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Dr. Sridhar DK
Associate Professor, Department of Orthopaedics Sri Siddhartha Medical College Tumkur, Karnataka, India

Dr. Mohamed Salman Sulfeeker
Post Graduate Student, Department of Orthopaedics Sri Siddhartha Medical College Tumkur, Karnataka, India

Dr. Smith Saurabh
Post Graduate Student, Department of Orthopaedics Sri Siddhartha Medical College Tumkur, Karnataka, India

Corresponding Author:
Dr. Sridhar DK
Associate Professor, Department of Orthopaedics Sri Siddhartha Medical College Tumkur, Karnataka, India

A prospective study to evaluate the functional outcome of metacarpal shaft fracture treated with mini plates

Dr. Sridhar DK, Dr. Mohamed Salman Sulfeeker and Dr. Smith Saurabh

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Abstract
Background: Metacarpal fractures are among the most common fractures of the hand. They may lead to loss of function if treated improperly. These injuries can be treated conservatively. However, if significant shortening, rotational deformity and angulation occur, surgical treatment is required. Recent studies have shown good functional results with surgical treatment of metacarpal fractures using miniplates and screws as compared to the conservative treatment or K –wire fixation. Hence the study aims to assess the functional outcomes of patients with metacarpal fractures, who will be undergoing open reduction and fixation with low profile titanium plates in our department.
Materials and Methods: Patients coming to the Department of Orthopaedic, at Sri Siddhartha Medical College, Tumakuru with metacarpal shaft fractures who are treated with open reduction and internal fixation with mini-plate. All patients are operated in supine position and under infraclavicular block or general anesthesia. After the tourniquet is inflated, the forearm is placed in pronation, a dorsal longitudinal incision is made and the fracture is exposed with adequate soft tissue dissection. A low profile 2.0 mm titanium miniplate is applied with four screws, two on each side of the fracture. In oblique or spiral type of fractures, initially fixed with inter fragmentary screws and then by plate. Metacarpal alignment and angulation will be confirmed with fluoroscopy. The plate and screws was covered with periosteum and soft tissues.
Results: The maximum subjects had injury on the right side (58.3%) and commones tbone to be involved was fracture of shaft of 5th metacarpal (37.5%). Transverse type (39.6%) was the commonest fracture pattern. Our study showed excellent functional outcome (54.2%) with lower complication rates and bone union was seen in minimum 6 weeks. Mean DASH score at 1 month (18.56), 3 month (11.56),6 months(3.02) with p value = 0.001.
Conclusion: Plate and screw fixation is a good option for treating closed unstable metacarpal fractures, where other modalities of fixation are less effective. The rigid stable fixation provided by plating which withstands load without failure allowed early mobilization and achieved good functional results. Detailed clinical and radiological assessment of fracture, careful preoperative planning, meticulous dissection, precision in surgical technique (coverage of plate with soft tissue) and choosing the correct implant (low profile plate) are critical in achieving good results and minimizing the complication.

Keywords: Low profile, metacarpal shaft fractures, miniplate

Introduction
Metacarpal fractures are most common fractures of the skeletal system and account for 36% of hand and wrist fractures. The peak incidence of metacarpal shaft fractures is between 20 and 40 years of age. Most of metacarpal shaft fractures can be treated conservatively. Various indications for operative treatment include malrotation, angulation, longitudinally shortening, multiple fractures and fractures associated with soft tissue injury or bone loss [1].
Direct trauma, mostly causes transverse and comminuted fracture whereas indirect trauma like falling on outstretched arm causes spiral and oblique fracture. If closed methods fail to achieve or maintain reduction surgery could be used[2]. Oblique and spiral fractures are prone to malrotation so operative fixation could be necessary, whereas comminuted fractures with or without segmental bone loss demand restoring and maintaining metacarpal length. Surgical methods include percutaneous or open Kirschner wire fixation, open or percutaneous inter fragmentary screw fixation and miniplate fixation [2]. Recent studies have shown good functional results with surgical treatment of metacarpal fractures using miniplates and screws

as compared to the conservative treatment or K –wire fixation [3].

Hence the study aims to assess the functional outcomes of patients with metacarpal fractures, who will be undergoing open reduction and fixation with low profile titanium plate.

Methods and Materials

This was a prospective study and includes 48 patients and samples for the present study were taken from those attending Department of Orthopaedic, at Sri Siddhartha Medical College, Tumakuru with metacarpal fractures Inclusion criteria-Age between 18 to 60 years of both sexes, Fresh fracture (fixed within 3 days) 10, 2–5 mm shortening, rotational deformity, angulation greater than 20° for index and long finger; greater than 30° for ring finger and greater than 40° for little finger, Patient who are willing to give informed written consent, Fractures with following geometry i.e. transverse, oblique, spiral or comminuted based on the fracture. Exclusion criteria includes - Open fracture, thumb metacarpal fracture, intra articular fracture, metacarpal neck and base fracture, and patients with other fractures in the same upper extremity, Open fractures, pathological fractures and fractures requiring bone grafting, Patients with previous injuries to the upper limbs will also be excluded.

