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# Results of Treatment of Oblique and Spiral Phalangeal Fractures of the Hand by Mini Lag Screws

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## ABSTRACT

**Background:** Fractures of the hand represent a considerable burden upon the society in terms of medical costs and reduced workplace productivity.

**Aim of the work:** The study aimed to evaluate the clinical outcome of patients with oblique and spiral phalangeal fracture managed with mini-screws fixation.

**Patients and Methods:** A total of 20 patients presented with oblique and spiral phalangeal fractures were treated by mini-screw fixation and were followed for a minimum of 6 months. The mean age of the patients was 33 years, ranging from 19 to 46 years. Eleven cases were males and nine were females.

**Results:** The functional results were graded as excellent in 14 patients (70%), good in two patients (10%), fair in two patient (10%), and poor in two patients (10%). The excellent and good results were considered as satisfactory, while the unsatisfactory included the fair and poor results. Thus, satisfactory results were found in 16 patients (80%), and the unsatisfactory ones were found in four patients only (20%).

**Conclusion:** Mini screw fixation offers an effective, simple and reliable method for treatment of oblique and spiral fracture with low incidence of complication.

**Keywords:** Oblique and Spiral Phalangeal Fractures - Mini Lag Screws.

## INTRODUCTION

Hand fractures represent a major burden to society in terms of medical costs and low productivity of the workplace [(1)].

Fractures of the metacarpals and phalanges are the most common fractures of the upper extremity [(2)]. They account for up to 10% of the upper extremity fractures [(3)]. Roughly 70% of all metacarpal and phalangeal fractures occur between the ages of eleven and 45 years [(4)]. Phalange column fractions are broadly classified into: transverse, oblique, spiral, and mantled. Each type of fracture presents distinct abnormalities that may lead to complications if they are not recognized or treated incorrectly [(5)].

Selection of the optimal treatment depends on many factors, including fracture location (intra-articular or extra-articular), fracture geometry (transverse, spiral, oblique or comminuted), deformity (angular, rotational or shortening), whether the fracture is open or closed, whether osseous and soft tissue injuries are associated and intrinsic fracture stability. Additional considerations include the patient's age, occupation and socioeconomic status as well as the presence of systemic illnesses, the surgeon's skill, and the patient's compliance [(6)]. Melone [(7)] in 1986 noted that approximately 10% of phalangeal and metacarpal fractures are irreducible by closed manipulation or percutaneous pinning and require open reduction. Oblique and spiral phalangeal fractures are unstable, even if reduced and are difficult to hold in reduction these fractures are prone to rotational malalignment and shortening with inadequate treatment. Oblique and spiral phalangeal fractures are usually the result of torsional forces and can cause rotational malalignment. Malrotation is poorly tolerated and is difficult to assess on plain radiographs. It is best judged clinically by asking the patient to flex all the fingers simultaneously If scissoring or malrotation is present with composite digital flexion, open reduction and internal fixation(ORIF) should be considered [(6)].

Stable bony construct has to be restored for early mobilization. Early mobilization minimizes adhesions and is the key to good clinical outcome [(8)]. Various treatment modalities have been described for the treatment of oblique and spiral fracture. The treatment options include closed reduction with cast or splint immobilization, percutaneous fixation with mini screws or Kirschner wires (K-wires) and open reduction with either pins or inter-fragmentary screw fixation [(9 & 10)].

## AIM OF THE WORK

The aim of this study was to evaluate the clinical outcome of patients with oblique and spiral phalangeal fracture managed with mini-screws fixation.

## PATIENTS AND METHODS

### Patients

During the period from January 2018 to January 2019, a total of 20 patients with oblique and spiral phalangeal fractures were treated by mini-screw fixation in the Department of Orthopedic Surgery of Al-Azhar University Male Hospitals, Cairo and Kafr El Dawar Hospital, Egypt. The 20 patients followed and constituted the basis of this prospective study. The shortest follow up period was six months, while the longest was twelve months with a mean follow up period of nine months. The fracture was open in four cases and the wound was about one cm and clean.



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**Ethical approval and written informed consent:**

**An approval of the study was obtained from Al- Azhar University academic and ethical committee.** Every patient signed an informed written consent for acceptance of the operation.

