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ORIGINAL ARTICLE

Is casting superior to plate fixation in metacarpal shaft fractures?

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ABSTRACT

Objectives: This study aimed to compare the outcomes and conduct a cost analysis between plate screw fixation and conservative treatment.

Patients and methods: The retrospective study was conducted with 36 patients (32 males, 4 females; mean age: 30.3±13.4 years; range, 16 to 65 years) between May 2019 and July 2023. The patients were divided into two groups: those who underwent surgery with miniplate fixation (n=21) and those who were conservatively managed (n=15). The differences in postoperative shortening and angulation were compared between these groups. Additionally, the patients' postoperative functional scores, complication rates, examination findings, and cost analyses were compared.

Results: The per-patient cost in the surgical group was higher than in the conservatively treated group (€246.96 *vs*. €45.07; p<0.001). While postoperative shortening and angulation were more pronounced in the nonoperative group, the other clinical parameters and functional scores were improved. The return-to-work time was longer in the nonoperative group due to prolonged immobilization.

Conclusion: Nonoperative splint treatment for metacarpal shaft fractures shows better radiological and clinical outcomes than surgery, except for angulation and shortening, which have limited impact on function. Due to higher costs in surgical cases, nonoperative treatment is more cost-effective. Larger, randomized trials are needed to confirm these findings.

Keywords: Cost analysis, metacarpal shaft fractures, nonoperative treatment, plate screw fixation, surgical treatment.

Metacarpal fractures account for 36 to 42% of hand fractures.[1] Studies have shown that 58% of metacarpal fractures are shaft fractures.[2] Diaphyseal fractures usually occur as a result of axial loading, direct impact, or torsional forces. They are classified as transverse, oblique, and comminuted fractures. The aim of treatment is to prevent functional loss by ensuring appropriate rotational alignment and length.[3,4] Surgical treatment of metacarpal diaphyseal fractures is preferred due to concerns about shortening of the metacarpals, which can lead to weakness and imbalance of tendons or rotational deformity, resulting in scissoring (overlapping) of the affected finger during flexion.[5] Although indications for surgery for metacarpal shaft fractures are rare, some studies suggest that surgical treatment may be necessary when there is displacement, rotation,

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and shortening of metacarpal fractures, and these cannot be corrected with closed reduction or maintained with reduction.[6-9] Surgical intervention should be considered when the amount of dorsal angulation exceeds 10° in the index and middle fingers, 20° in the ring finger, and 30° in the small finger. Bone shortening leading to extensor lag, malrotation, or scissoring are also indications for surgery. A rotational deformity of more than 5° can cause scissoring of the fingers.[10] Other relative indications for surgery include open fractures, polytrauma patients, multiple metacarpal shaft fractures in the same hand, and, most importantly, patient preference.[10] Surgical treatment options include K-wire fixation, plate screw fixation, interfragmentary lag screws, external fixators, and intramedullary fixation using headless screws.[11,12]

There is no consensus on the treatment method for these common fractures encountered in orthopedic clinics.[13,14] Surgical methods, while providing good fracture reduction and stability, are prone to complications and can be costly. Operatively treated metacarpal fractures can lead to stiffness due to iatrogenic soft tissue damage secondary to scar/adhesion formation. Immobilization with a splint or cast may result in weakness in the hand due to loss of reduction, but it can be a rational and cost-effective treatment method in a compliant patient. Prolonged immobilization during healing can lead to joint stiffness.[15,16]

In this study, we focused on fracture deformity, follow-up duration, complications, grip strength, range of motion (ROM) of finger joints, functional outcome measures reported by the patient, return to work time, and cost of treatment in metacarpal shaft fractures. To our knowledge, while there are numerous comparisons of different surgical techniques in the literature, the comparison of the plate screw fixation technique with a nonoperative cast/splint treatment method is not present in Türkiye.[17] Hence, this study aimed to determine whether plate screw fixation surgery has superiority over non-operative treatment with splint in metacarpal shaft fractures.

