ORIGINAL RESEARCH

Surgical management of metacarpal shaft fractures: A prospective study using mini plates and screws

[1]Dr. Raghavendra, [2]Dr. Manjunath Japatti, [3]Dr. Santosh, [4]Dr. Sunil Kumar K R

Corresponding Author
Dr. Sunil Kumar K R

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ABSTRACT

Background: In unstable fractures (which typically account for less than 5% of hand fractures) where closed treatment techniques result in poor functional results, accurate open reduction and internal fixation of metacarpal fractures are necessary. When utilised in carefully chosen cases, small plates and screws offer firm fixation that enables early joint mobilisation and, as a result, good functional success.**Patients and methods**: In 25 patients with closed metacarpal shaft fracturestreated with mini plates and screws between December 2017 to December 2019 at Vijayanagara institute of medical sciences Ballari. The functional outcome was assessed using Disability of Arm, Shoulder and Hand (DASH) score and Visual Analog Score (VAS) over a period of two years in prospective manner.**Results:**In all cases of metacarpal shaft fractures treated with plate osteosynthesis in our study, there was 100% bone union. In 21 out of 25 cases, or 84% of the patients, the functional outcome was excellent; in 3 out of 25 cases, it was good; and in 1 out of 25 cases, it was bad. A superficial wound infection that two patients experienced resolved with daily dressing changes and antibiotics; this had no bearing on the result.**Conclusion:**For closed metacarpal shaft fractures, plate and screw fixation is a useful alternative when other fixation modalities are less successful. The stiff, robust fixation offered by plating allows for early mobilisation and produces satisfactory functional outcomes.

Keywords: metacarpal fracture, mini plate and screws, internal fixation

INTRODUCTION

Although hand fractures are among the most common fractures in humans, there are significant regional variations in the care of these injuries. Numerous factors, such as the accessibility of resources, social dynamics, geographical limitations, surgeon choice and experience, and regional practice patterns, contribute to this diversity. Less expensive techniques of treating hand fractures are more frequently used in developing nations.

The metacarpal bone fractures in the hand account for 14–28% of hospital visits that occur after trauma from diverse sources, such as assault, vehicle accidents, industrial accidents, and agricultural mishaps [1].

These metacarpal fractures are far too frequently ignored or treated as mild trauma, which leads to significant deformity and permanent impairment [2,3].

Hand fractures are frequently complicated by deformity resulting from inadequate therapy, stiffness resulting from excessive treatment, and both deformity and stiffness resulting from inadequate treatment [4]. The goal of hand fracture healing is not isolated; rather, the outcome's functional significance is critical [5].

In comparison to conservative treatment or K-wire fixation, recent studies have demonstrated intelligent and beneficial outcomes when operating on metacarpal fractures employing miniplates and screws. The functional result of metacarpal fractures treated with miniplates and screws is being evaluated in this study [6].

MATERIAL AND METHODS

In this prospective study, we looked at 25 cases of metacarpal fractures that were admitted between December 2020 and December 2022to the VIMS Hospital, which is a part of the Vijayanagar Institute of Medical Sciences in Ballari. The institutional medical ethics committee gave the work its approval. Written informed consent.

INCLUSION CRITERIA

1. Age more than 18 years.
2. Physical fitness for surgery
3. Sex : Both male and female

EXCLUSION CRITERIA

1. Age less than 18 years.
2. Patient not willing or medically unfit for surgery
3. Compound injury

INDICATIONS

Indications for plate fixation of the metacarpals are

1. Displaced diaphyseal transverse, short oblique, or short spiral fractures
2. Multiple fractures with gross displacement
3. Comminuted fractures with shortening or malrotation or both
4. Comminuted intraarticular and periarticular fractures –displaced

METHOD OF COLLECTION OF DATA

During the study period from December 2020 to December 2022, patients with metacarpal fractures are chosen based on clinical and radiographic investigation.

Every patient chosen for the study will undergo a protocol-compliant examination, have any related injuries documented, and have clinical and laboratory evaluations completed in order to determine their surgical eligibility.

Surgery will proceed with the patient's consent. The patient will receive follow-up care until both clinical and radiological union are established.

We will look closely at the amount of time needed for union, the range of mobility in the surrounding joints, and any issues that happened before, during, or after surgery.

There was no sampling technique used in the analysis of 25 cases.

OPERATIVE PROCEDURE – OPEN REDUCTION INTERNAL FIXATION WITH PLATE OSTEOSYNTHESIS

In every case, a tourniquet was used prior to surgery.For the first and second metacarpals, a dorsal incision is performed on the radial border; for the fifth metacarpal, the ulnar boundary is used.