***1- Age incidence:***

The ages of the patients ranged from 19 to 46 years with a mean age of 33 years.

**Table (1):** Age incidence

| Age | No. of patients | Percentage |
|---|---|---|
| <20 | 1 | 5% |
| 20- <30 | 7 | 35% |
| 30-<40 | 7 | 35% |
| ≥40 | 5 | 25% |
| Total | 20 | 100% |

***2- Gender:***

There were 11 males and 9 females with male to female ratio 1.22: 1.

**Table (2):** Gender

| Gender | No. of patients | Percentage |
|---|---|---|
| Males | 11 | 55% |
| Females | 9 | 45% |
| Total | 20 | 100% |

***3- Side affected:***

The dominant hand was injured in 15 patients, while the non-dominant hand was injured in five patients.

**Table (3):** Side incidence

| Dominance | No. of patients | Percentage |
|---|---|---|
| Dominant | 15 | 75% |
| Non dominant | 5 | 25% |
| Total | 20 | 100% |

***4- Patient's occupation:***

Injuries occurred in manual workers (15 cases), followed by students (2 cases), and house wives (3 cases).

**Table (4):** Occupation

| Occupation | No. of patients | Percentage |
|---|---|---|
| Manual workers | 15 | 75% |
| Students | 2 | 10% |
| house wives | 3 | 15% |
| Total | 20 | 100% |

***5- Mechanism of injury:***

Most injuries occurred following Indirect trauma (15 cases), and following direct trauma (5cases).

**Table (5):** Mechanism of injury

| Mechanism of injury | No. of patients | Percentage |
|---|---|---|
| Indirect trauma | 15 | 75% |
| Direct trauma | 5 | 25% |
| Total | 20 | 100% |

***6- Special habits:***

Five patients were smokers with average 20 cigarettes per day, and the other 15 patients had no special habits.

**Methods**

***Patient Selection:***

**Inclusion criteria**:

***A- Age of the patient***

Skeletally mature patients (18 years or more).

***B- Type of the fracture***.

Displaced oblique and spiral phalangeal fracture.

***C- Timing of the surgery:***

All fractures will be treated within 10 days after trauma.

**Exclusion Criteria:**

1. Nondisplaced fractures.
2. Comminuted fractures.
3. Fractures associated with tendon injuries and/or significant neurovascular injuries.
4. High grade open fractures.
5. Fire arm injuries.

***Initial evaluation:***

On admission, first aid for fractures was done in the form of rest, ice, elevation. Then all patients were subjected to history taking and clinical examination with special emphasis on:

**Personal history:**

- Name, Age, Gender, Residency, special habits.
- Occupation and the level of physical activity
- Hand dominance.

**Present history:**

- Mechanism of injury.
- Duration of trauma.

**Past history:**

- History of medical problems.
- History of drug allergy.

***Clinical Examination:***

**General examination:**

Blood pressure, pulse, temperature, respiration and other body systems.

**Local examination:**

- Vascular and neurological assessment of the affected finger.
- Soft tissue condition (e.g. skin wound and tendon injury).

- Tenderness: on palpation the site of fracture and whether the range of motion is decreased due to pain especially during flexion and extension
- Deformity, swelling and subtle rotation can be detected by evaluating the patient's fist or semiflexed fingers.
- Abnormal mobility.

***Radiological evaluation:***

Anteroposterior, lateral, and oblique radiographs of the affected hand were done**.**

***Laboratory evaluation:***

Routine preoperative laboratory investigations were done (complete blood picture, liver function tests, kidney function tests, coagulation profile, and random blood sugar).

***Methods of treatment:***

**Operative Procedure:**

- ***Anesthesia*:** The procedure was performed under general anesthesia in ten patients, under local intravenous in ten patients.
- ***Intraoperative intravenous antibiotics***: one gm. of a broad-spectrum antibiotic was given 30 minutes prior to operation.
- The patient was placed in supine position.
- Free draping of the affected limb to above the elbow to allow easier manipulations and positioning of the hand.
- Pneumatic tourniquet was done in all cases.
- ***Operative technique*:** All patients were treated by open reduction and internal mini screw fixation (1.5-2.0 mm, Titanium).