PATIENTS AND METHODS

Thirty-six patients (32 males, 4 females; mean age: 30.3±13.4 years; range, 16 to 65 years) referred to the orthopedic outpatient clinics of the Ankara University Faculty of Medicine and Bilkent City Hospital between May 2019 and July 2023 were retrospectively evaluated. The flowchart of the study is shown in Figure 1, and the inclusion

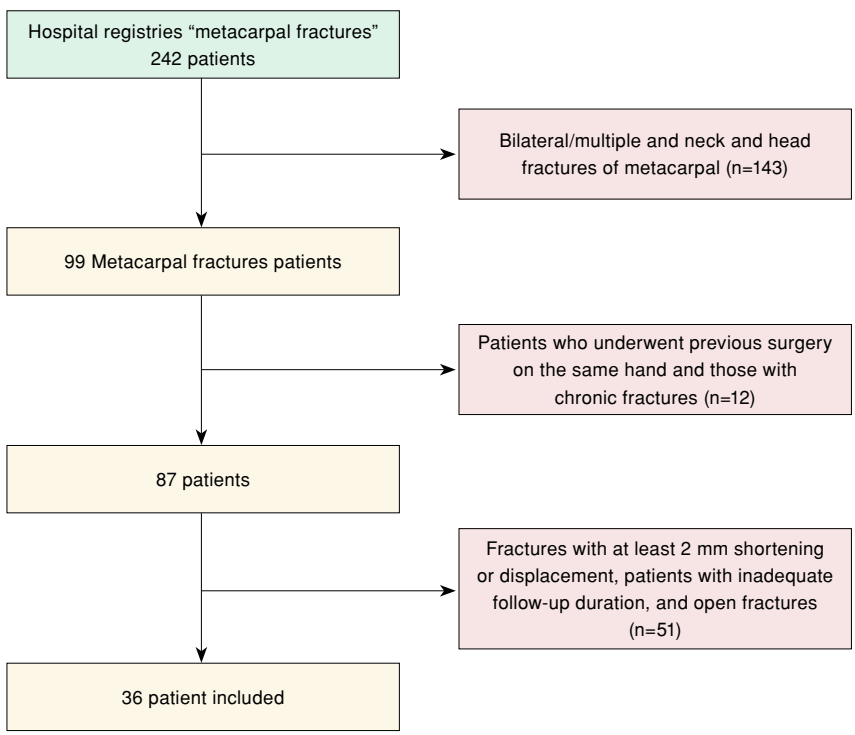

FIGURE 1. The flowchart of patients included in the study.

TABLE I
Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Patients with a minimum of 12 months of follow-up	Bilateral metacarpal fractures
Isolated fractures of the 2nd, 3rd, 4th, or 5th metacarpal	Open fractures
Spiral, transverse, oblique fractures	Multiple metacarpal fractures
Acute fractures (<10 days)	Fractures ≥10 days
	Patients with a history of previous hand surgery
	Patients with less than 2 mm shortening and no rotational deformity

and exclusion criteria are presented in Table I. A decision for nonoperative (n=15) or surgical (n=21) follow-up was made after obtaining detailed information, considering patient preference. Patients who underwent nonoperative follow-up were initially treated with closed reduction using the Jahss maneuver and then immobilized with a splint for three weeks. The Jahss maneuver involves dorsal-directed force applied along the axis of the proximal phalanx of the same finger after full flexion at the metacarpophalangeal joint.[18] All splints used were in the Edinburgh intrinsic plus position (30° of wrist extension, 90° of metacarpophalangeal flexion, and 0° of interphalangeal extension; Figure 2).[19] The study protocol was approved by the Ethics Committees of Ankara University Faculty of Medicine and Bilkent City Hospital (date: 16.08.2023, no: E1-23-3797, and 03.04.2024, no: İ03-253-24, respectively). The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants.