The method for the third and fourth metacarpals involves making a dorsal longitudinal incision between these bones. Following the retraction of the extensor tendons, the fracture fragments were anatomically reduced. Point reduction forceps or a stabilising K wire are used to hold the reduction in place. Long spiral and oblique fractures were treated with interfragmentary lag screws. Screws were utilised to secure the plate configuration, which was selected based on the kind of fracture (straight plate for shaft fractures, T or L shaped plates for periarticular fractures).

Careful consideration was given to soft tissue dissection and appropriate soft tissue coverage (periosteum) was made over the plate to avoid irritation to overlying extensor tendon. The wound was cleaned thoroughly and closed without the need for a drain. The hand was splinted using a volar below elbow slab.

POST OPERATIVE PROTOCOL

For a duration of 24 to 48 hours, the hand was elevated in order to manage pain and edema. Wound was evaluated at second post operation day. Active finger mobilisation then began and gradually increased up to the point of pain tolerance. On the fifth postoperative day, the patients were released from the hospital, and outpatient physiotherapy was provided. After ten days of surgery, the sutures were taken out.

At four, six, and eight weeks a follow-up assessment was conducted to evaluate clinical improvement in terms of range of motion and radiographic evaluation to identify fracture union or any loss of reduction.

EVALUATION OF RESULTS

We used the Total Active Flexion (TAF) scoring method [7,8], the Visual Analogue Score (VAS), and the Disability of Arm, Shoulder, and Hand (DASH) score [9], to assess the functional outcome of unstable metacarpal fractures treated with plate osteosynthesis.

This approach considers the degree of flexion at the interphalangeal and metacarpophalangeal joints for fingers (2–5), as well as the degree of flexion at the proximal and distal interphalangeal joints for the thumb.

The total active flexion score is calculated by subtracting the extensor deficit from the sum of the flexions at the metacarpophalangeal and interphalangeal joints. The extensor deficit is expressed in degrees.

TAF from MCPJ to DIPJ: digit 2-5

DEGREE OF FELXION	RATING
220-260	EXCELLENT
180-220	GOOD
130-180	FAIR
<130	POOR

TAF from MCPJ and IPJ: thumb

DEGREE OF FELXION	RATING
120-140	EXCELLENT
100-120	GOOD
70-100	FAIR
<70	POOR

DASH SCORE

DASH SCORE	RATING
90-100	EXCELLENT
80-89	GOOD
70-79	FAIR
<70	POOR

VISUAL ANALOG SCALE

SCORE	GRADE
10-9	WORST POSSIBLE PAIN
8-7	LOT OF PAIN
6-4	CONSIDERABLE PAIN
2-3	LITTLE PAIN
0-1	NO PAIN

RESULTS

25 patients were included in this study. 9 patients had multiple metacarpal fractures (36% cases). Right hand

was involved in 17 of the patients (68%). 3 out of 25 were female patients (12%). All the 25 patients who underwent open reduction and internal fixation with plate osteosynthesis for unstable metacarpal fractures achieved bone union (100%). In most of the cases bony union was seen between 9-11 weeks, average period being 10.2 weeks (range 8-12 weeks). Spiral and oblique fractures united at 9 weeks, transverse and comminuted fractures united at around 12 weeks.
Functional outcome assessed by DASH SCORE (Disability of Arm, Shoulder and Hand score, Visual Analog Score (VAS) and TAF (Total Active Flexion) score was excellent in 20 patients (80%), good in 3 patients (12%), fair in one patient (4%), poor in one patient (4%). The overall results are satisfactory.
2 patients developed superficial wound infection, both were the case ofmultiple metacarpal fractures (both of these case had involvement of twometacarpal). Both these cases with superficial infection settled with daily dressing and antibiotics. 2 patients had stiffness of metacarpophalangeal and interphalangeal joints and both were cases of multiple metacarpal fractures for whom physiotherapy was continued and patients showed improved range of motion, and the results in these patients are fair & poor.