**Operative steps:**

A dorsal longitudinal skin incision used only in three cases, while midaxial incision used in 17 cases. The fracture was approached through an incision creating an interval between the common extensor and the lateral band. Fracture reduction follows local debridment of haematoma and interposing of the soft tissue. Periosteal stripping limited to 1 or 2 mm was only enough to ensure anatomical reduction. Reduction forceps or k-wires provide temporary fixation. Pre drilling using 1.5 mm drill bit was done and then 1.5 or 2 mm self-tapping mini screws were inserted. The site of screws was planned according to fracture anatomy (perpendicular to fracture site).

The central slip and lateral band were re-approximated with absorbable running 4/0 sutures. The wound was closed with simple non absorbable interrupted 3/0 sutures and a dorsal slab was applied in a position of 90 degrees of MP flexion with IP extension. The PIP joints are held in nearly full extension.

***Postoperative Regimen and Rehabilitation:***

- Antero-posterior and oblique radiographs of the hand were taken, and were checked for reduction of the fracture.
- After surgery, The hand was immobilized for 7 days at which time the dorsal slab was changed to a custom removable splint to allow daily active and passive range of motion (ROM) exercises while ROM of the other fingers were begun from the first post operative day.
- Rehabilitation was guided by soft tissue condition, fracture stability, and the patient's pain tolerance.
- Protective splints were worn between exercise sessions and at night to protect the healing fracture.
- Physiotherapy was done to maintain joint range of motion, to reduce edema, to reduce pain and to maintain functional ability.
- Types of exercises in physiotherapy include, active exercise, passive physiological movements, passive stretching in cases of soft tissue adhesion and hot fomentation.
- The splint was discontinued when bony union was confirmed by radiograph.

***Follow up:***

- Patients were followed-up in the Outpatient Clinic every two weeks for clinical evaluation of finger ROM.
- Radiological assessment was done every month until union and then at six months at least for recording the final results.

***Methods of evaluation***

- **Clinical evaluation:**

***Subjective***:

After six months follow-up, patients were asked to flex and extend the joints of the affected finger and compare it with the normal side according to **TAM** score (total active motion) to evaluate and to score the functional outcome. All patients were asked about time of work.

***Objective assessment:***

**Grip strength** and **pinch strength** was measured by a modified sphygmomanometer. The data were compared with those of the opposite side. To exclude any discrepancy between dominant and non-dominant hand strength, the scores for analysis based on the equation proposed by ***Crosby et al.*** [11] stated that the pinch strength and grip strength are 5% and 6% higher on dominant sides compared with the non-dominant sides respectively.

1) The modified strength of the injured dominant hand = the measurement × (1 – percentage).
2) The modified strength of the injured non dominant hand = the measurement × (1 + percentage).

The modified scores were compared with the opposite sides.

**Active range of motion** (flexion–extension range of MP and IP joints) was measured by goniometer and compared to the other side.

***Radiological evaluation:***

Serial radiographs were evaluated for stability of fixation, reduction congruity of the articular surface, for the presence and the extent of a gap or a step, union, and deformity of the finger.

**Grading of the results**

The results were graded according to **TAM** score, functional, and radiological outcomes as follow:

**Functional**

**TAM** involves the sum of angles formed by the MP joints and the proximal and distal interphalangeal joints of the involved single digit in maximal active flexion minus the sum of the extension deficits of those joints. **TAM** is divided by the normal value, which is **260** degrees and expressed as a percentage.

- **Excellent:** TAM score (85-100% of normal), grip strength and pinch strength (90% - 100%) of the normal side.
- **Good:** TAM score (70%-84% of normal), grip strength and pinch strength (80-90%) of the normal side.
- **Fair:** TAM score (50%-69% of normal), grip strength and pinch strength (70-80%) of the normal side.
- **Poor:** TAM score (<50% of normal), grip strength and pinch strength (< 70%) of the normal side.