After obtaining the informed consent from the patient, detailed history of the patient was noted and clinical examination is done then patients is sent for radiological investigation. All patients are operated in supine position and under infraclavicular block or general anesthesia. After the tourniquet is inflated, the forearm is placed in pronation, a dorsal longitudinal incision is made and the fracture is exposed with adequate soft tissue dissection. A low profile 2.0 mm titanium miniplate is applied with four screws, two on each side of the fracture. In oblique or spiral type of fractures, initially fixed with interfragmentary screws and then by plate. Metacarpal alignment and angulation will be confirmed with fluoroscopy. The plate and screws was covered with periosteum and soft tissues. After the operation, limb is immobilized in a below elbow short arm splint in functional position. Check X-ray done on second postoperative day and active finger movement initiated within the limits of pain tolerance, antibiotic given for two days. On third day patient discharged, advised to continue oral antibiotics for five days and to review after one week for check dressing, below elbow short arm splint maintained for two weeks. On fourteenth day suture removal done, splint discarded and advised for active finger and wrist movement, during the follow up, total range of motion will be assessed, grip power will be measured and compared with the normal extremity. DASH scoring will be performed in all patients, the complications will be noted.

Fig 1: X-ray shows oblique fracture of second metacarpal

Fig 2: Skin incision dorsoradial to the second metacarpal

Fig 3: Deep dissection done and extensor tendon exposed

Fig 4: Fracture fragments exposed

Fig 5: Traction is exerted by an assistant, while the surgeon reduces the fracture, using pressure from a periosteal elevator, or a dental pick

Fig 6: Drill for interfragmentary screw

Fig 7: Interfragmentary screw inserted

Fig 8: Suitable sized plate (6 hole) chosen

Fig 9: Drill for cortical screws

Fig 10: Cortical screw applied using screw driver

Fig 11: Proximally - 2 cortical screw
Distally – 3 cortical screw

Fig 12: Skin suturing done using 3-0 reverse cutting Ethilon

Statistical Analysis

Data was feeded into Microsoft excel data sheet and was analyzed with SPSS 20 version software. Quantitative variables were expressed as mean and standard deviation and qualitative variables were expressed as frequencies and percentages. For this study, qualitative data analysis was done, the test of significance was Chi-square test. Mean and standard deviation was used to show continuous data. Comparison of Dash score was done using Repeated Measure ANOVA. p value 0.001 was considered statistically significant.

Results

Table 1: Age distribution

Age Category	Frequency	Percent
<=35	12	25.0
36-45	19	39.6
>45	17	35.4
Total	48	100.0
Mean ± SD	42.42 ± 10.11	

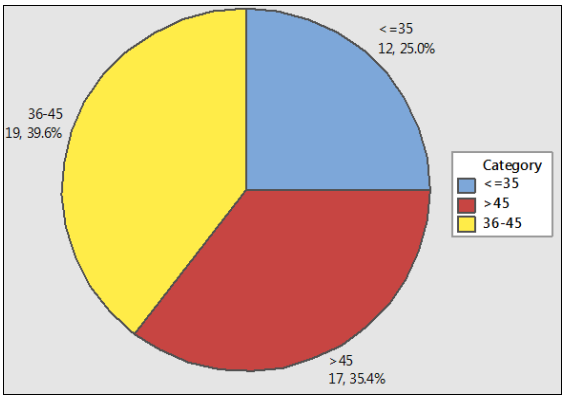


Fig 1: Age distribution

The study included the maximum subjects in the age range of 36-45 years i.e. 39.6% (19 out of 48 subjects) and the mean age was 42.42.

Table 2: Sex distribution

Sex	Frequency	Percent
Male	32	66.7
Female	16	33.3
Total	48	100.0

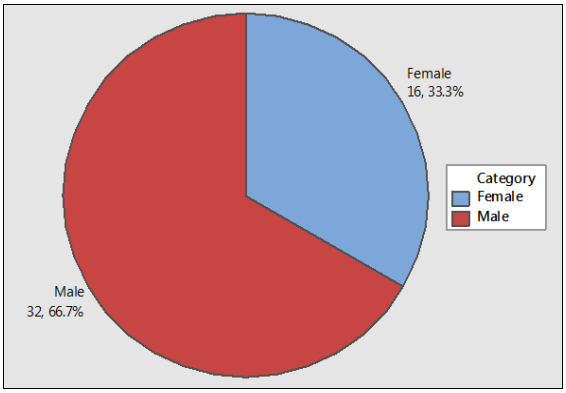


Fig 2: Sex distribution

66.7% (32 0ut of 48 subjects) were males whereas 33.3% (16 out of 48 subjects) were females.