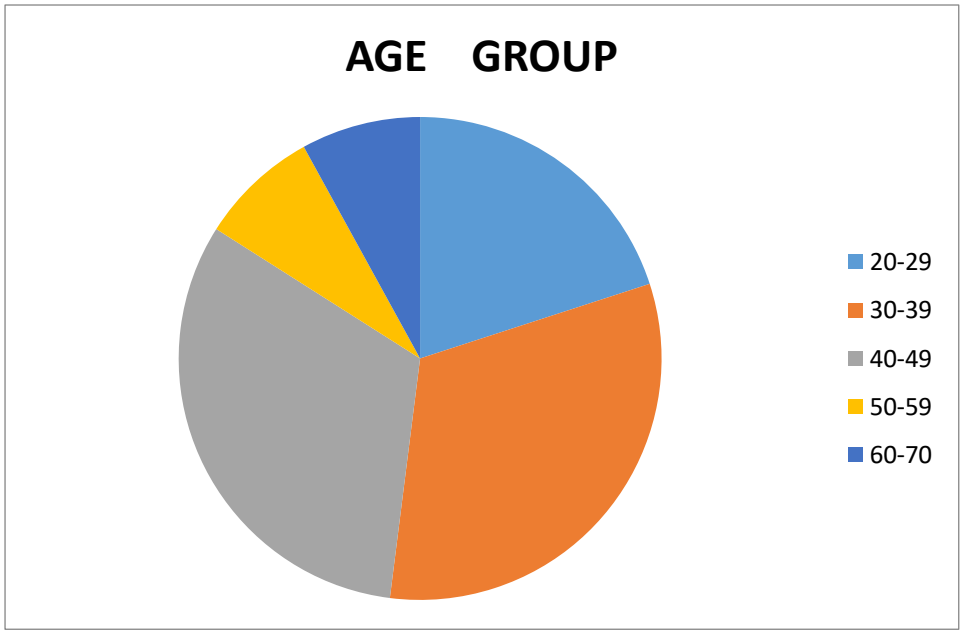
None of the patients in our study developed tendon irritation, this is dueto extra cautious effort taken to cover the plate (low profile plate) with soft tissue (periosteum)for free gliding of overlying extensor tendon. No cases had angular or rotational displacement of fractures. No cases had implant breakage.None of the patients required implant removal.

I. AGE DISTRIBUTION

Age group varied from 20 years to 70 years with mean age of 45years. Incidence of fracture was observed maximum between 20-50 years.

TABLE 1: AGE DISTRIBUTION

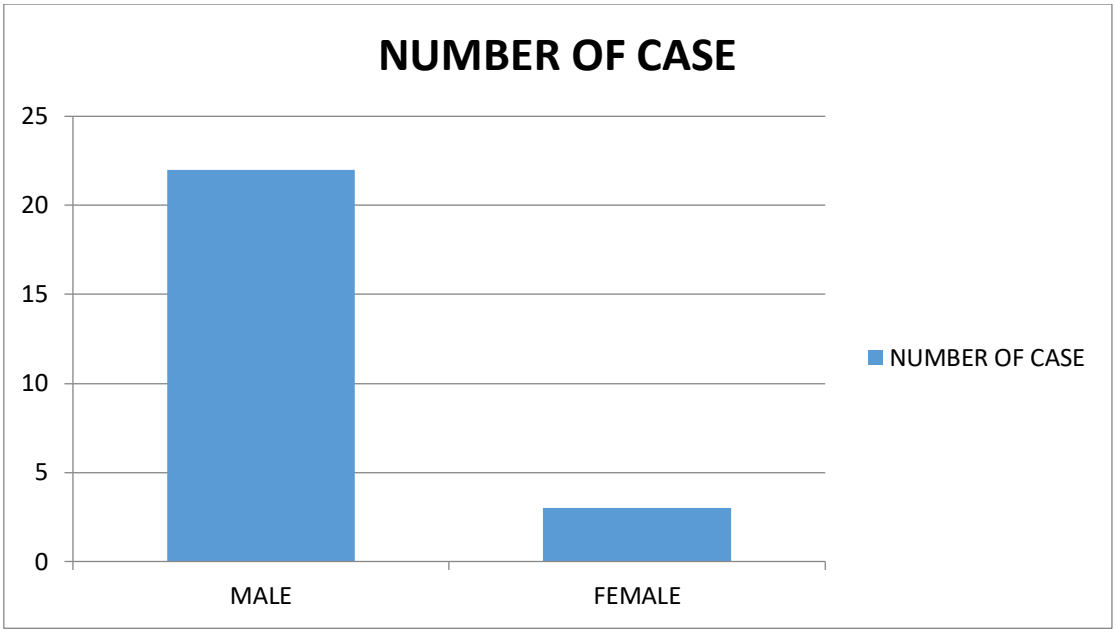
Age group	Number of cases	Percentage
20-29	5	20
30-39	8	32
40-49	8	32
50-59	2	8
60-70	2	8