**Radiological**

All of the 20 fractures studied went on to bony union with no delayed union, or nonunion. Two cases had angulation about 10 degrees but no patient had rotational malunion. Specifically there was no loss of fixation or fracture alignment based on the comparison of intraoperative and immediate postoperative x-rays with final x-rays except in two cases who had 10 degrees of angulation deformity. The mean union healing time was 5 weeks (range 4 – 8 wk). Radiographic evidence of callus confirmed bony union.

- Excellent: angulation <5 degrees and no rotation
- Good: angulation (5-<10) degrees and no rotation
- Fair: angulation (10-15) degrees with/or without rotation
- Poor: angulation >15 degrees with rotation

**RESULTS**

**Functional Results:**

According to TAM score and clinical evaluation, the functional results were graded as excellent in 14 patients (70%), good in two (10%), fair in two (10%), and poor in two (10%). The excellent and good results were considered as satisfactory, while the unsatisfactory included the fair and the poor results. Thus, satisfactory results were achieved in 16 patients (80%), and the unsatisfactory were found in 4 patients (20%). Comparing the satisfactory results (80%) and the unsatisfactory (20), the results were statistically significant (p = 0.001) (table 6).

**Table (6):** The functional end results

| End results | No of patients | % |
|---|---|---|
| Excellent | 14 | 70 |
| Good | 2 | 10 |
| Fair | 2 | 10 |
| Poor | 2 | 10 |
| Total | 20 | 100 |
| $X^2$ | 32.189 | |
| P value | 0.001* | |

***1. The TAM score:***

The mean TAM score (as compared to the normal side) was 90.66% (range from 49% to100%) as shown in table (7).

**Table (7):** TAM score

| TAM score | No of patients | | % |
|---|---|---|---|
| 85%-100% (excellent) | 14 | | 70 |
| 70%-<85% (good) | 2 | | 10 |
| 50%-<70% (fair) | 2 | | 10 |
| <50% (poor) | 2 | | 10 |
| Total | 20 | | 100 |
| **Mean** | **Max** | **Min** | **SD** |
| 90.66% | 100% | 49% | 17.04 |

***2. Grip strength:***

According to grip strength (as compared to the normal side), the end results were graded from 90%-100% in 15 patients (75%), from 80%-< 90% in one patient (5%), from 70%-< 80% in two patients (10%) and < 70% in two patients (10%).The mean grip strength (as compared to the normal side) was 93.04% (range from 64.5% to100%) as shown in table (8).

**Table (8):** Grip Strength

| **Grip strength** | No of patients | | % |
|---|---|---|---|
| 90% - 100%(excellent) | 15 | | 75 |
| 80%-<90% (good) | 1 | | 5 |
| 70%-<80% (fair) | 2 | | 10 |
| <70% (poor) | 2 | | 10 |
| Total | 20 | | 100 |
| **Mean** | **Max** | **Min** | **SD** |
| 93.04% | 100% | 64.5% | 11.51 |

***3. Pinch strength:***

According to pinch strength (as compared to the normal side), the end results were graded from 90% - 100% in 15 patients (75%), from 80%-< 90% in two patients (10%), from 70%-< 80%) in two patients (10%) and < 70% in one patient (5%). The mean

pinch strength (as compared to the normal side) was 93.9% (range from 69.77% to 100%) as shown in table (9).

**Table (9):** Pinch Strength

| **Pinch strength** | No of patients | | % |
|---|---|---|---|
| 90% - 100%(excellent) | 15 | | 75 |
| 80%-<90% (good) | 2 | | 10 |
| 70%-<80% (fair) | 2 | | 10 |
| <70% (poor) | 1 | | 5 |
| Total | 20 | | 100 |
| **Mean** | **Max** | **Min** | **SD** |
| 93.94% | 100% | 69.77% | 9.57 |

***4. Pain:***

15 patients (75%) had no pain, while the other five patients (25%) had mild pain. This was statistically significant (p = 0.001) as shown in table (10).

**Table (10):** The pain

| **Pain** | **Number of patients** | **%** |
|---|---|---|
| **No** | 15 | 75% |
| **Mild** | 5 | 25% |
| **Total** | 20 | 100% |
| **$X^2$** | 11.523 | |
| **P value** | 0.001* | |

***5. Time off work:***

Patients returned to work after a mean of 3.8 weeks (range from 2 to 8 week) as shown in table (11).

