73	259	2
24	17	F	L	Yes	4	7	14	101.81	0	0	66	268	2

M = male, F = female, L = left, R = right.

Figure 1. A patient treated with screws using the interfragmentary compression technique. Preoperative, intraoperative, and postoperative images and functional outcome at the end of follow-up.

Figure 2. A patient treated with a 2 mm osteosynthesis plate. Postoperative images and functional outcome at the end of follow-up.

Table 2. Series of patients treated with plates and screws

N°	Age	Sex	Injured hand	Dominant hand	Metacarpal affected	Presurgical days	Days of immobilization	% strength	Pulp-to-palm distance	DASH score	Days until return to work	Total active motion	Complication
1	58	M	L	No	5	6	14	89.74	2	6.8	98	200	
2	56	M	R	Yes	5	8	17	109.37	1	7.5	89	265	
3	49	M	R	Yes	4	5	16	87.5	0	3.33	79	266	
4	29	M	R	Yes	5	7	15	88	0.5	1.72	63	235	
5	28	M	R	Yes	5	9	14	100	0	0	81	271	
6	31	M	L	No	3	4	15	100	0	0	57	260	
7	37	F	R	Yes	4	6	15	100	0	1.17	67	258	
8	47	F	L	Yes	4	5	19	92	1	2016	85	241	Retirement
9	32	M	R	Yes	2	8	16	102.56	0	0	71	272	
10	42	M	L	No	3	7	18	93.83	0	0	67	265	
11	71	M	R	Yes	5	11	19	100	2	8.31		238	Removal and tenolysis
12	35	M	L	Yes	4	6	14	91.57	0	0	73	268	
13	43	M	R	Yes	3	7	16	98.79	0	1.31	59	259	
14	45	M	R	No	4	4	17	93.9	0.5	3.36	70	249	
15	22	M	R	Yes	4	10	18	100	0	0	68	266	
16	69	F	R	Yes	5	14	15	79.24	1	2.18		237	
17	17	M	R	Yes	2	5	16	98.41	0	0		273	

M = male, F = female, L = left, R = right.

Postoperative follow-up

A gutter plaster slab was indicated for an average of 16 days (range 10-19). Then the sutures were removed and the rehabilitation process with occupational therapy began. Anteroposterior and lateral radiographs were taken before surgery, in the immediate postoperative period, and at the end of follow-up. An outcome was considered satisfactory if it met the criteria established by Pun et al. (in metacarpals, shortening <6 mm without rotation or angulation of the head).

The subjective evaluation at the end of the follow-up was carried out with the DASH score.

The objective evaluation included goniometry, pulp-to-palm distance, and dynamometry. Using a goniometer, the total active range of motion was recorded, defined as the sum of the active flexion of the metacarpophalangeal, proximal, and distal interphalangeal joints, minus the extension deficit of these joints. An outcome was considered excellent if it was >150º; good, from 125º to 149º; fair, from 90º to 124º; and poor <90º.

The pulp-to-palm distance, expressed in centimeters, was compared. The outcome was considered excellent if the distance was ≤1cm; good, 1 to 1.5 cm; fair, 1.6 to 3 cm; and poor >3 cm.

The dynamometric evaluation was carried out with a Baseline® hydraulic dynamometer, and the percentage of strength recovery in comparison to the contralateral side was recorded. The number of days from the injury to the return to normal work activities and the surgical complications were recorded.

The statistical analysis was performed with the IBM SPSS Statistics 19.0 program. A nonparametric median test was used. A p value <0.05 was considered significant.

RESULTS

The average follow-up time was 24.5 months (range 12-43). Group 1 (treated with screws only) had an average postoperative DASH score of 1.6 (range 0-4.8), an average total active motion of 253.7 ° (range 230-280 °), an average pulp-to-palm distance of 0.15 cm (range 0-1) and an average fist strength recovery of 97.6% compared to the contralateral. This group of patients returned to their usual work activity in an average of 77 days (range 52-107).

Group 2 (treated with plates and screws) had an average DASH score of 2.1 (range 0-8.3), an average total active motion of 254.2 ° (range 200-273 °), a pulp-to-palm distance of 0.5 cm (range 0-2), and an average fist strength recovery of 96.1% in comparison to the contralateral one. This group of patients returned to work in an average of 68.5 days (range 57-98).

The statistical analysis of the results did not show statistically significant differences for: DASH score ($p = 0.5$), total active motion ($p = 0.3$), pulp-to-palm distance ($p = 0.10$) and dynamometry ($p = 0.38$).