II. SEX DISTRIBUTION

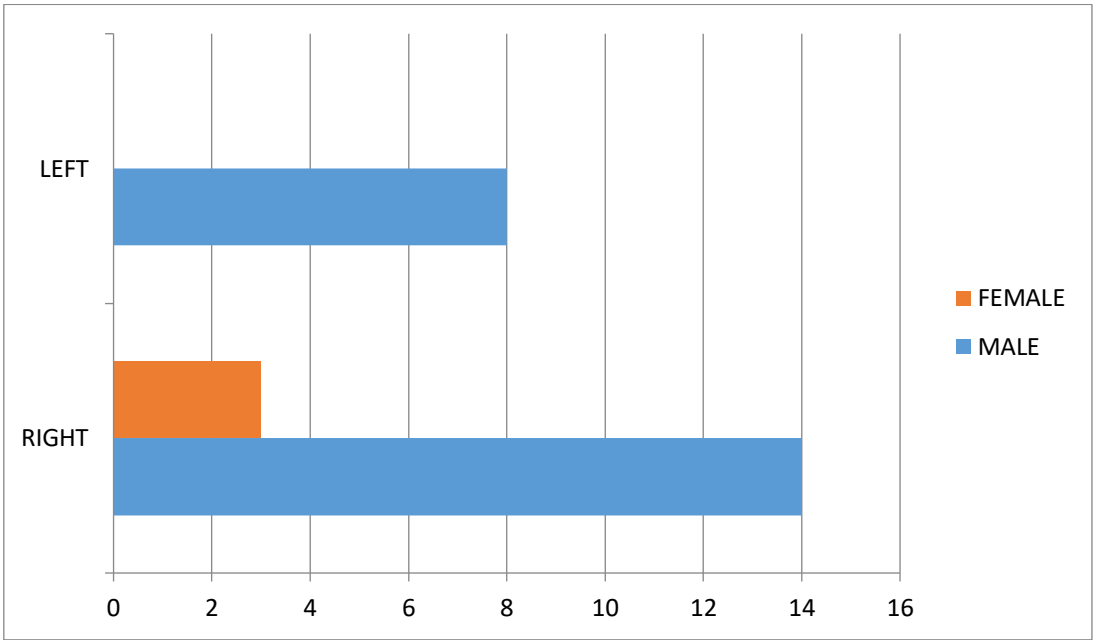
Among the 25 cases, males were predominant

SEX	NUMBER OF CASE	PERCENTAGE
MALE	22	88
FEMALE	3	12



III. SIDE OF INJURY

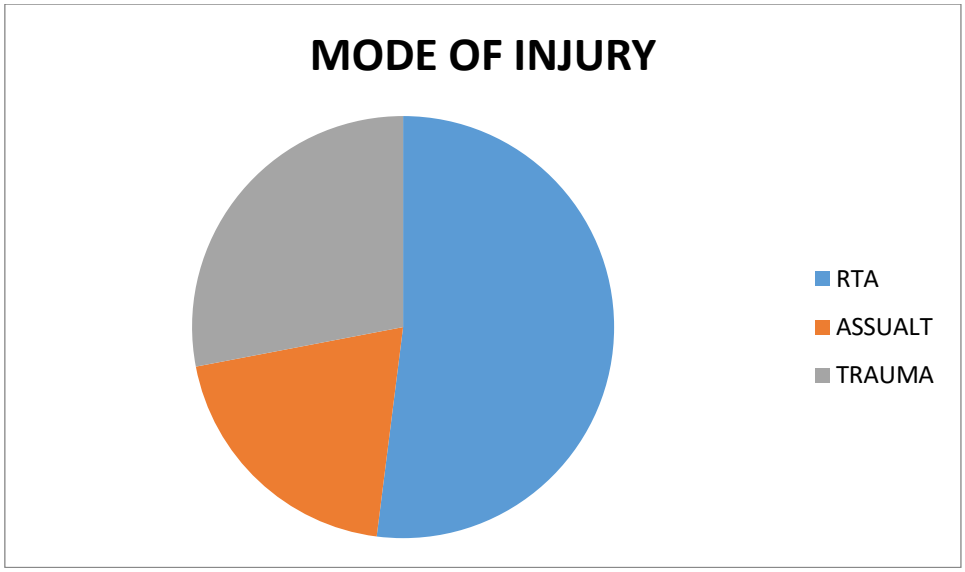
SEX	RIGHT	LEFT	BILATERAL	TOTAL
MALE	14	8	0	22
FEMALE	3	0	0	3
PERCENTAGE	60	40	-	-



IV. MODE OF INJURY

Commonest mode of injury being Road Traffic Accident (RTA)