**Table (11):** Off **w**ork time

| Time off work | No. of patients | Percentage | |
|---|---|---|---|
| 2weeks | 4 | 20% | |
| >2 - 4 weeks | 13 | 65% | |
| >4 - 6 weeks | 2 | 10% | |
| >6 - 8 weeks | 1 | 5% | |
| Total | 20 | 100% | |
| **Mean** | **Max** | **Min** | **SD** |
| 3.81 w | 8 w | 2 w | 1.47 |

**Radiological results:**

According to radiological evaluation the results were graded as excellent in 18 patients (90%), and fair in two patients (10%). Comparing the satisfactory and non satisfactory results, it was statistically significant (p = 0.001) as shown in table (12).

**Table (12):** Radiological end results

| End results | No of patients | % |
|---|---|---|
| Excellent | 18 | 90% |
| Fair | 2 | 10% |
| Total | 20 | 100% |
| $X^2$ | 27.518 | |
| P value | 0.001* | |

***1. Articular surface congruity:***

Reduction with no joint surface step was achieved in all cases in which the fracture was intra-articular. This was statistically significant (p = 0.001) as shown in table (13).

**Table (13):** Articular surface step

| Articular surface step | N | % |
|---|---|---|
| Yes | 0 | 0 |
| No | 20 | 100 |
| Total | 20 | 100 |
| $X^2$ | 42.0 | |
| P value | 0.001* | |

***2. Angulation deformity:***

On the final radiological examination, there were only two cases that showed angulation 10 degrees. This was statistically significant (p = 0.001) (Table 14).

**Table (14):** Angulation deformity

| Angulation | No of patients | % |
|---|---|---|
| No | 18 | 90% |
| Yes | 2 | 10% |
| Total | 20 | 100% |
| $X^2$ | 27.518 | |
| P value | 0.001* | |

***3. Rotation deformity:***

On the final radiological examination, there was no rotation deformity in any case. This was statistically significant (p = 0.001) (Table 15).

**Table (15):** Rotation deformity

| Rotation | N | % |
|---|---|---|
| Yes | 0 | 0 |
| No | 20 | 100 |
| Total | 20 | 100 |
| $X^2$ | 42.0 | |
| P value | 0.001* | |

***4. Time to union:***

Radiological union of the fracture was achieved in all cases (100%) at a mean time of five weeks (range from 4 to 8 weeks) as shown in table (16).

**Table (16):** Time to union

| No. of patients | Time to union | Percentage | |
|---|---|---|---|
| 14 | 4weeks | 70% | |
| 3 | >4 - 6 weeks | 15% | |
| 3 | >6- 8 weeks | 15% | |
| 20 | Total | 100% | |
| **Mean** | **Max** | **Min** | **SD** |
| 5 w | 8 w | 4 w | 1.48 |

**Factors Affecting the Results**

***1. Age and the end results:***

The mean age of patients with excellent results was 29 years and that of patients with good results was 40 years, while the mean age in patients with fair results was 32.5 years and the mean age in patients with poor results was 40.5 years. Studying the relation between different age groups, the result was statistically insignificant (p = 0.138) (Table 17).

**Table (17):** Age and the end results

| Age | Excellent | Good | Fair | Poor |
|---|---|---|---|---|
| **Range** | 19 – 46 | 38 – 42 | 25 – 40 | 37 – 44 |
| **Mean ± SD** | 29.0 ± 8.2 | 40.0 ± 2.8 | 32.5 ± 10.6 | 40.5 ± 4.9 |
| **F test** | 2.101 | | | |
| **P value** | 0.138 | | | |

***2. Smoking and functional end results:***

In this study, there were five smokers, three of them had excellent results, one had good results and one had poor results. Studying the relation between smoking and the final end results showed to be statistically insignificant (p = 0.079) (Table 18).

