Outcomes of osteotomy and rigid internal fixation treatment for the correction of phalangeal malunions

Ignacio Rellán, Luis Ferreira, Pablo De Carli, Gerardo L. Gallucci, Agustín Donndorff, Ezequiel E. Zaidenberg, Jorge G. Boretto

Hand and Upper Limb Surgery Unit, Institute of Orthopedics "Prof. Dr. Carlos E. Ottolenghi", Hospital Italiano de Buenos Aires (Buenos Aires, Argentina)

ABSTRACT

Objective: To present the results and complications of a series of phalangeal malunion patients. **Materials and Methods:** A retrospective study was conducted on phalangeal malunion patients treated with an osteotomy at the deformity site and stabilized with rigid internal fixation. Postoperative mobility of the digit was recorded. The subjective assessment used the Disabilities of the Arm, Shoulder and Hand (DASH) score and a Visual Analogue Scale (VAS) to rate their function and pain at rest and during activity. **Results:** Twelve patients (13 phalanges) met the inclusion criteria. The average time between fracture and osteotomy was 14 months and the mean follow-up was 34 months. Final mobility in flexo-extension was: 89 degrees for metacarpophalangeal joint, 74 degrees proximal interphalangeal joint, 54 degrees distal interphalangeal joint. The average VAS pain score was 0 at rest and 1 during activity, and the average function was 7 points. The average DASH score was 6. There were no cases of nonunion. Five patients required plate removal. No patients with articular osteotomy presented signs of Osteoarthritis. **Conclusions:** Phalangeal osteotomy at the deformity site is an effective procedure with good objective and subjective short-term outcomes. Patients should be warned about the possibility of a second procedure in cases of plate fixation due to a higher complication rate associated with plate and screw fixations.

Key words: Osteotomy; phalanx; malunion.

Level of Evidence: IV

Resultados de la osteotomía y la osteosíntesis rígida en la consolidación viciosa de falange

RESUMEN

Objetivo: Evaluar los resultados y las complicaciones de una serie de pacientes con consolidación viciosa de falange. **Materiales y Métodos:** Se realizó un estudio retrospectivo que incluyó a pacientes con consolidación viciosa de falange tratados mediante osteotomía en el sitio de la deformidad, estabilizados con osteosíntesis rígida. Se registró la movilidad de los dedos. La valoración subjetiva consistió en el puntaje DASH y una escala analógica visual para el dolor en reposo, en actividad y la función. **Resultados:** Doce pacientes (13 falanges) cumplieron los criterios de inclusión. El tiempo promedio entre la lesión inicial y la osteotomía fue 14 meses y el seguimiento promedio, 34 meses. La movilidad final promedio en flexo-extensión fue 89° metacarpofalángica, 74° interfalángica proximal, 54° interfalángica distal y 3 mm la distancia pulpejo-palma. El puntaje promedio de la escala analógica visual en reposo fue 0; en actividad, 1 y la función promedio fue de 7 puntos; el puntaje DASH promedio fue 6. No hubo casos de seudoartrosis. Cinco pacientes requirieron el retiro de la placa. Los pacientes con osteotomía articular no presentaron signos de artrosis. **Conclusiones:** La osteotomía de falange en el sitio de la deformidad es un procedimiento eficaz con un buen resultado objetivo y subjetivo a corto plazo. La utilización de placas y tornillos conlleva una tasa más alta de complicaciones; por lo tanto, los pacientes deben ser advertidos sobre la posibilidad de una segunda intervención quirúrgica.

Palabras clave: Osteotomía; falange; consolidación viciosa.

Nivel de Evidencia: IV

Received on December 12th, 2018. Accepted after evaluation on November 3rd, 2019 • IGNACIO RELLÁN, MD • ignacio.rellan@hospitalitaliano.org.ar

How to cite this paper: Rellán I, Ferreira L, De Carli P, Gallucci GL, Donndorff A, Zaidenberg EE, Boretto JG. Outcomes of osteotomy and rigid internal fixation treatment for the correction of phalangeal malunions. *Rev Asoc Argent Ortop Traumatol* 2020;85(2):125-132. http://dx.doi.org/10.15417/issn.1852-7434.2020.85.2.932

INTRODUCTION

Phalangeal malunions may include rotation, angulation, shortening, intraarticular step-off or a combination thereof. As a result, a limited fist grip may develop due to digit scissoring, extensor mechanism unbalance, loss of grip strength and joint pain.[1]