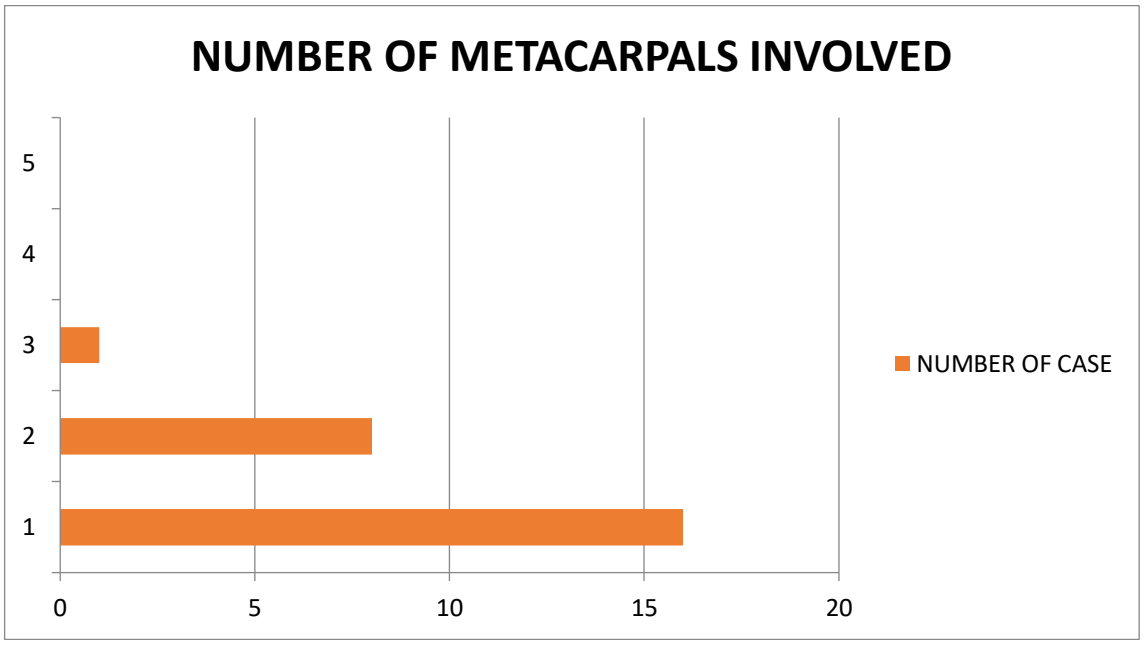
MODE OF INJURY	NUMBER OF CASES	PERCENTAGE
RTA	13	52
ASSUALT	5	20
TRAUMA	7	28



V. NUMBER OF METACARPAL INVOLVED

Single metacarpal involvement being the most common accountingfor 70% of the cases.

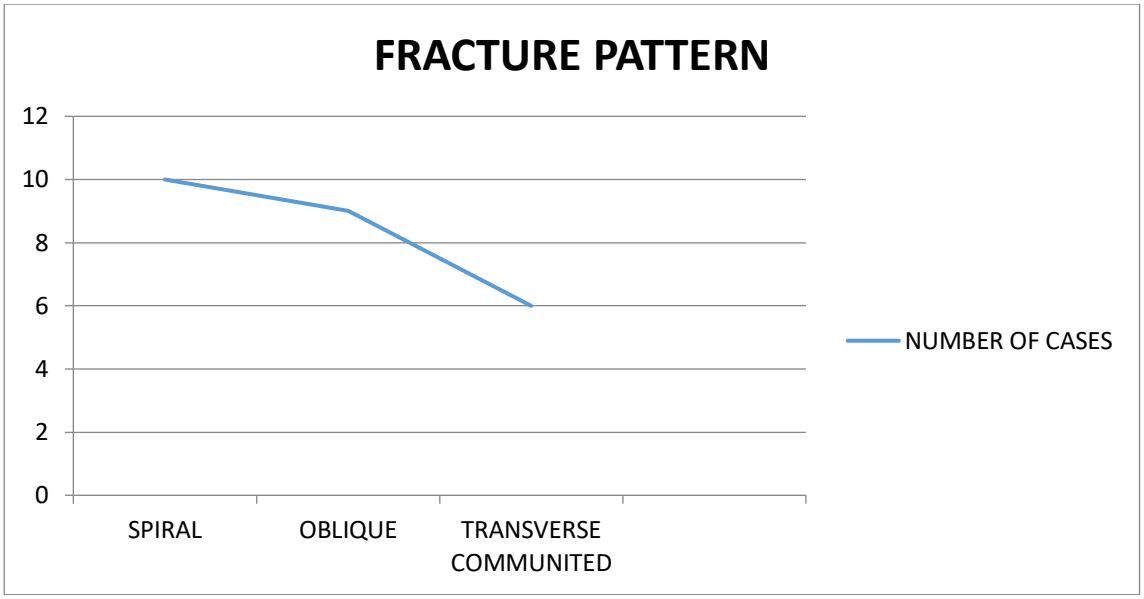
NUMBER OF METACARPALS INVOLVED	NUMBER OF CASE	PERCENTAGE
1	16	64
2	8	32
3	1	4
4	0	-
5	0	-