**Table (18):** Smoking and functional end results

| Smoking | | Excellent | Good | Fair | Poor | Total |
|---|---|---|---|---|---|---|
| **No** | **N** | 12 | 0 | 2 | 1 | 15 |
| | **%** | 80.0% | 0% | 13.33% | 6.66% | 100% |
| **Yes** | **N** | 3 | 1 | 0 | 1 | 5 |
| | **%** | 60% | 20% | 0% | 20% | 100% |
| **Chi-square** | **$X^2$** | 6.790 | | | | |
| | **P-value** | 0.079 | | | | |

***3. Smoking and time to union:***

The mean time required for fracture union was seven weeks in smokers and 4.2 weeks in non smokers. Studying the relation between smoking and the time required for fracture union showed to be statistically significant (p = 0.001) as shown in table (19).

**Table (19):** Smoking and time to union:

| Time of union | Smoking | |
|---|---|---|
| | **No** | **Yes** |
| **Range** | 4 – 6 week | 6 – 8 week |
| **Mean + SD** | 4.20 ± 0.56 | 7.0 ± 1.09 |
| **T. test** | 21.385 | |
| **P. value** | 0.001 | |

***4. Hand dominance and functional end results:***

Studying the relation between hand dominance and the functional end results showed to be statistically significant (p = 0.034**).** Dominant hands achieved more excellent and good functional end results than non-dominant (Table 20).

**Table (20):** Hand dominance and functional end results

| Hand dominance | | Excellent | Good | Fair | Poor | Total |
|---|---|---|---|---|---|---|
| **Dominant** | **N** | 13 | 1 | 1 | 0 | 15 |
| | **%** | 86.66% | 6.66% | 6.66% | 0.0% | 100% |
| **Non dominant** | **N** | 2 | 0 | 1 | 2 | 5 |
| | **%** | 40% | 0.0% | 20% | 40% | 100% |
| **Chi-square** | **$X^2$** | 8.694 | | | | |
| | **P-value** | 0.034* | | | | |

***5. Occupation and the functional end results:***

Occupation had no statistically significance correlation with functional end results (p = 0.650) (Table 21).

**Table (21):** Occupation and the functional end results

| Occupation | | Excellent | Good | Fair | Poor | Total |
|---|---|---|---|---|---|---|
| Manual work | N | 10 | 2 | 2 | 1 | 15 |
| | % | 66.66% | 13.33% | 13.33% | 6.66% | 100% |
| House wife | N | 2 | 0 | 0 | 1 | 3 |
| | % | 66.66% | 0% | 0% | 33.33% | 100% |
| Student | N | 2 | 0 | 0 | 0 | 2 |
| | % | 100% | 0% | 0% | 0% | 100% |
| Chi-square | $X^2$ | 4.200 | | | | |
| | P-value | 0.650 | | | | |

***6. Correlation between radiological and functional scores:***

Studying the relation between radiological and functional end results showed it to be statistically significant (p = 0.024) (Table 22).

**Table (22):** Radiological and the functional end results

| Radiological Functional | | Excellent | Good | Fair | Poor | Total |
|---|---|---|---|---|---|---|
| Excellent | N | 15 | 1 | 1 | 1 | 18 |
| | % | 83.33% | 5.55% | 5.55% | 5.55% | 100.0% |
| Fair | N | 0 | 0 | 1 | 1 | 2 |
| | % | 0.0% | 0.0% | 50.0% | 50.0% | 100.0% |
| Total | N | 15 | 1 | 2 | 2 | 20 |
| | % | 75.0% | 5% | 10% | 10% | 100.0% |
| Chi-square | $X^2$ | 9.394 | | | | |
| | P-value | 0.024* | | | | |

## DISCUSSION

Phalangeal fractures are the most common fractures in the upper limb. Spiral and oblique fractures are common type of these fractures. Spiral and long oblique fractures tend to rotate along a longitudinal axis, whereas short oblique fractures may rotate or angulate or both [(12)]. Physicians must always bear in mind that stiffness, angular or rotational deformities affect the function of not only the involved digit but also adjacent digits as well as overall hand performance [(13)].

In this study, two patients had intra-articular fractures, while the other 18 had non articular fractures. Three patients had a middle phalangeal fractures, while the other 17 had a proximal phalangeal fractures. The average age of the patients was 33 years, ranging from 19 to 46 years. The shortest follow up period was six months, while the longest was ten months with a mean follow up period of eight months.