Table 3: Mode of Injury

Mode of Injury	Frequency	Percent
Assault	5	10.4
Crush injury	2	4.2
RTA	23	47.9
Self fall	18	37.5
Total	48	100.0

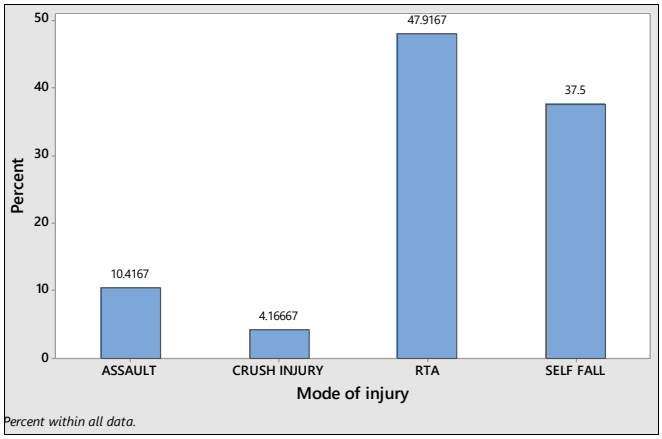


Fig 3: Mode of Injury

The commonest mode of injury was RTA i.e. 47.9% (23 out of 48 subjects).

Table 4: Side of Injury

Side	Frequency	Percent
Right	28	58.3
Left	20	41.7
Total	48	100.0

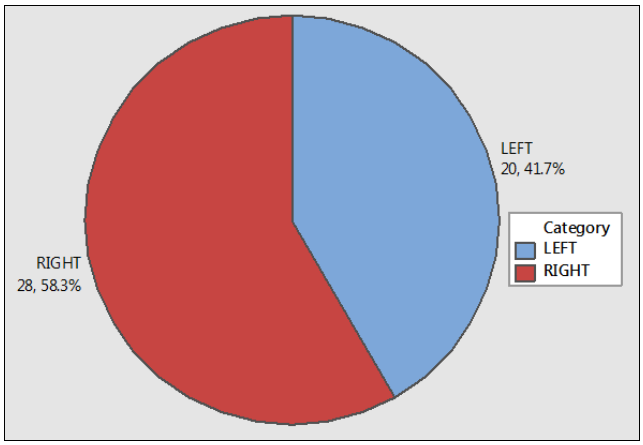


Fig 17: Side of Injury

The commonest side of injury was right side i.e. 58.3% (28 out of 48 subjects).

Table 5: Diagnosis

Diagnosis	Frequency	Percent
#Shaft of 2nd Metacarpal	7	14.6
#Shaft of 3rd Metacarpal	9	18.8
#Shaft of 4th Metacarpal	10	20.8
#Shaft of 5th Metacarpal	18	37.5
#Shaft of 2nd and 3rd Metacarpal	1	2.1
#Shaft of 3rd AND 4th Metacarpal	1	2.1
#Shaft of 4th and 5th Metacarpal	2	4.2
Total	48	100.0

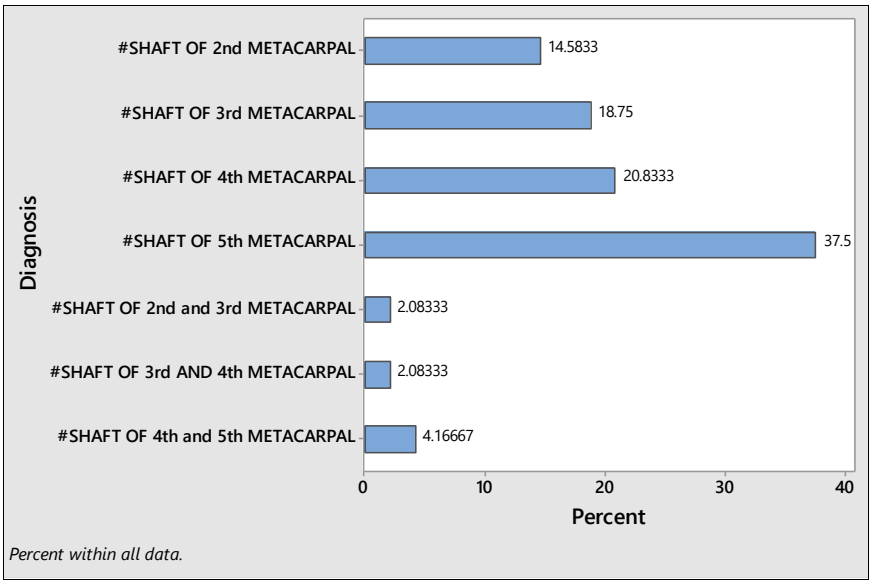


Fig 5: Diagnosis

The maximum subjects i.e. 18 out of 48 subjects (37.5%) were diagnosed with fracture of shaft of 5th metacarpal.