VII. FRACTURE PATTERN

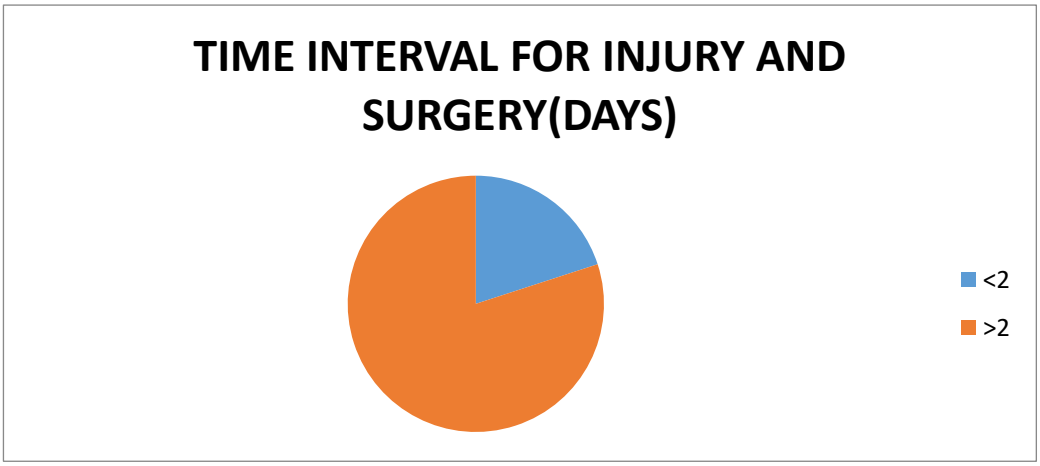
Spiral fracture pattern being most common accounting for40%

FRACTURE PATTERN	NUMBER OF CASES	PERCENTAGE
SPIRAL	10	40
OBLIQUE	9	36
TRANSVERSE COMMINUTED	6	24



III. TIME INTERVAL BETWEEN INJURY AND SURGERY

TIME INTERVAL(DAYS)	NUMBER OF CASES	PERCENTAGE
<2	5	20
>2	20	80



X. COMPLICATIONS

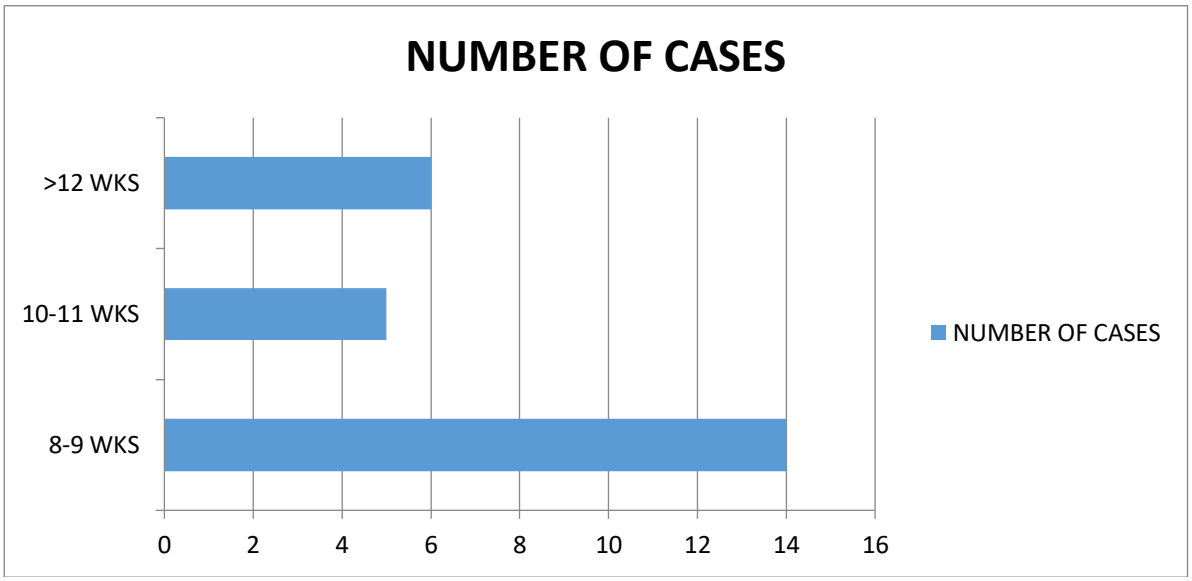
4 Cases developed complications. Infection seen in 16% (2 out of 25cases). Stiffness seen in 16% (2 out of 25 cases)

COMPLICATIONS	NUMBER OF CASES	PERCENTAGE
INFECTION	2	16
STIFFNESS	2	16
MAL UNION	-	-
NON UNION	-	-
IMPLANT BREAKE	-	-
TENDON IRRITATION	-	-

XI. UNION TIME

In most of the cases bony union was achieved in 6-7 weeksaccounting for 65%.