The literature on the fixation site for rotational deformities presents advantages and limitations for fixation at the deformity site and at the metacarpal level. Malunion correction at fracture site allows for the performance-related procedures, such as tenolysis or capsulotomy, as well as a more efficient treatment of rotational, angular and combined deformities, and the only approach to treating joint deformities.[2] On the other hand, correction at metacarpal level is a more simple technique and may prevent tendon adhesion.[3] However, this type of correction may only be performed on malrotations and cadaver studies have shown that it is limited to less than 15 degrees malrotations.[4]

Although there are exceptions,[2,5,6] the available literature is comprised of small series, which consist of corrective osteotomies at the metacarpal level[7-9] or non-rigid internal fixations and limited follow-up periods.[10,11]

The aim of this study is to assess the results and complications of a series of phalangeal malunion patients treated with osteotomy at the deformity site and stabilized with rigid internal fixation.

MATERIALS AND METHODS

We reviewed the medical records of patients who had been treated in our center and called in the patients who had had a phalangeal malunion for a follow-up evaluation.

Article inclusion criteria included: (1) patients over 18 years, (2) who had had a phalangeal malunion, (3) were treated osteotomy at the deformity site and (4) stabilized with plates and/or screws. Patients below 18 years or patients who had not been treated with rigid internal fixation were excluded.

The study variables included sex and presence of Osteoarthritis (in patients with joint deformities) as qualitative dichotomous variables. The affected bone and digit, the type of malunion, history and previous surgeries, the used approach, the used internal fixation, the additional surgical procedures, the subsequent operations and postoperative complications were documented as categorical qualitative variables. Age, the time between fracture and osteotomy, and the follow-up period up to the institution of this study revision were documented as continuous quantitative variables. The type of deformity was classified as angular, rotational, articular or a combination of them.

Complications were defined as any deviation from the expected postoperative course that caused pain, limited function or required additional treatment (operative or nonoperative). Complications then were classified following Dindo *et al*. classification of surgical complications.[12] The level of training of the treating surgeons was classified following Tang *et al*.[13] classification: Level I: Non-specialist surgeon; Level II: Specialist with less than 5 years of experience; Level III: Specialist with more than 5 years of experience; Level IV: Highly experienced specialist; Level V: Expert.

Correction planning for lateral angular deformities was carried out measuring the radial/ulnar deviation in order to achieve neutral alignment (0º). Correction planning for anteroposterior angulation was carried out using lateral X-rays and measuring the palmar/dorsal angle in order to achieve an axis correction of 0º.

Malrotations was clinically studied by assessing digit scissoring and, in patients that were unable to make a fist, by assessing the parallel alignment of the nail plates. The objective for joint deformities was to achieve anatomic reduction.

Postoperative assessment

Patients were reached and appointments were arranged for a new control. They were subject to objective evaluation, documenting mobility of the affected digit at different levels: metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP). Measurements were obtained with a manual goniometer on the posterior aspect of the digit in maximal active extension and flexion. Fingertip-palm distance was also documented: the patient was asked to make a fist drawing their digits as close as they could to their palms and the distance between the fingertip of the affected digit and the distal palmar crease. The subjective evaluation consisted of a DASH score and a VAS to rate from 0 to10 their pain at rest (0 being no pain at all and 10 being maximum pain

possible) and during activity (0 being no pain at all and 10 being maximum pain possible), and their function (0 being complete disability and 10 being normal function). Patients who could not make the appointment or refused to attend for a face-to-face evaluation were subject only to the subjective evaluation via telephone or email (DASH and VAS), and it was documented that they underwent subjective follow-up alone.

Statistical analysis

Continuous variables were described as mean and standard deviation, and categorical and ordinal variables were described as percentages.

RESULTS

In an 8-year period (2008-2016), 20 phalanges (19 patients) were surgically intervened in our Center following phalangeal malunions. Six patients were excluded: 1 due to lost to follow-up, 2 due to having undergone non-rigid fixations, and 3 who had less than a 6-month follow-up due to refusing to attend a new control at our Center. Twelve patients (13 phalanges) met the inclusion criteria (Table 1): 7 males and 5 females with a mean age of 34 years (range, 19-60; SD, 13.3). The average time between fracture and osteotomy was 14 months (range, 1-96 months; SD, 26.2). Four patients (one of them with fractures in 2 phalanges) had previously undergone surgery in another center with percutaneous Kirchner pin fixation to stabilize fractures, which resulted in insufficient reductions. The remaining 8 patients were initially treated with cast immobilization.