Table 6: Number of Metacarpals

Number of MC	Frequency	Percent
1	44	91.7
2	4	8.3
Total	48	100.0

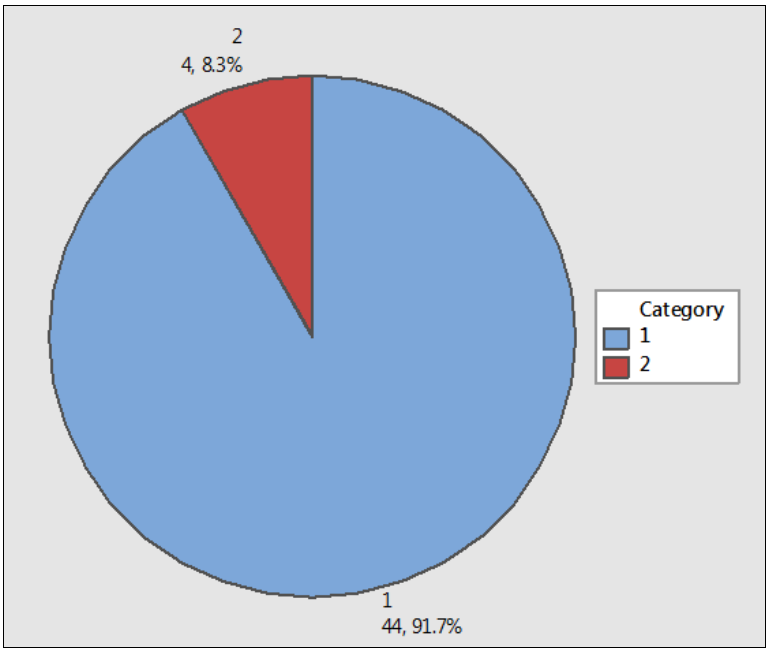


Fig 6: Number of MC

Out of 48 cases in 44 cases i.e. (91.7%) only one metacarpal was involved

Table 7: Fracture Pattern

Fracture Pattern	Frequency	Percent
Oblique	16	33.3
Spiral	13	27.1
Transverse	19	39.6
Total	48	100.0

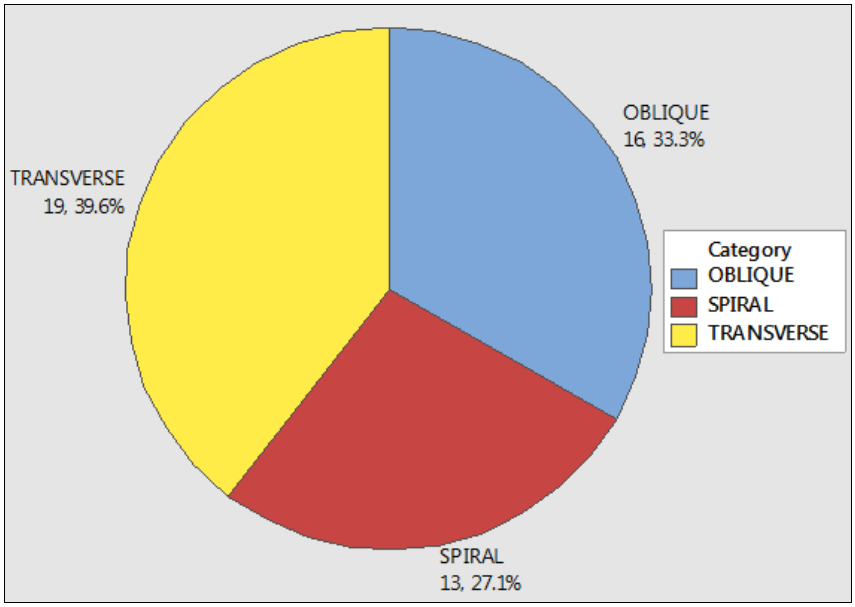


Fig 7: Fracture Pattern

The maximium subjects had transverse fracture pattern i.e. 39.6% (19 out of 48 subjects).

Table 8: Post-operative Complications

Post-operative Complications	Frequency	Percent
Stiffness	5	10.4
Infection	3	6.3
Nil	40	83.3
Total	48	100.0

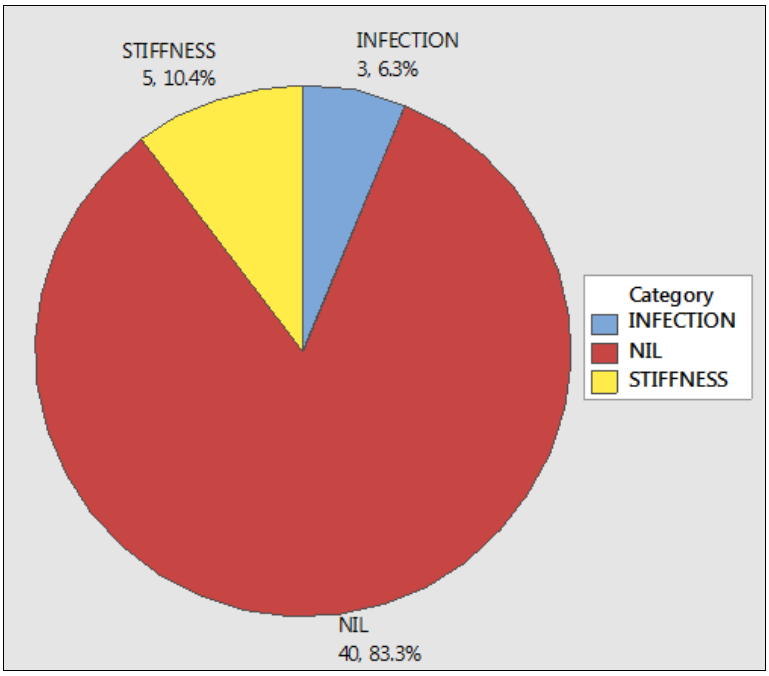


Fig 8: Post-operative Complications

8 out of 48 subjects developed post operative complications. 5 out of 8 subjects (10.4%) developed stiffness whereas 3 out of 8 subjects (6.3%) got infected.