DURATION IN WEEKS	NUMBER OF CASES	PERCENTAGE
8-9	14	56
10-11	5	20
>12	6	24

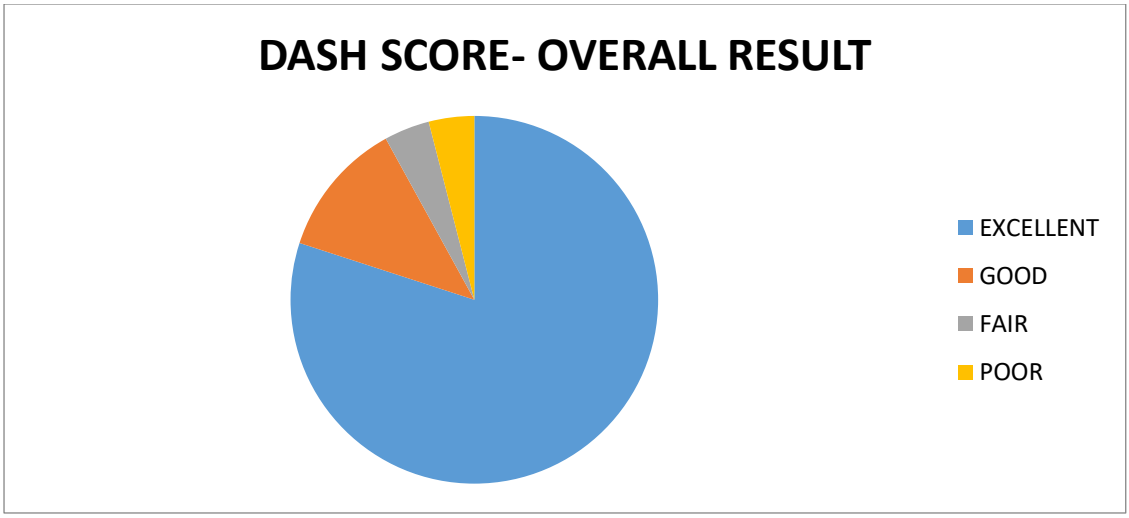


ANALYSIS OF FUNCTIONAL OUTCOME

The functional outcome was assessed using Disability of Arm , Shoulder and Hand(DASH)score and Visual Analog Score(VAS) the following results were obtained.