Regarding complications, there were no cases of infection, nonunion, malunion, implant loosening or rupture, neurovascular injury, or complex regional pain syndrome. Only in group 2 (plates and screws), there were two cases of extensor tenosynovitis related to the implant (after removal of the osteosynthesis material), added, in one of them, to tendon adherence. Extensor tenolysis was performed.

DISCUSSION

Metacarpal shaft fractures represent a significant proportion of traumatic events treated by the hand surgeon. In this study, we retrospectively compared functional outcomes after treatment with interfragmentary screws alone or with plates and screws.

Based on previous biomechanical studies, the tolerable limits of metacarpal shortening, angulation, and rotation in shaft fractures are clearly established. Due to its high incidence, it would be logical to think that surgical resolution predominates over bloodless treatment, but the current literature opposes this argument: the percentage varies between 5% and 30% of the cases, with a wide preference for Kirschner wires, followed, in descending order, by screws alone and exceptionally plates and screws.[13]

Both systems, screws alone and plates and screws, provide anatomical reduction and stable fixation to begin early rehabilitation and to achieve complete or close to ideal restoration of the hand.[1-3,6,8,10,11,13]

The use of interfragmentary screws alone implies the correct application of the interfragmentary compression technique. For this to be achieved, the length of the fracture line must be at least twice the diameter of the metacarpal and the location of the screw hole must be perpendicular to the line. The proximal hole (smooth canal) must have the same thread diameter as the screw, exerting a direct effect on the pull-out resistance. The distal hole typically respects the diameter of the screw core, exerting a direct effect on flexural and tensile strength.[1,2,6,7,14,15] Adams et al. consider that the axial stability provided by only one interfragmentary screw is limited. For this reason, the application of two or more screws according to the length of the line provides an increase in the rigidity of the system, even if the torsional strength is not neutralized.

The plates and screws provide greater stability at the expense of a higher biological cost due to wasting. From the biomechanical point of view, the dorsal application of the plate (tension strut) is favorable, as it resists the fracture bending force (compression strut). Factors considered when choosing the plate for osteosynthesis include the type of implant (with or without angle lock) and unicortical or bicortical screw fixation.[1,14,15]

Prevel et al. and Cordey et al. demonstrated that metacarpal locking plates provide more rigidity than non-locking plates, since they are the result of the sum of all the bone-screw interfaces of the system. The failure of non-locking plates results from the loosening of individual screws while locking plates fail as a unit.[14,15]

Ochman et al. experimentally studied possible differences between unicortical and bicortical screws. In particular, there were no significant differences in stiffness between the unicortical and bicortical screw groups with non-locking and locking plates.[16]

Trevisan et al. reported acceptable outcomes with a prompt return to work when using plates with screws, although they considered the frequent irritation of the extensor tendons due to the approach, and of the flexors due to the excess palmar length of the screws.[17]

Firoozbakhsh et al. evaluated the quantitative differences in fatigue resistance and stability against cyclical loads in cadaveric hands where metacarpal fractures were reproduced. They divided the treatment into a dorsal plate and screws, two compression dorsal screws, tension bands, and intramedullary Kirschner wires. Plating showed greater resistance to the flexion (1.5 times), torsion (1.6 times), and axial load (2.5 times) tests, compared to the second strongest fixation (compression dorsal screws).[18]

Basar et al. compared both treatments in metacarpal shaft fractures. Plating with screws provided a more rigid fixation compared to the screws alone, allowing a better initial fist strength, especially beneficial in manual workers, accelerating the return to work, although no significant differences were observed at the end of the follow-up.[1]

In our study, we consider it is important to mention that the surgical approach in one plane for intrinsic muscles and periosteum provides the technical advantage of a comfortable closure over the osteosynthesis material and its consequent less possibility of irritation or tendon adherence.[4,6] In the comparison of this series of patients, both techniques were effective and reproducible. Interfragmentary screws alone represented a less complex and less exposed procedure; furthermore, there were no complications (although the time to return to work was longer). For its part, the use of a plate with screws gave the system more rigidity, allowing an earlier return to work, although with more complications and biological cost.

We consider that the limiting factors of this study are its retrospective design, the limited sample of subgroups, the heterogeneity of the material used, and the presence of different surgeons. However, its strengths are the population with a homogeneous condition and minimal follow-up.

CONCLUSIONS

The treatment of patients with long spiral or oblique metacarpal fractures by open reduction and internal fixation with interfragmentary screws alone or plates and screws achieved similar outcomes. The shorter time to return to work and the greater number of complications in the group treated with plates and screws are noteworthy.

Conflict of interest: The authors declare they do not have any conflict of interest.

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