Research Article

Anterograde Vs Retrograde

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Comparison Of Functional Outcome of Metacarpal Fractures Treated by Anterograde Vs Retrograde Approach of Intramedullary Pinning

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Purpose: Metacarpal fractures are a common injury, constituting a significant portion of upper extremity fractures. The purpose of this study is to compare the functional and radiological outcomes of anterograde vs. retrograde intramedullary pinning in the treatment of shaft metacarpal fractures.

Material and Method: This prospective study was conducted from February 2021-September 2022, involving 60 patients aged 18-65 years with closed, displaced metacarpal fractures. 30 patients received anterograde and another 30 received retrograde intramedullary pinning. Follow-up assessments were done at 2, 4, 6, and 12 weeks. Radiological and clinical outcomes were evaluated using TAM score, grip strength measurements, VAS scores, and standard radiographic analyses.

Results: Mean age of patients in anterograde group was 34.60±7.35 years, while the retrograde group had a mean age of 32.53±8.80 years. The anterograde group demonstrated significantly higher grip strength at both 6 and 12 weeks postoperatively (p-value<0.0001) and lower VAS scores for pain at 2 and 6 weeks (p-value<0.0001). Radiological union was achieved faster in the anterograde group (mean union time=5.21 weeks) compared to the retrograde group (6.89 weeks). Stiffness was the most common complication, observed in 16.7% of the anterograde group and 23.3% of the retrograde group. The anterograde group also showed a higher percentage of patients achieving excellent results (46.4% vs. 23.4% in the retrograde group).

Conclusion: Anterograde intramedullary percutaneous pinning is a superior technique compared to retrograde pinning for the management of metacarpal fractures. It offers faster functional recovery, better grip strength, and reduced pain in the early postoperative period, with fewer complications.

Keywords: Metacarpal fractures, anterograde pinning, retrograde pinning, functional recovery, grip strength

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Introduction

Fractures of the metacarpals and phalanges are prevalent, constituting approximately 10% of all upper extremity fractures. **[1]** Epidemiologically, 30-40% of all hand fractures involve the metacarpals, with the border metacarpals (specifically the 1st and 5th) being most frequently affected. [2,3] The 5th metacarpal alone represents 50-55% of total metacarpal fractures, while the 1st metacarpal accounts for 7-10%. [2,3] Fractures commonly occur at the base of the metacarpal rather than at the neck, and diaphyseal fractures are more typical in the non-border metacarpals. [2,3] The lifetime incidence of metacarpal fractures is estimated at 2.5%, with these injuries being more prevalent in males, particularly between the ages of 10 and 40 years—a period often associated with increased athletic activity and industrial exposure. [2,3] Hand fractures can result in deformity due to inadequate treatment, stiffness from excessive treatment, or a combination of both from suboptimal management. [4] Historically, the closed treatment of hand fractures has garnered a poor reputation due to complications such as malunion, stiffness, shortening, and, in some cases, loss of skin or other soft tissues. However, advancements in modern techniques and materials for internal fixation have significantly improved outcomes, offering a superior alternative to older methods. [4,5] The selection of optimal treatment for metacarpal fractures depends on several factors, including the location of the fracture (intra-articular vs. extra-articular), fracture geometry (transverse, spiral, oblique, or comminuted), the presence of deformity (angular, rotational, shortening), whether the fracture is open or closed, associated soft tissue injury, and fracture stability. [6] In some cases, the fracture fragments may be small and comminuted, making reduction and stabilization challenging, which can result in malunion, incongruity, or joint space narrowing. Additional factors that complicate treatment include damage to tendons, ligaments, and the articular capsule at the time of injury. [7,8] The fundamental principles in managing these fractures include anatomical reduction, stable fixation, and early mobilization to restore hand function fully and rapidly. Operative fixation should be employed judiciously, with the expectation that the outcome will be at least as favourable, if not superior, to that of non-operative treatment. [7,8] The primary goals of treatment are to achieve full and rapid restoration of hand function and to allow early movement, thereby avoiding the risks associated with prolonged immobilization. The specific aim of this study is to compare the functional and radiological outcomes of anterograde versus retrograde intramedullary pinning in the treatment of shaft metacarpal fractures.