During follow-up, patients were called for regular visits every week to monitor the degree of angulation and shortening. In the group of patients who were decided for surgical treatment, after dorsal approach open reduction and internal fixation with a dorsal miniplate screw fixation, a volar short arm splint was applied for one week, followed by the initiation of wrist and finger exercises after splint removal (Figures 3, 4). Treatments were performed by orthopedic hand surgeons (with experience in level 3 category).[20] Function was assessed postoperatively using the Disabilities of the Arm, Shoulder, and Hand (DASH) score and the Numerical Rating Scale (NRS). Numerical Rating Scale is a tool mostly used for assessing clinical, pain, and cosmetic outcomes.[21-23] In the NRS, patients are asked to circle the most appropriate number between 0 and 10. For pain, the severity increases from 0 to 10, while for cosmetic appearance and patient satisfaction, satisfaction increases from 0 to 10.[21] Grip strength and percentage ratio with the contralateral side were measured using a handheld dynamometer (Baseline Hydraulic Hand Dynamometer, New York, USA) on the operated side. Patient satisfaction and cosmetic appearance were evaluated using NRS.[21-23] Flexion and extension deficits were measured using a goniometer. Radiological and clinical complications were noted. Measurements of patients who were followed and treated were taken one year after treatment. Similarly, the functional scores were obtained at the time when the patients' radiological measurements were taken during their one-year follow-up visit. At the end of treatment, radiological parameters were measured, including angulation, calculated by measuring the angle between lines drawn obliquely on a radiograph taken with a 45° angle between the cassette and hand, one line passing through the distal and proximal ends of the fracture line and the other passing through the midline of the medullary canal (Figure 5). Shortening was calculated as the difference (cm) between the length from the highest point of the metacarpal head to the midpoint of the two corners of the metacarpal base on anteroposterior hand radiographs and the length of the same metacarpal on the unaffected side (Figure 6). Additionally, cost

FIGURE 2. Intrinsic plus splint application used in conservatively managed metacarpal shaft fractures.

FIGURE 3. The preoperative radiograph of the metacarpal shaft fracture treated surgically.

FIGURE 4. The postoperative radiograph of the metacarpal shaft fracture treated surgically at the third week.

documentation of patients was obtained from the billing units of the hospitals' information systems. Cost analyses during the treatment period were conducted for the two groups treated conservatively and surgically.

Statistical analysis

Data were analyzed using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were presented as mean ± standard deviation (SD) for the normally distributed variables and

FIGURE 5. Angular measurement in an oblique radiograph.

as median (min, max, interquartile range) for the nonnormally distributed variables. Nominal variables were presented as frequency and percentage. The significance of the difference between the groups in terms of the mean values was analyzed using Student's t-test, and the significance of the difference between the groups in terms of the median values was analyzed using the Mann-Whitney U test. Categorical variables were evaluated using the two proportions test. A p-value <0.05 was considered statistically significant.

RESULTS

Of the 36 patients, 21 (58.3%) underwent surgery. The demographic information of the patients and distribution of affected metacarpals are shown in Table II. Fractures of the fourth and fifth metacarpals were most commonly observed (13 and 15 patients, respectively).

The clinical and radiological outcomes of all included patients are presented in Table III. The per-patient cost in the surgical group was higher than in the conservatively treated group (p<0.001), with values of €246.96 and €45.07, respectively (Table IV). The return-to-work times was longer in conservatively treated patients (p<0.001; Table V).

The clinical and radiological outcomes of patients between the two groups are shown in Table VI. Grip strength and grip ratio were found to be statistically better in the nonoperative group (p<0.001 and p<0.001, respectively). Similarly, flexion and extension deficits were lower in the nonoperative group (p<0.001 and p<0.001, respectively). However, postoperative shortening and angulation were higher in the nonoperative group.

FIGURE 6. Measurement of shortening on anteroposterior radiographs. The length measurement of the unaffected fifth metacarpal bone (left hand) is shown on the left side. The length measurement of the fifth metacarpal bone (right hand), which healed following a shaft fracture, is demonstrated on the right side. The difference in length (a-b) between the two was calcuted.