In the present study, male to female ratio was 1.22:1 (55% were males and 45% were females), Patients' age ranged from 19 to 46 years with a mean age of 33 years and dominant hand was injured in 75% of patients while 25% of injuries were in non-dominant hand. In the study of **Rajesh and Ip [(14)]** on 32 patients with proximal phalangeal fractures in the department of Orthopedic and Traumatology, University of Hong Kong, Queen Mary Hospital. Patients' age ranged from 12 to 74 years with a mean age of 38.8 years, there were 24 patients aged ≤50 years and 8 patients aged >50 years, 10 had dominant hand injuries and 22 had non-dominant hand injuries, and 20 patients were males while other twelve were females. **Hill and Riaz** [(15)] in a study of 4873 phalangeal fractures showed that the male:female ratio was 2:1, the age group for injury was 21– 40 years with a mean age of 26.4 years, and the dominant hand was more commonly injured, the dominant to non-dominant ratio was 1.5:1. These results were nearly similar to our study.

In the present study, 75% of patients were manual workers and 71.4% of injuries occurred following fall on the hand. In a prospective study of 924 phalangeal fractures described by the group of Chow from Hong Kong, 67.3% of patients were manual workers. **De Jonge *et al.*[(16)]** noted in a study of 6857 phalangeal fractures of the hand that fall on the hand was the main cause of fracture in the age between 10-29 years due to sport and accidental fall, which is in agreement with our results.

In the present study, only three patients had a spiral fracture, while the other 17 patients had an oblique fracture, two patients (10%) had intra-articular fractures, while the other 18 (90%) had non-articular fractures. **Feehan and Sameul [(17)]** in a study on 310 phalangeal fractures noted that 72% were non-

articular fractures, whereas, 28% were intra-articular fractures. **Butt** [18] noted that spiral and oblique phalangeal fractures are common in adult males and manual workers due to higher physical activities which increase the risk of exposure to causative trauma and most injuries occur following fall on the hand. Both results are in accordance with our results.

In this study most patients (80.0%) had a satisfactory functional end result with a mean TAM score 90.66%. **Nalbantoğlu *et al.*** [19] in a study on 18 phalangeal fractures treated by mini screws and plates, the functional outcome after fracture treatment was assessed by calculating TAM score. The final end result were 72.7% excellent in the group treated with mini screws, and the mean grip strength was 92.5%. **Gupta *et al.*** [20] in a prospective study on 45 phalangeal fractures were reduced using various techniques including conservative, K- wires, and mini screws. The functional outcome after fracture treatment was assessed by calculating TAM score, the final end result were 92% excellent in the group treated with mini screws. These results are concomitant with our results.

In the present study, 80% of patients had a satisfactory hand function with mean grip strength 93.04% and mean pinch strength 93.94% as compared to the other side. According to the results of the present and previous studies, a good functional outcome regarding the grip and pinch strength can be achieved with screw fixation. This is again attributed to perfect reduction, rigid internal fixation, and rapid union, which allowed early rehabilitation and early return to work. In the present study, union occurred in all cases. **Roth *et al.*** [21] in a study on 37 patients with oblique and spiral phalangeal fractures all treated by ORIF with mini screws, all of the 37 fractures studied had bony union with no delayed union, malunion, or loss of fixation. In a study of **Nalbantoğlu *et al.*** [19] in a study on 18 phalangeal fractures treated by mini screws and plates, union was obtained in all patients with no delayed union, malunion, or loss of fixation, and the mean grip strength was 92.5% in the group treated with mini screws. All of these results are in agreement with our results. **Buchler and Gupta** [22] noted that greater degrees of malrotation and angulation result in functional impairment and diminished grip and pinch strength.

In the present study, angular deformity occurred in only two cases due to comminution occurred intraoperative and rotational deformity not found in any case. This can be attributed to perfect reduction and more stability provided by screw fixation.

In the present study, patients regained normal hand activities and returned to their work at a mean of 3.8 weeks post-operative (range from two to eight weeks). Early return to work and normal hand activities was attributed to two factors. The first is the rapid achievement of union, as the screws fixation allow compression at the fracture site. The mean time to union in this study was five weeks (range from four to eight weeks). The second factor is the early range of motion. In this study all cases started range of motion one week after surgery when the splint was removed. This is because of the relatively rigid screw fixation, which provides adequate fracture stability allowing the early range of motion. Contrary to the traditionally used k-wires in previous studies, which must be removed 3 to 4 weeks after insertion where fixation is inheritantly unstable enough to allow early active exercise.