Table 9: Functional outcome

Functional outcome	Frequency	Percent
Poor	5	10.4
Fair	4	8.3
Good	13	27.1
Excellent	26	54.2
Total	48	100.0

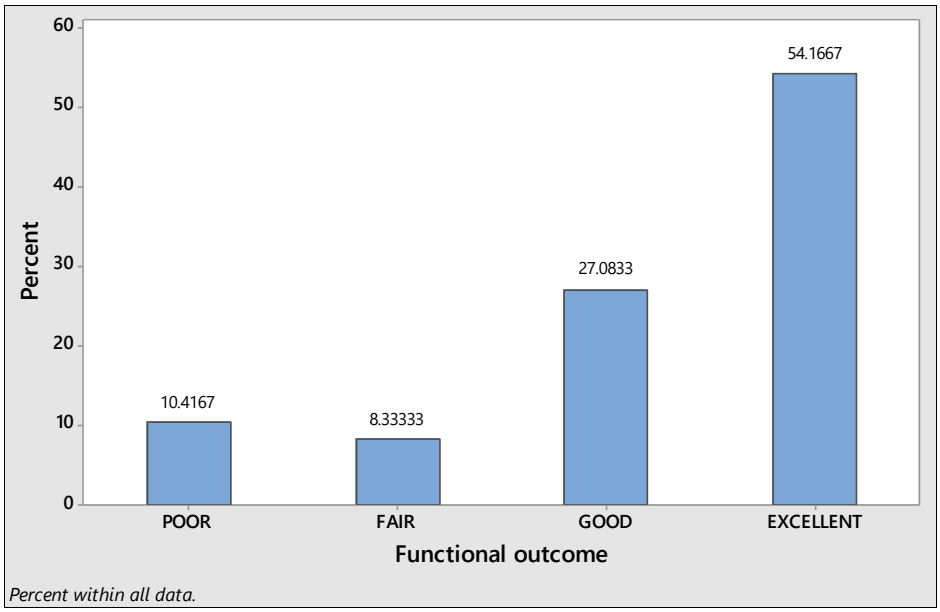


Fig 9: Functional outcome

The functional outcome was assessed and 26 out of 48 subjects (54.2%) had excellent outcome.

Table 10: Association of Post-operative Complications and sex

Post-operative Complications	Sex		Total	Chi-Square, P-value
	Male	Female		
Stiffness	3 (9.4%)	2 (12.5%)	5 (10.4%)	0.113, 0.945
Infection	2 (6.3%)	1 (6.3%)	3 (6.3%)	
Nil	27 (84.4%)	13 (81.3%)	40 (83.3%)	
Total	32 (100.0%)	16 (100.0%)	48 (100.0%)	

* Chi-Square test

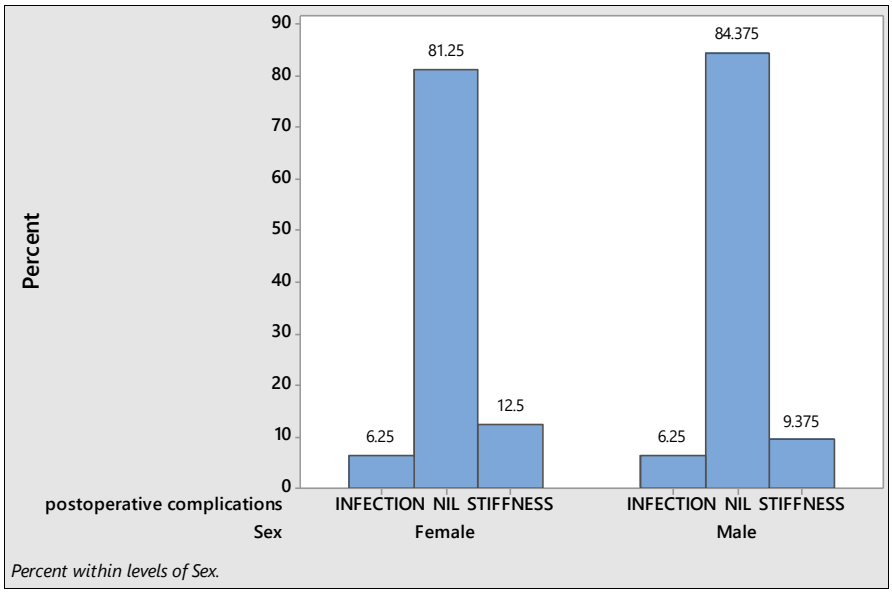


Fig 10: Association of Post-operative Complications and sex

5 out of 32 males had developed post operative complications. 3 (9.4%) had stiffness whereas 2 (6.3%) had developed infection. 3 out of 16 females developed post operative complications. 2 (12.5%) had stiffness and 1 (6.3%) developed infection.