TABLE II
Demographic and clinical characteristics

	n	%	Mean±SD
Age (year)			30.3±13.4
Sex			
Male	32	88.9	
Female	4	11.1	
Side			
Right	20	55.6	
Left	16	44.4	
Smoking	5	14	
Metacarpal			
5	15	41.7	
4	13	36.1	
3	4	11.1	
2	4	11.1	
Surgical condition			
Conservative group	15	23.5	
Operative group	21	58.3	

SD: Standard deviation.

TABLE III
Clinical and radiological characteristics

	Mean±SD	Median	Min-Max
Back to work time (day)	20±12.58		
Cost		2062.38	59.82-6601.74
Grip	38.33±5.83		
Grip strength	85.86±5.15		
Disabilities of the Arm, Shoulder and Hand		22	8-32
Numerical rating scales		2	0-4
Shortness		0.29	0-8.32
Cosmetic appearance		8	6-10
Patient satisfaction		8.5	5-10
Flexion deficit	14.91±5.86°		
Extension deficit	14.66±6.13°		
Angulation	25.18±14.81°		

SD: Standard deviation.

TABLE IV
Comparison of cost analysis of groups

	Surgical technique						
	Conservative (n=15)			ORIF (n=21)			
	Median	Min-Max	IQR	Median	Min-Max	IQR	*p**
Cost (TL)	455.52	59.82-4967.93	836	3848.77	211-6601.74	3088	<0.001
Cost (Dollar)	54.80	7.37-868.48	96.66	258.73	11.77-938.08	164.06	<0.001
Cost (Euro)	45.07	6.78-790.01	86.02	246.96	10.26-842.43	130.47	<0.001

ORIF: Open reduction internal fixation; IQR: Interquartile range; * Mann-Whitney U test.

TABLE V
Comparison of return to work time of groups

	Surgical technique						*p**
	Conservative (n=15)			ORIF (n=21)			
	Median	Min-Max	IQR	Median	Min-Max	IQR	
Back to work time (day)	28	19-51	11	11	2-39	9	<0.001

ORIF: Open reduction internal fixation; IQR: Interquartile range; * Mann-Whitney U test.

TABLE VI
Comparison of clinical and radiological data of the groups after treatment

	Surgical technique												
	Conservative (n=15)						ORIF (n=21)						
	n	%	Mean±SD	Median	Min-Max	IQR	n	%	Mean±SD	Median	Min-Max	IQR	*p*
Grip				42	30-47	5				38	24-42	6.5	<0.001*
Grip strength ratio				90	79-95	3				82	78-95	3.5	<0.001*
Shortness (mm)				0.73	0-8.32	3.56				0	0-7.96	1.24	0.006*
Flexion deficit				10	5-14	7				19	9-24	4	<0.001*
Extension deficit				7	4-18	6				19	11-23	3	<0.001*
Angulation			25.18±14.81						NA				NA
Complication	5	33.3					3	14.2					0.187**

ORIF: Open reduction internal fixation; SD: Standard deviation; IQR: Interquartile range; NA: Not Available, * Mann-Whitney U test; ** Two proportions test.

TABLE VII
Comparison of functional scores between groups after treatment

	Surgical technique								
	Conservative (n=15)				ORIF (n=21)				
	Mean±SD	Median	Min-Max	IQR	Mean±SD	Median	Min-Max	IQR	*p*
DASH	12.6±3.5				25.71±3.3				<0.001*
Pain on NRS		1	0-3	1		3	1-4	1	<0.001**
Cosmetic appearance on NRS		9	8-10	1		7	6-9	1	<0.001**
Patient satisfaction on NRS		10	9-10	1		7	5-9	1	<0.001**

ORIF: Open reduction internal fixation; SD: Standard deviation; IQR: Interquartile range; DASH: The Disabilities of the Arm, Shoulder and Hand; NRS: Numerical Rating Scale; * Student's t-test; ** Mann-Whitney U test.