DASH SCORE- OVERALL RESULT

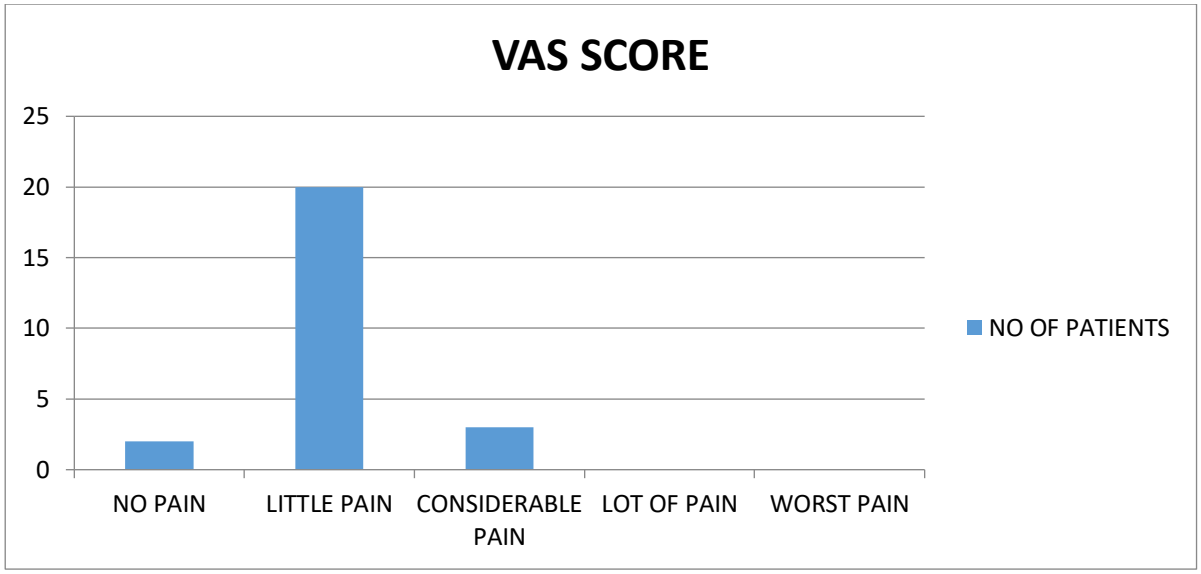
GRADING	NO OF CASES	PERCENTAGE
EXCELLENT	20	80
GOOD	3	12
FAIR	1	4
POOR	1	4



GRAPH: DASH SCORE OVERALL RESULTS

TABLE: VAS SCORE

GRADING	NO OF PATIENTS	PERCENTAGE
NO PAIN	2	8
LITTLE PAIN	20	80
CONSIDERABLE PAIN	3	12
LOT OF PAIN	0	-
WORST PAIN	0	-



GRAPH: VAS SCORE

DISCUSSION

The majority of metacarpal fractures are successfully treated with conservative protective splinting followed by early mobilisation when they are stable either before or after closed reduction [10,11]. The functional outcomes of closed treatment are not good in patients with metacarpal fractures, which account for a very small number of fractures. These are the cases—which typically account for less than 5% of hand fractures—that are recommended for open reduction and internal fixation[12,13]. According to James et al.[14] 77% of fingers with closed methods for treating unstable fractures had lost function.

Open reduction and internal fixation with K wire is one of the treatment modalities in these unstable fractures but they give less stiff fixation and are rotationally unstable, there is greater association of pin tract infection and issues owing to protruding ends of K-wire are substantial.

Although it offers a firm fixation comparable to plating, interosseous wiring with K-wire is only beneficial for transverse diaphyseal fractures.

An external fixator can be used to treat metacarpal fractures [15-19]. Report by Shehadi et al [16] demonstrated full restoration of total range of motions in up to 100% of metacarpal fractures treated with external fixator.

When there is bone loss and compound metacarpal fractures, this fixing method can be helpful. However, frequent use of an external fixator is not advised due to loosening of the construct after a pintract infection, which results in loss of fixation, and difficulties with applying and constructing the fixator.

Transverse and short oblique fractures were treated with intramedullary fixation using prebent K-wires [20-23].When screw and plate fixation are used, they yield functional results that are similar. But there is incidence of loss of reduction, penetration of metacarpophalangeal joint by hardware, therefore demanding a second surgery for hardware removal.

Numerous studies in the literature have demonstrated the effectiveness of AO miniplate and screws in treating unstable metacarpal and phalangeal fractures [24,25-35].

In 18 of the 19 patients for whom plate fixation was performed for closed unstable metacarpal fractures, a research by Souer et al. demonstrated favourable functional result by total active mobility greater than 230 degrees[36]. In a different study, Gupta et al.[1] reported that all of his patients with unstable metacarpal fractures treated with plate fixation had excellent functional outcomes with total active motions greater than 230 degrees. In another investigation, 27 unstable metacarpal fractures treated with plate fixation showed no complications, according to DabeziesSchutte[27]. Our study's low rate of complications was comparable to these findings.

Two of the twenty-five individuals in our study experienced superficial wound infections. The second post-operative day in both of these superficial infection patients had wound drainage, but this resolved with daily dressing changes and medicines, and it had no bearing on the outcome. Two patients experienced finger stiffness as a result of numerous metacarpal fractures; one patient's case involved fractures in all four metacarpals, while the other patient's case involved fractures in two metacarpals.After PT, all patients eventually had increased range of motion.

Plate fixation is a preferable treatment for metacarpal shaft fractures for a number of reasons[9]:

1) They enable early finger mobilisation by offering stable fixation in all unstable metacarpal fractures.

2) When several metacarpal fractures are repaired with plating, the interossei muscle's power is restored, allowing the hand's grip strength to be retained. This is known as shortening.

3) Severe soft tissue damage is typically connected to multiple metacarpal fractures. When plate osteosynthesis is used to treat unstable metacarpal

fractures, the fracture is anatomically reduced with rigid stabilisation, allowing for early joint mobilisation without losing reduction. This prevents stiffness and produces good functional outcomes.

CONCLUSION

In our investigation of plate osteosynthesis-treated metacarpal shaft fractures, 100% of the cases exhibited bone union. In twenty of the twenty-five patients, the Disability of Arm, Shoulder, and Hand (DASH) score indicated an excellent functional outcome; in the other three instances out of twenty-five, the score was good. Mini plates and screws offered a stable and robust attachment that allowed fingers to mobilise early, preventing stiffness and achieving overall satisfactory functional results. While 8% (two cases) of superficial infections occurred, all of them resolved with conservative treatment and antibiotics without compromising functional result.

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