Table 10: Association of Functional outcome and sex

Functional outcome	Sex		Total	Chi-Square, P-value
	Male	Female		
Poor	2 (6.3%)	3 (18.8%)	5 (10.4%)	3.658, 0.301
Fair	4 (12.5%)	0 (0.0%)	4 (8.3%)	
Good	9 (28.1%)	4 (25.0%)	13 (27.1%)	
Excellent	17 (53.1%)	9 (56.3%)	26 (54.2%)	
Total	32 (100.0%)	16 (100.0%)	48 (100.0%)	

*Chi-Square test

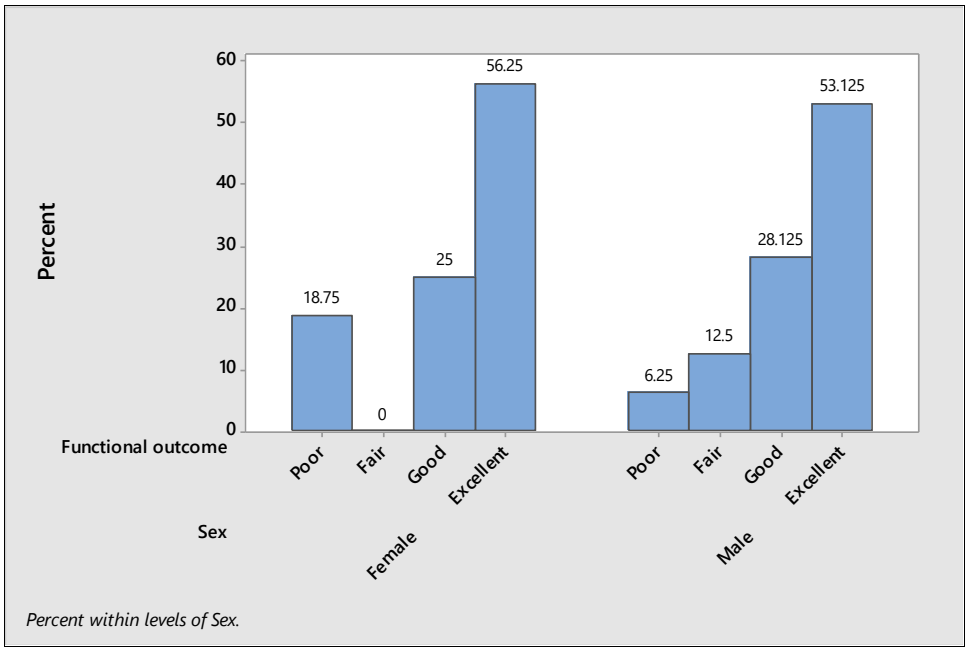


Fig 10: Association of Functional outcome and sex

The functional outcome was excellent for 53.1% (17 out of 32 males) and 56.3% (9 out of 16 females).

Table 11: Association Post-operative Complications with age

Post-operative Complications	Age Category			Total	Chi-Square, P-value
	<=35	36-45	>45		
Stiffness	1 (8.3%)	2 (10.5%)	2 (11.8%)	5 (10.4%)	2.360, 0.670
Infection	1 (8.3%)	0 (0.0%)	2 (11.8%)	3 (6.3%)	
Nil	10 (83.3%)	17 (89.5%)	13 (76.5%)	40 (83.3%)	
Total	12 (100.0%)	19 (100.0%)	17 (100.0%)	48 (100.0%)	

* Chi-Square test

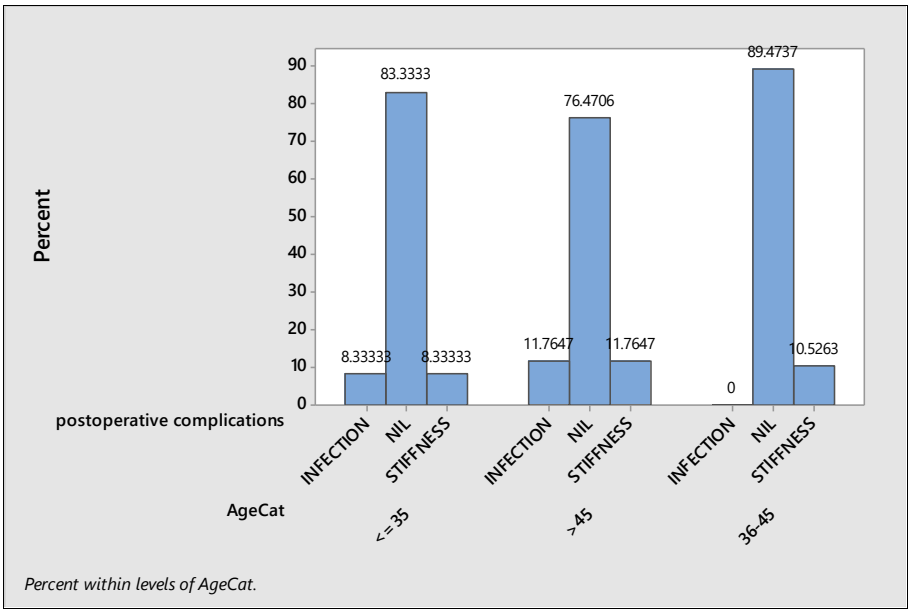


Fig 11: Association Post-operative Complications with age

Stiffness was common in the age range of 36-45 years and >45 years whereas infection was maximum seen in the age group of >45 years.