Looking at the functional outcomes of the patients, DASH scores and NRS-based pain, cosmetic appearance, and patient satisfaction scores were better in the conservatively treated patient group ($p<0.001$, $p<0.001$, $p<0.001$, and $p<0.001$, respectively; Table VII).

Regarding complications of the patients, a total of five complications occurred in the conservatively followed group, with four cases of angulation and one case of malunion. Three complications were observed in the operated group, two of which were delayed union, and one was superficial infection. However, the difference was not statistically significant ($p=0.187$; Table VI).

DISCUSSION

The comparison of treatment methods for metacarpal shaft fractures has been addressed in the literature.[24-26] However, the analysis of cost-effectiveness between nonoperative treatment

and isolated locked miniplate screw system has not been sufficiently investigated in the literature. Peyronson et al.[25] conducted a study comparing nonoperative treatment with surgical treatment (lag screw and miniplate screw) in metacarpal shaft fractures. They found similar results in both groups. Due to the shorter sick leave in the conservatively followed group, they concluded that nonoperative treatment was less costly. Therefore, they demonstrated that nonoperative treatment should be preferred. In our study, patients in the nonoperative group had better clinical and radiological outcomes in the postoperative period, except for shortening and angulation.[27] In all functional outcomes, the nonoperative group was significantly better; thus, it was observed that shortening and angulation did not affect the postoperative functional status of the patients.[27]

The volar plate of the metacarpals, interconnected by the deep transverse intermetacarpal ligament, serves as the primary stabilizer of the palmar arch of the hand and helps prevent proximal migration of the metacarpal head following shaft fractures.[28] As long as this anatomical structure remains intact, it is evident that regardless of the treatment administered, shortening will not affect function. Cosmetically, fracture shortening alone may manifest as a relatively mild loss of joint contour.

Excessive angulation of the metacarpal can lead to compensatory hyperextension of the metacarpophalangeal joint and, consequently, delayed extension of the extensors at the proximal and distal interphalangeal joints (extensor lag). This condition known as "pseudoclawing" can impair the patient's grasping ability. In this study, immobilizing the hand in intrinsic plus position in the nonoperative group prevented the development of pseudoclawing.

Malrotation is often the least tolerated deformity in metacarpal fractures, as even minor degrees of rotation tend to be indications for surgical intervention by surgeons. In this study, rotational deformity was the most important surgical decision-making factor. In a survey study conducted by Retrouvey et al.[29] involving 113 plastic surgeons, the most common surgical indications were determined to be rotational deformity, intra-articular fracture, shortening, and angulation. It was observed that surgeons similarly preferred immobilization splinting over early mobilization splinting.

In measuring shortening, we utilized the difference between the length from the apex of the metacarpal head to the midpoint of the two corners of the metacarpal base and the length of the same metacarpal on the unaffected side. We did not employ the metacarpal line or overlapping method described in the literature for shortening measurement.[25] We believe that the method we used provides a more accurate and precise evaluation. Additionally, we observed that shortening may be greater than expected with this method. Therefore, a study comparing our shortening measurement method with other methods could be beneficial.

In the study by Peyronson et al.,[25] the sick leave duration in the nonoperative group was shorter, whereas in our study, the return-to-work time was significantly shorter in the operated group. In our study, after achieving stable fixation with locked miniplate screw in the operated group, we removed the splint after one week and initiated early motion exercises. We believe that providing early mobilization resulted in a shorter return-to-work time for patients. On the other hand, closer monitoring and longer immobilization were applied in the conservatively followed group due to the risk of splint slippage. The prolonged immobilization period also extended the sick leave.

The duration of immobilization in conservatively followed patients is also a topic of debate. Some studies have concluded that early mobilization after splinting is reliable, yields good outcomes, and even has a positive impact on strength and joint ROM, thereby shortening the return-to-work time.[30-32] In contrast, there are publications emphasizing the importance of immobilization for a period after splinting to prevent shortening.[33,34] A study by Retrouvey et al.[29] showed that the majority of surgeons in Canada still prefer prolonged immobilization (3 to 4 weeks) after splinting in conservatively followed patients.