Material and method

This prospective study was conducted from February 2021 to September 2022, after approval from the Institutional Ethics Committee. The study included 60 consenting patients aged between 18 and 65 years with closed, displaced fractures affecting one or two metacarpals.

Patients outside this age range or with more than two metacarpal fractures, ipsilateral fractures in the same limb, neurovascular deficits, or compound metacarpal fractures were excluded. Upon admission, a detailed history and examination were conducted to identify any associated injuries, including vascular injuries, compartment syndrome or peripheral nerve injuries. Standard radiographs, including anteroposterior and oblique views, were taken for diagnosis and fracture pattern assessment.

Laboratory investigations, such as complete blood counts, serum electrolytes, and RA factor, were also conducted. Temporary immobilization using Charnley's splint was provided while awaiting surgery. Thirty patients were treated using the anterograde approach of intramedullary pinning, while the remaining thirty patients underwent the retrograde approach of intramedullary pinning. The surgical procedure was carried out under regional anaesthesia (brachial or wrist block). Patients were positioned supine, and the affected limb was abducted and prepped in sterile conditions. Closed reduction was attempted under image intensifier guidance, and the procedure was performed accordingly.

Post-operatively, intravenous antibiotics were administered for three days, followed by oral antibiotics for an additional five to seven days. Patients were encouraged to engage in early finger and wrist movements to reduce oedema and promote circulation. Post-operative radiographs were taken the day after surgery to confirm reduction and pin placement. Regular follow-up visits were scheduled at two, four, six, and twelve weeks post-operatively to assess union, complications, and improvement in range of motion at the metacarpophalangeal joint. Grip strength, range of motion, and pain (measured via the VAS score) were evaluated at each follow-up visit. Clinical outcomes were measured using several parameters, including the Total Active Motion (TAM) score for the 2nd to 5th metacarpals and Gingrass criteria for the 1st metacarpal. Grip strength was assessed using a dynamometer. The final outcomes were categorized as excellent, good, fair, or poor based on these measurements.

Statistical analysis was done using SPSS 25.0 (trial version). Continuous data was expressed in mean and standard deviation. The descriptive representation of data was done in the form of frequencies and percentages. Analytical part was done using t-test. The result was considered significant at 95% level of significance and p-value<0.05.

Results

Table 1 presents the distribution of various parameters among the two groups of study participants. The mean age of patients in Group 1 was 34.60±7.35 years, while Group 2 had a slightly younger mean age of 32.53±8.80 years. Gender distribution showed that 70% of the patients in Group 1 were male, compared to 56.7% in Group 2. The majority of patients in both groups were labourers, accounting for 63.3% in Group 1 and 53.3% in Group 2. Regarding the dominant hand, 53.3% of patients in Group 1 were right-handed, compared to 73.3% in Group 2.

Table 1: Distribution of various parameters among the two groups of study participants