Table 12: Association functional outcomes with age

Functional outcome	Age Category			Total	Chi-Square, P-value
	<=35	36-45	>45		
Poor	2 (16.7%)	0 (0.0%)	3 (17.6%)	5 (10.4%)	5.118, 0.529
Fair	0 (0.0%)	2 (10.5%)	2 (11.8%)	4 (8.3%)	
Good	3 (25.0%)	6 (31.6%)	4 (23.5%)	13 (27.1%)	
Excellent	7 (58.3%)	11 (57.9%)	8 (47.1%)	26 (54.2%)	
Total	12 (100.0%)	19 (100.0%)	17 (100.0%)	48 (100.0%)	

* Chi-Square test

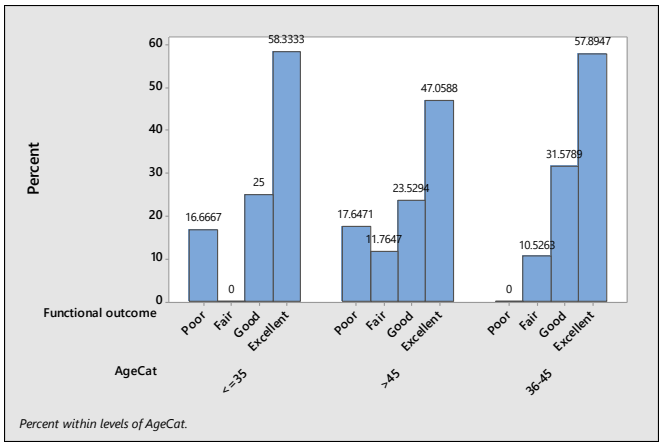


Fig 12: Association functional outcomes with age

The functional outcome was excellent for subjects mostly in the age range of 36-45 years i.e. 57.9% (11 out of 19 subjects).

Table 13: Union time and return to work (in weeks)

Variable	N	Mean	Median	Std. Deviation	Minimum	Maximum
Union time (in weeks)	48	7.35	7.00	1.345	6	11
Return work (in weeks)	48	8.65	8.00	1.732	7	14

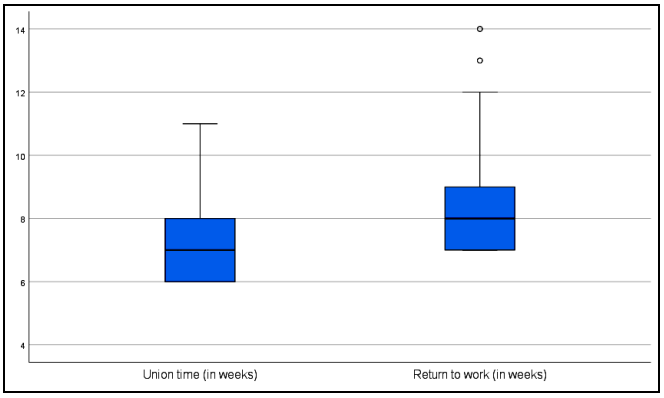


Fig 13: Union time and return to work (in weeks)

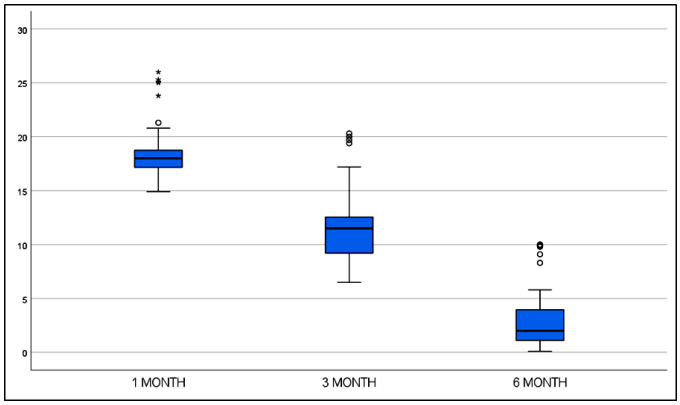
In most cases maximum union was seen in 11 weeks and returned to work in 14 weeks.

Table 14: Comparison of DASH Scores

DASH SCORE	N	Mean	Std. Deviation
1 Month	48	18.56	2.60
3 Month	48	11.60	3.43
6 Month	48	3.02	2.67
F-value	494.830		
P-value*	<0.001		