The greater loss of flexion and extension in the operated group may have resulted from adhesions due to open surgery and the applied plate. Despite our preference for early mobilization in the postoperative period, the nonoperative group demonstrated better total ROM. This finding suggests that conservatively followed patients, even if stiffness occurs after splint removal, can achieve good long-term full ROM.

When evaluating patients' cosmetic outcomes, the loss of joint contour commonly observed in nonoperative treatment is not considered significant, but the dorsal surgical scar is more noticeable.

Although the bones had completely healed in all patients, the relatively higher level of pain in the surgical group was attributed to the trauma associated with surgery activating pain-related mediators in tissues, particularly irritation of dorsal sensory nerves.

Metacarpal shaft fractures commonly affect the working population, and due to the risk of poor union, surgical treatment is often preferred by most surgeons.[35] However, in our study, although the number of complications was higher in the conservatively managed group (n=5 *vs.* n=3), it

FIGURE 7. The pretreatment radiograph of the metacarpal shaft fracture treated conservatively.

FIGURE 8. The posttreatment one-year radiograph of the metacarpal shaft fracture treated conservatively.

was not statistically significant. This discrepancy stems from the higher incidence of accepted angulation and shortening in the nonoperative group. Therefore, the question arises whether the complications should be considered if the accepted level of shortening and angulation does not pose a functional problem. Among these five patients, malunion was observed in one patient, and there were no cases of nonunion. It is important to emphasize that although malunion occurred in the patient with rotational deformity of the metacarpal, no functional impairment affecting hand function was observed. Surgical nonunion can be easily encountered in the practice of surgeons with little experience and is much more important than other complications.

In this study, since patients who smoked were not operated on, no issues with union or any other complications were encountered (Figures 7, 8). While the ultimate decision for treatment lies with the patient, bias towards treatment with a splint may be present when patients are informed.

In our study, the complication rate appears to be lower compared to the literature.[36-38] The experienced nature of the participating surgeons may have contributed to the lower complication rate. Additionally, due to the inadequate number of patients, we believe that the statistical analysis may not have been highly reliable.

Although radiological results beyond acceptable parameters were obtained in patients treated with nonoperative therapy in the study, it was observed that functional outcomes were not significantly affected. The most important reason for this is that the accepted parameters are reported as a result of anatomy and cadaver studies. It should be recognized that even if these parameters are not met by the moving live hand, it can successfully complete many daily tasks. In our study, cost analysis was obtained from the hospital database. It included the patient's radiological examinations, performed surgery, postoperative care, and outpatient follow-ups. The loss of workforce due to absence from work was not included in this analysis.

The limitations of the study include its retrospective design and small sample size. Additionally, delayed return to work, patients' occupations (incomes), whether or not they received compensation, and employment status may have influenced the cost, potentially introducing a limitation in the study. The strengths of the study include comparing isolated locked miniplate screw surgery with surgical and nonoperative treatment methods with a splint in metacarpal shaft fractures. Moreover, the cost analysis of these two groups is an important inference in terms of the correct utilization of healthcare expenses, which is an issue in many countries.

In conclusion, nonoperative treatment with splint in metacarpal shaft fractures was radiologically and clinically superior compared to surgical treatment, except for angulation and shortening. The better functional outcomes with nonoperative treatment suggest that the impact of shortening and angulation on functional outcomes is limited. Considering the significantly higher cost in patients undergoing surgical treatment, nonoperative treatment is preferred for its cost-effectiveness. Prospective randomized trials with larger sample sizes are needed for more definitive results.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Performed the analysis, collected the data, wrote the paper: O.E.B.; Wrote the paper, collected the data: U.B.; Performed the analysis, contributed data or analysis tools: E.A.; Performed the analysis, collected the data: O.T.N.; Performed the analysis and statistics: E.D.; Conceived and design the analysis: M.A.

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