Parameter	Group 1 (Anterograde approach)N=30	Group 2 (Retrograde approach)N=30	TotalN=60
Age			
Age (in years) Mean±S.D.	34.60±7.35	32.53±8.80	32.43±8.08
Gender			
Male n (%)	21 (70.0%)	17 (56.7%)	38 (63.3%)
Female n (%)	9 (30.0%)	13 (43.3%)	22 (36.7%)
Occupation			
Labourer	19 (63.3%)	16 (53.3%)	35 (58.3%)
House wife	3 (10.0%)	4 (13.3%)	7 (11.7%)
Student	5 (16.7%)	7 (23.3%)	12 (20.0%)
Professional	2 (6.7%)	3 (10.0%)	5 (8.3%)
Businessman	1 (3.3%)	0	1(1.7%)
Dominating hand			
Left hand n (%)	14 (46.7%)	8 (26.7%)	22 (36.7%)
Right hand n (%)	16 (53.3%)	22 (73.3%)	38 (63.3%)
Mode of injury			
Assault by hard object n (%)	7 (23.3%)	3 (10.0%)	10 (16.7%)
Fall form 2w n (%)	8 (26.7%)	10 (33.3%)	18 (30.0%)
Fall of ground n (%)	1 (3.3%)	0 (0.0%)	1 (1.7%)
Fall of heavy object n (%)	2 (6.7%)	0 (0.0%)	2 (3.3%)
Fall on ground n (%)	4 (13.3%)	11 (36.7%)	15 (25.0%)
RTA 2w vs 2w n (%)	8 (26.7%)	6 (20.0%)	14 (23.3%)
Pattern of fracture			
Oblique	15 (50%)	15 (50%)	30 (50.0%)
Transverse	10 (33.3%)	11 (36.7%)	21 (35.0%)
Spiral	4 (13.3%)	4 (13.3%)	8 (13.3%)
Comminuted	1 (3.3%)	0 (0.0%)	1 (1.7%)
Implant removal at			
5 weeks n (%)	7 (23.3%)	5 (16.7%)	12 (20%)
6 weeks n (%)	17 (56.7%)	10 (33.3%)	27 (45%)
7 weeks n (%)	3 (10%)	11 (36.7%)	14 (23.3%)
8 weeks n (%)	1 (3.3%)	2 (6.7%)	3 (5%)
9 weeks n (%)	1 (3.3%)	1 (3.3%)	2 (3.3%)
10 weeks n (%)	1 (3.3%)	1 (3.3%)	2 (3.3%)
Radiological union at			
4 weeks n (%)	6 (20%)	5 (16.7%)	11 (18.3%)
5 weeks n (%)	13 (43.3%)	2 (6.7%)	15 (25%)
6 weeks n (%)	7 (23.3%)	9 (30%)	16 (26.7%)
7 weeks n (%)	3 (10%)	13 (43.3%)	16 (26.7%)
8 weeks n (%)	1 (3.3%)	1 (3.3%)	2 (3.3%)
Complications			
Stiffness n (%)	6 (20%)	9 (30%)	15 (25%)
Pin irritation n (%)	3 (10%)	2 (6.7%)	5 (8.3%)
Shortening n (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Malunion n (%)	1 (3.3%)	0 (0.0%)	1 (1.7%)
No complications n (%)	20 (66.7%)	19 (63.3%)	39 (65%)
TAM compared to normal hand (in percentage)			
50-69 n (%)	6 (20%)	8 (26.7%)	14 (23.3%)
70-84 n (%)	10 (33.3%)	16 (53.3%)	26 (43.3%)
85-100 n (%)	14 (46.7%)	6 (20%)	20 (33.3%)
Total	30 (100%)	30 (100%)	60 (100%)

The mode of injury varied, with fall from two-wheelers being the most common cause in both groups (26.7% in Group 1 and 33.3% in Group 2). Fracture patterns were similar across both groups, with 50% of fractures being oblique. 56.7% of patients in Group 1 had implants removed at 6 weeks, compared to 36.7% in Group 2 who had it removed at 7 weeks. Radiological union was achieved in 43.3% of Group 2 patients by the 7th week, and in Group 1 by 5 weeks. Complications were relatively low across both groups, though Group 2 had a higher incidence of stiffness (30%) compared to Group 1 (20%). 46.7% of patients in Group 1 had TAM scores between 85-100%, while Group 2 had a higher percentage (53.3%) within the 70-84% range, indicating slightly better overall motion in Group 1. Table 2 compares the grip strength and Visual Analog Scale (VAS) scores between the two groups. At 6 weeks postoperatively, the mean grip strength in Group 1 was 19.87±4.01, significantly higher than the 14.06±4.17 in Group 2 (p-value<0.0001). At 12 weeks, Group 1 maintained higher grip strength (81.29±5.39) compared to Group 2 (74.48±6.51); (p-value <0.0001). The pre-operative VAS scores were similar between the groups, with no significant difference (p=0.053). However, at 2 weeks postoperatively, Group 1 reported significantly lower pain levels (VAS 3.98±0.94) compared to Group 2 (VAS 4.97±0.98); p-value=0.0002. This trend continued at 6 weeks, where Group 1 had a VAS score of 1.28±0.63 compared to 1.96±0.57 in Group 2 (p-value <0.0001). By 12 weeks, the VAS scores between the groups were not significantly different (p=0.197), suggesting similar pain levels at this later stage of recovery. These findings suggest that the anterograde approach might provide better grip strength and lower pain levels in the earlier postoperative period compared to the retrograde approach.