Table 1. Demographics

Case	Age	Time between fracture and osteotomy (months)	Affected bone	Deformity	Final Osteoarthritis	Previous surgery	Fixation
1	34	36	Distal phalanx, ring finger	Rotational	N/A	Yes	Plate
2	28	96	Distal phalanx, ring finger	15º ulnar deviation	N/A	No	Plate
3	60	3	Distal phalanx, middle finger	Articular	Yes	No	Screws
4	37	1	Distal phalanx, middle finger	Articular	Yes	No	Screws
5	22	9	Distal phalanx, middle finger	Articular	Yes	No	Plate
6	56	2	Distal phalanx, middle finger	Rotational	N/A	No	Plate
7	23	2	Middle phalanx, ring finger	10º ulnar deviation	N/A	No	Plate
8	28	9	Distal phalanx, middle finger	10º radial deviation	N/A	Yes	Plate
		9	Distal phalanx, ring finger	13º ulnar deviation	N/A	Yes	Plate
9	40	1.5	Distal phalanx, middle finger	20º ulnar deviation	N/A	No	Plate
10	19	10	Distal phalanx, ring finger	10º ulnar deviation	N/A	Yes	Plate
11	23	7	Distal phalanx, index finger	Rotational	N/A	No	Screws
12	41	1.5	Distal phalanx, index finger	Articular	Yes	No	Plate
Average	34	12					

The mean objective follow-up (mobility, VAS and DASH) following the osteotomy was of 34 months (range, 6-62 months) (Figure). Three patients refused or were unable to attend to new control at our center, and thus we could only update their subjective evaluation (DASH and VAS) via email and considered their last mobility assessment from their medical records. The affected phalanges were the proximal phalanx in 12 cases and the middle phalanx in 1 case. The osteotomy indication was due to varus/valgus deformity (6 phalanges), joint deformity (4 phalanges), and rotational deformity (3 phalanges).

Figure. A. X-rays and clinical images of a 2-month evolution combined malunion. **B.** Postoperative X-ray. **C.** Situation 62 months after internal fixation removal and an associated tenolysis due to adhesions. The remnant of a drill bit is evidenced in the phalanx, which caused no discomfort.

Surgical technique

Twelve procedures were performed through dorsal approaches and the remaining case through a lateral approach. All procedures were conducted by 3 surgeons at level IV of training. Osteotomy in 4 phalanges was intra-articular due to joint involvement and extra-articular in the remaining 9 phalanges. The fixation methods were: 8 locking plates, 2 non-locking plates, and 3 interfragmentary screws. Three patients required an autologous bone graft, 2 patients underwent arthrolysis, and 1 patient underwent tenolysis of the extensor tendon as an additional surgical procedure (Table 2).

Table 2. Functional outcomes

Case	Subjective follow-up	Objective follow-up	Tenolysis and/or arthrolysis	VAS at rest	VAS during activity	Function VAS	Postoperative DASH	MCP ROM	PIP ROM	DIP ROM	FPD (mm)	Compli-cations
1	54	54	Yes	0	0	8	0	90	80	55	0	ROM
2	66	66	No	0	2	8	2	120	124	55	0	No
3	51	31	Yes	0	0	8	0	116	80	86	0	No
4	100	15	No	0	3	6	20	95	105	70	0	No
5	48	6	No	0	0	6	5	120	80	61	0	Hardware removal
6	62	62	No	0	0	9	0	100	85	40	0	Hardware removal
7	49	49	No	0	2	8	10	90	85	65	0	No
8	26	26	No	0	1	7	0	60	78	45	10	Hardware removal
			No	0	1	7	0	32	80	50	10	Hardware removal
9	62	62	No	2	4	6	18	88	10	10	15	Reduc-tion loss
10	8	8	No	0	1	7	6	90	24	42	0	Rigidity
11	36	16	Yes	0	0	7	2	80	85	60	0	No
12	16	16	No	0	0	8	16	70	50	60	25	Fixation failure
Aver-age	48	34		0	1	7	6	89	74	54	3	

DASH: Disabilities of the Arm, Shoulder and Hand; DIP: distal interphalangeal; FPD: fingertip-palm distance; MCP: metacarpophalangeal; PIP: proximal interphalangeal; VAS: Visual Analogue Scale; MCP, PIP and DIP ROM is established as total active movement (flexion/extension) and expressed in degrees. ROM: range of motion

Postoperative period

Patients were immobilized for 7-14 days and then began their rehabilitation program supervised by an occupational therapist, with the exception of the patients who underwent tenolysis/arthrolysis, who began their rehabilitation program within the first week.