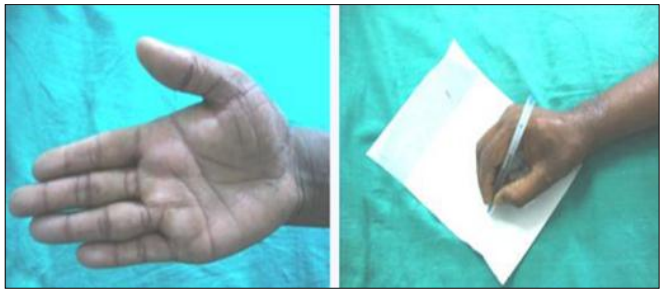
*Repeated Measure ANOVA

Fig 14: Comparison of DASH Scores



Case 1

Pre OP



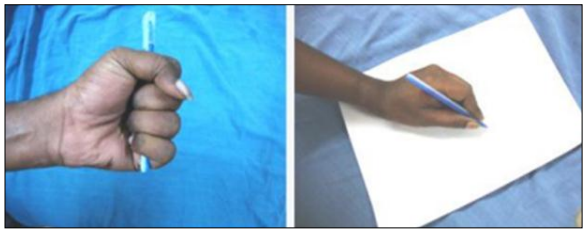
Extension at MCP, IP joints pinch

Flexion at MCP, IP joints

Case 2

Pre OP Post OP

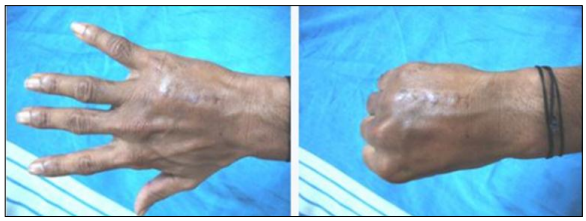
Extension at MCPJ, IPJ Flexion at MCP, IP joint



Grip strength Pinch strength

Case 3

Pre OP Post OP

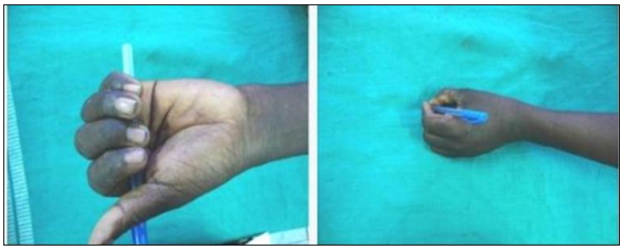


Extension at MCPJ, IPJ Flexion at MCP, IP joint

Case 4

Pre OP Post OP

Extension at MCPJ, IPJ Flexion at MCP, IP joint



Grip Strength Pinch Strength

Discussion

Plate and screws provide a stable fixation in metacarpal fractures, and thus, allow for early motion and contribute significantly to the outcome. K-wire is a stable method in cases where soft tissue is intact. Soft tissues support the power of fracture fixation. Plate fixation is used in comminuted metacarpal fractures. A stable fixation allows for passive and active movements in intrinsic muscles affected by the trauma, significantly improving hand functions. Preservation of the anatomic reduction prevents rotational deformity. In patients treated with plate and screw osteosynthesis, an adequate stability was achieved and early motion was initiated. 2 Most of the metacarpal fractures are stable and are managed successfully by conservative method of protective splinting followed by early mobilization.Only a small percentage of metacarpal fractures are unstable and in these patients the functional results following closed treatment are unsatisfactory. James *et al.* 15 reported that

closed method used in treatment of unstable fractures had loss of function in 77% of fingers. Kirschner wires are the most commonly used fixation materials after closed or open reduction. However, late initiation of movement resulting in a stiff hand, pin tract infection, and pin migration are the disadvantages of this method. The average age in our series was 42 year and the study conducted by Raghavendra V *et al.* showed average age of patients was 38 year. The male preponderance was seen in the present study with 66.7% of patients being male which was similar to the study conducted by Raghavendra *et al.* which showed 80% were males in his study and the study conducted by AL Madaway *et al.* showed 93.3% of males patients in his study. The Right side was more commonly affected side with 28 patients. In the study conducted by Ayukt *et al.* in 18 patuents 11 patients showed right side The most common mode of injury in our study was RTA (23 patients) which was similar to the study conducted by Raghavendra *et al.* with total of 15 patients with mode of injury was RTA. The most common type of fracture in our study was Transverse which was similar to the studies conducted by Ford *et al.* which showed transverse type of fractures being the most common type and in the study conducted by Raghavendra *et al.* showed 16 patients with transverse as common type. Our study showed lower complication rates with stiffness seen in 5 patients hich is similar to the study conducted by Raghavendra *et al.* which showed siftness in 3 patients. Our study showed an excellent functional outcome similar to the study conducted Raghavendra *et al.* showed 60% of functional outcome, Kirsch B *et al.* showed 62% of functional outcome.

In our study bone union was seen in minimum 6 weeks whereas in study conducted by Nour *et al.* 5 time of union ranged between 4 and 5 weeks. In unstable metacarpal fractures, plate fixation is a better option for several reasons1) They provide stable fixation, thus allowing early mobilization of fingers 2) Shortening seen in multiple metacarpal fractures which are corrected by plating, restores the power of interossei muscle thereby retaining the grip strength of hand. In these unstable metacarpal fractures, treatment with plate osteosynthesis provides anatomical reduction of fracture with rigid stabilization allowing early mobilization of joints without loss of reduction thus preventing stiffness and yields good functional results.

Conclusion

Plate and screw fixation is a good option for treating closed unstable metacarpal fractures, where other modalities of fixation are less effective. The rigid stable fixation provided by plating which withstands load without failure allowed early mobilization and achieved good functional results.

Detailed clinical and radiological assessment of fracture, careful preoperative planning, meticulous dissection, precision in surgical technique (coverage of plate with soft tissue) and choosing the correct implant (low profile plate) are critical in achieving good results and minimizing the complication.

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