Table 2: Comparison of grip strength and VAS score among the two groups of study participants

Parameter	Group 1 (Anterograde approach)N=30Mean±S.D.	Group 2 (Retrograde approach)N=30Mean±S.D.	t-test value	p-value
Grip strength				
Grip strength 6 weeks	19.87±4.01	14.06±4.17	5.501	<0.0001*
Grip strength 12 weeks	81.29±5.39	74.48±6.51	4.413	<0.0001*
VAS score				
VAS Pre Operative	9.67±0.61	10.03±0.79	1.976	0.053
VAS 2 weeks	3.98±0.94	4.97±0.98	3.993	0.0002*
VAS 6 weeks	1.28±0.63	1.96±0.57	4.384	<0.0001*
VAS 12 weeks	0.15±0.43	0.29±0.40	1.306	0.197

*P-value significant

Discussion

Various internal fixation methods for metacarpal fractures are available, but the primary goals of treatment remain the same: restoring articular anatomy, ensuring stable fracture fixation, correcting angular or rotational deformities, and rapidly restoring mobility and function.

Although plating has been effective, it has been associated with complications such as soft tissue trauma and postoperative fibrosis, as highlighted in numerous studies. Kirschner wires (K-wires) have been shown to provide a safer alternative for reducing and stabilizing metacarpal fractures, although they can lead to issues such as impingement and insufficient functional stability. Foucher G [9] introduced the technique of using multiple K-wires, known as "bouquet" osteosynthesis, which is based on Ender's flexible intramedullary pinning. In our study, we modified this approach by using a single pin of adequate diameter (1.5mm, 1.8mm, or 2mm), pre-bent to provide elastic support. This method achieves three-point fixation, offering sufficient stability to allow early mobilization. The minimal soft tissue dissection and avoidance of periosteal stripping in our approach encourage abundant periosteal callus formation, which facilitates fracture healing. Additionally, this procedure is straightforward, reduces operating time, limits radiation exposure, and can be performed as a day-case surgery, thereby lowering hospital costs. However, the pinning technique is not without drawbacks, such as lack of absolute stability, wire migration, impingement of soft tissues, pin site problems, infection, and the need for implant removal. Foucher G [9] recommended leaving a sufficient length of wire exposed for easier secondary removal, a practice we also followed to monitor pin migration and manage pin sites more effectively, reducing the risk of infection. Our approach was to leave the pins on the skin surface, preventing soft tissue impingement and facilitating easier pin site care. Additionally, we employed a single thicker K-wire, which provided adequate stability and allowed for early passive range of motion exercises. Mohammed R et al. [10] also used a single K-wire for metacarpal fractures but directed the wire differently from our approach, which involved both anterograde and retrograde intramedullary pinning. In our study, we used non-locking pins, unlike the approach in the study by Orbay J [11], which utilized locking pins with a sleeve. We initiated early range of motion exercises immediately after fixation, in contrast to Kim JK et al.'s [12] study, where immobilization lasted up to 5 weeks. To enhance functional outcomes, we began with assisted finger and wrist mobilization, followed by unassisted movements and ball-squeezing exercises. In our study, the incidence of metacarpal fractures was higher among males, with 73.3% in the anterograde group and 66.7% in the retrograde group. This male predominance is consistent with other studies, such as Stanton J S et al [13] who reported a male-to-female (M: F) ratio of 4:1, Mohammed R et al. [10] (6:1), Margić K [14] (6.7:1), and Chammaa RH et al. [15] (9:1). The mean age of patients in our study was 35.79 years in the anterograde group and 31.03 years in the retrograde group. This aligns with findings from Stanton J S et al [13] (mean age=31 years), Omokawa S et al [16] (38 years) and Reddy PK and Javali V [17] (34 years), indicating that metacarpal fractures are most common in young adults. In our study, the most common mode of injury was a fall on the ground (33.3%), followed by road traffic accidents involving two-wheelers (23.3%). This differs from Stanton J S et al [13], who found road traffic accidents (RTA) to be the leading cause in 40% of cases, followed by home-related injuries (28%). Similarly, Gupta R et