The final average mobility in flexo-extension was: 89 degrees for MCP joint (range, 32-120 degrees), 74 degrees PIP joint (range, 10-124 degrees, 54 degrees DIP joint (range, 10-86 degrees, and 4 mm fingertip-palm distance (range, 0-25 mm). The average VAS pain score was 0 at rest (range, 0-2) and 1 during activity (range, 0-4), and the average function score was 7 (range, 6-9). The average DASH score was 6 (range, 0-20).

All patients achieved deformity correction and healed between 7 and 8 weeks after surgery.

Complications

Four patients (5 phalanges) required plate removal. The implant caused pain in all cases. In 3 cases pain was associated with extensor mechanism tenolysis (zone 4) performed during plate removal to increase the ROM, and in 1 case a flexor tendon tenosynovectomy and tenolysis were performed due to adhesion of the original fracture, The average removal time was of 4 months (range, 3-7 months).

Two patients had early postoperative reduction loss. In one case a new reduction was performed with additional pin fixation. In the other case, reduction loss was due to implant failure, so a revision was performed using a new plate. One patient had PIP stiffness (range in flexo-extension, 24 degrees), but declined to undergo a new surgical procedure. All these complications were classified as IIIa (complications requiring surgical intervention. No patients with articular osteotomy presented signs of Osteoarthritis in the radiographic evaluation conducted at final follow-up. None of the 3 patients that were treated with interfragmentary screw only reported complications nor discomfort associated with the internal fixation.

DISCUSSION

Phalangeal malunions were initially treated with osteotomies at the metacarpal level based on the principle that avoiding deformity site may reduce adhesion incidence.[7-9] Based on their good results and low stiffness incidence, Buchler *et al*.[2] recommended phalangeal malunion treatment to be osteotomy at deformity site. They reported a 59 osteotomy series which patients were treated with different stabilization methods including cerclage wires, Kirchner pins, plates, screws and/or a combination thereof. They reported that all but 3 patients increased their ROM. However, the study provided no data on the pre-operative and post-operative ROM. The average post-operative follow-up was 11 months, thus no long-term complications are available in their series.

Van der Lei *et al*.[14] reported a series of 9 osteotomies at deformity site stabilized with cerclage wire (3), K-wire (4), and plates and screws (2). Seven patients achieved adequate correction. The remaining 2 required reoperation due to failure to correct the initial deformity, only one of them achieving correction after the second procedure. The authors reported that there was no loss of preoperative ROM; however, they failed to report ROM values. Based on our series, we may infer that their patients lacked full preoperative ROM. Trumble *et al*.[5] reported a series of 11 extra-articular osteotomies stabilized with dorsal plates, which average follow-up period was 35 months. On average, the patients improved PIP and DIP ROM. However, all plates had to be removed due to recurring discomfort. Unfortunately, they failed to report the time between osteotomy and hardware removal, information that would have been worth comparing with that of our case series.

Potenza *et al*.[6] reported a retrospective series of 24 osteotomies treated with rigid fixations (6 with screws, and 18 with plates and screws), which average follow-up period was 24 months. Two patients underwent a second surgery for tenolysisis and/or arthrolysis and implant removal. At final follow-up, 2 of the 4 intra-articular osteotomies patients presented with signs of mild Osteoarthritis. In all cases, patients achieved an average improvement of 30% in ROM, and there were no cases of stiffness or discomfort associated with the internal fixation.

We report a series of 13 phalangeal osteotomies (12 patients) performed at deformity site and stabilized with rigid internal fixation, which objective and subjective follow-up periods averaged 34 and 48 months, respectively. Although our plate removal rate (50%, 5 out of 10 plates) is lower than the rate of Trumble *et al.*[5] (100%), it is nonetheless high. However, implant-associated pain should not be held as a rare scenario and should prompt discussing with the patient the strong chances of a removal procedure during postoperative follow-up.

ROM loss and pseudarthrosis do not constitute common complications of these procedure, as showed by our results and the aforementioned studies.[2,5,6,14] However, maintaining or improving preoperative ROM requires a rigid internal fixation that would allow for an early active rehabilitation.[15-17]

The strengths of our study include a considerable amount of subjects, considering that this procedure is rather uncommon.

The main limitations of our study are its retrospective nature and the inclusion of intra- and extra-articular osteotomies.

Phalangeal osteotomy at the deformity site is an effective procedure to correct phalangeal deformities, and has a good objective and subjective medium-term outcome. Plate and screw fixations imply a higher complications rate due to associated intolerance and adhesion in the extensor mechanism; thus, patients must be warned about the possibility of a second surgical procedure.