al. [18] and Feehan LM, Sheps SB [19]. reported RTA as the most frequent cause of hand fractures, accounting for 60% and 48% of cases, respectively. In contrast, Reddy PK and Javali V [17] observed a broader distribution, with 33.33% of injuries due to punching, 26.66% from RTAs, and 20% each from sports activities and falls. Our study demonstrated that the mean union time was 5.21 weeks in the anterograde group and 6.89 weeks in the retrograde group. These findings align with studies by Rhee SH et al [20] and Harris AR et al [21], who reported average union times of 5.6 weeks and 5 weeks, respectively. However, Roth JJ, Auerbach DM [22] found a slightly longer average union time of 7 weeks; Singh VJS [23] observed it to be 7.2 weeks and, Omokawa S et al [16] reported it to be 8 weeks, which corresponds more closely with our retrograde group. In terms of fracture patterns, our study found that 46.6% of fractures were oblique, and 40% were transverse, with spiral and comminuted fractures making up 11.6% and 1.6%, respectively. These results are consistent with Gupta R et al. [18] who found that 53.1% of fractures were transverse and 45% were oblique or spiral. The majority of fractures in our study occurred on the dominant side (53.3%=anterograde group and 73.3%=retrograde group), a finding supported by Stanton J S et al [13], who observed that 65% of injuries occurred in the dominant hand, and by Khan W, Fahmy N [24] and Anakwe RE et al [25] who reported a similar distribution. Regarding the TAM score, 46.7% of anterograde group had TAM scores between 85-100%, while retrograde group had a higher percentage (53.3%) within the 70-84% range, indicating slightly better overall motion in anterograde group. This result is comparable to the study by She Y, Xu Y [26], who found that the mean total active motion (TAM) was 270°, with excellent functional outcomes in the majority of cases. Aly T [27] also reported that 61.9% of patients had excellent results using the TAM for functional outcome assessment. The VAS pain score in our study decreased significantly from preoperative levels to follow-up at 6 and 12 weeks, with the anterograde group showing a more substantial reduction in pain. This is in line with the findings of Kim JK et al [12], who reported lower median VAS scores in the anterograde group compared to the retrograde group. In terms of complications, 76.6% of patients in the anterograde group and 70% in the retrograde group experienced no complications. Stiffness was the most common complication, affecting 16.7% of patients in the anterograde group and 23.3% in the retrograde group, consistent with findings from Aski B, Bhatnagar A [28] and She Y, Xu Y [26], who reported complications such as skin irritation, nerve injuries, and joint stiffness. Singh VJS [23] reported infection and stiffness, while Aly T [27] observed complications ranging from minor infections to significant deformities and stiffness. Conversely, Reddy PK and Javali V [17] reported no major complications, with patients generally satisfied with their outcomes. 46.4% of patients in the anterograde group achieved excellent results, compared to 23.4% in the retrograde group. Our findings suggest that the modified technique used in our study, particularly the single K-wire approach with early mobilization, provides favorable outcomes with fewer complications compared to traditional methods, as also noted by Singh VJS [23] and Aly T [27].

Conclusion

Anterograde intramedullary percutaneous pinning presents a viable alternative as it is a simple, cost-effective technique that spares the joints and minimizes complications. This method facilitates maximal functional recovery, reduces joint stiffness, and promotes early recovery compared to retrograde pinning. It is particularly effective for managing transverse or short oblique metacarpal fractures, which typically heal within 6-8 weeks. The procedure, performed under wrist or supraclavicular block, is associated with minimal postoperative pain, shorter hospital stays, and reduced operative time compared to open reduction and internal fixation with miniplates and screws. However, timely intervention is crucial, given the close relationship between hand form and function; delays can lead to stiffness, malunion, and compromised functional outcomes.

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