Conflict of interests: Authors claim they do not have any conflict of interests.

L. Ferreira ORCID ID: http://orcid.org/0000-0003-0356-9510
P. De Carli ORCID ID: http://orcid.org/0000-0002-9474-8129
G. L. Gallucci ORCID ID: http://orcid.org/0000-0002-0612-320X
A. Donndorff ORCID ID: http://orcid.org/0000-0002-6384-4820
E. E. Zaidenberg ORCID ID: http://orcid.org/0000-0002-1535-0586
J. G. Boretto ORCID ID: http://orcid.org/0000-0001-7701-3852

REFERENCES

1. Lee SG, Jupiter JB. Phalangeal and metacarpal fractures of the hand. *Hand Clin* 2000;16(3):323-32, vii. PMID: 10955206
2. Büchler U, Gupta A, Ruf S. Corrective osteotomy for post-traumatic malunion of the phalanges in the hand. *J Hand Surg Br* 1996;21(1):33-42. https://doi.org/10.1016/s0266-7681(96)80009-x
3. Manktelow RT, Mahoney JL. Step osteotomy: a precise rotation osteotomy to correct scissoring deformities of the fingers. *Plast Reconstr Surg* 1981;68(4):571-6. PMID: 7280104
4. Gross MS, Gelberman RH. Metacarpal rotational osteotomy. *J Hand Surg Am* 1985;10(1):105-8. https://doi.org/10.1016/s0363-5023(85)80259-8
5. Trumble T, Gilbert M. In situ osteotomy for extra-articular malunion of the proximal phalanx. *J Hand Surg Am* 1998;23(5):821-6. https://doi.org/10.1016/S0363-5023(98)80156-1
6. Potenza V, De Luna V, Maglione P, Garro L, Farsetti P, Caterini R. Post-traumatic malunion of the proximal phalanx of the finger. Medium-term results in 24 cases treated by "in situ" osteotomy. *Open Orthop J* 2012. https://doi.org/10.2174/1874325001206010468
7. Botelheiro JC. Overlapping of fingers due to malunion of a phalanx corrected by a metacarpal rotational osteotomy--report of two cases. *J Hand Surg Br* 1985;10(3):389-90. https://doi.org/10.1016/s0266-7681(85)80070-x
8. Menon J. Correction of rotary malunion of the fingers by metacarpal rotational osteotomy. *Orthopedics* 1990;13(2):197-200. PMID: 2308879
9. Pieron AP. Correction of rotational malunion of a phalanx by metacarpal osteotomy. *J Bone Joint Surg Br* 1972;54(3):516-9. https://doi.org/10.1302/0301-620X.54B3.516
10. Gollamudi S, Jones WA. Corrective osteotomy of malunited fractures of phalanges and metacarpals. *J Hand Surg Br* 2000;25(5):439-41. https://doi.org/10.1054/jhsb.2000.0418
11. Pichora DR, Meyer R, Masear VR. Rotational step-cut osteotomy for treatment of metacarpal and phalangeal malunion. *J Hand Surg Am* 1991;16(3):551-5. https://doi.org/10.1016/0363-5023(91)90031-6
12. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications. *Ann Surg* 2004;240(2):205-13. https://doi.org/10.1097/01.sla.0000133083.54934.ae
13. Tang JB. Re: Levels of experience of surgeons in clinical studies. *J Hand Surg Eur Vol*. 2009;34(1):137-8. https://doi.org/10.1177/17531934097321

14. van der Lei B, de Jonge J, Robinson PH, Klasen HJ. Correction osteotomies of phalanges and metacarpals for rotational and angular malunion: a long-term follow-up and a review of the literature. *J Trauma* 1993;35(6):902-8. https://doi.org/10.1097/00005373-199312000-00017
15. Balaram AK, Bednar MS. Complications after the fractures of metacarpal and phalanges. *Hand Clin* 2010;26(2):169-77. https://doi.org/10.1016/j.hcl.2010.01.005
16. Gajendran VK, Gajendran VK, Malone KJ. Management of complications with hand fractures. *Hand Clin* 2015;31(2):165-77. https://doi.org/10.1016/j.hcl.2014.12.001
17. Ataker Y, Uludag S, Ece SC, Gudemez E. Early active motion after rigid internal fixation of unstable extra-articular fractures of the proximal phalanx. *Hand Surg Eur Vol* 2017;42(8):803-9. https://doi.org/10.1177/1753193417709949