Pain is a potential sequelae of phalangeal fractures and fractures of the MP and IP joints [23]. In the present study, 15 patients (75%) had no pain, while the other five patients (25%) had mild pain during heavy manual work**.** The pain was found in one patient with articular fractures and in four patients in which fractures fixed by prominent and too long screws.

In this study, there was significant correlation between radiological and functional end results. This reflects the importance of anatomical reduction in the treatment of oblique and spiral fracture. One patient had poor functional results but he had reported excellent radiological result. This may reflect that the poor functional result was due to tendon adhesions, capsular contracture and immobilization for long time and not due to improper reduction or fixation. This because the patient was not compliant to the rehabilitation instructions as mentioned before. Our results are in accordance with the results of **Roth *et al.*** [21] in a study on 37 patients with oblique and spiral phalangeal fractures all treated by ORIF with mini screws, noted that stiffness occured in two cases, and was due to tendon adhesion and capsular contracture so after tenolysis and capsular release they regained the range of motion.

Many methods for treating spiral and oblique fractures have been described and the treatment results of these methods have been evaluated [9 & 10]. It was found that open reduction and rigid internal fixation by mini screws results in excellent outcome. In our study, excellent results were found in 70%. Excellent results (92%) also were reported by **Roth *et al.*** [21] in the study on 37 patients and excellent results (72.2%) also were reported by **Nalbantoğlu *et al.*** [19] in the study on 17 patients. In addition, **Gupta *et al.*** [20] in the study on 45 patients treated by many methods of fixation, noted that 92% excellent in the group treated with mini screws, 60% excellent in the group treated with k-wires, and 55% excellent in the group treated conservatively. **Pun *et al.*** [24] prospectively, reported on 109 unstable digital fractures treated with K-wires fixation, Nearly 70% had a fair and poor results. These unsatisfactory results because K-wires do not provide stable fixation, so cast or splint is necessary for long time, which may result in stiffness and the longitudinal K-wires does not provide rotational

stability. Besides, crossed K-wires may distract the fracture, while screws fixation enhance stability by using the lag technique to achieve interfragmentary compression and rotational stability.

According to the results of the present and previous studies, a good functional outcome, regarding range of motion, fracture union, grip, and pinch strength can be achieved with screw fixation in treating oblique and spiral phalangeal fracture. This is again attributed to both relatively rigid internal fixation and rapid union, which allows early range of motion which is the key to a good functional outcome.

**Complication:**

In the present study angular deformity was found in two cases where comminution occurred intraoperative. Infection either superficial or deep, neuro-vascular injuries, or delayed union were not recorded in any case. In the study of **Gupta *et al.*** [20], they reported complications in patients treated by k-wires as finger stiffness (15.56%) sand angular deformity (7%) were reported at fracture site as the k-wire was removed four weeks postoperatively before union. **Ikuta and Tsuge**[25] at 1974 reported that distraction with crossed k-wires fixation using two wires was responsible for delayed union in 20% 0f patients.

## CONCLUSION

- Mini screw fixation offers an effective, simple and reliable method for treatment of oblique and spiral fracture with low incidence of complication.
- Satisfactory functional outcomes usually follow anatomical reduction. Surgeons must pay all effort to obtain anatomical reduction.
- Stable internal fixation by mini screws allows early range of motion which is the key to a good functional outcome.

## REFERENCES


1. **Dean BJF, Little C (2011):** Fractures of the metacarpals and phalanges. Orthop Trauma, 25 (1): 43–56.
2. **Shin EK (1980):** Hand Fractures and joint injuries. In: Skirven TM, Osterman LA, Fedorczyk JM, Amadio PC, editors. Rehabilitation of the Hand and Upper Extremity. 6th ed. Philadelphia: Elsevier Mosby, Pp: 351.
3. **Emmett JE, Breck LW (1958):** A review and analysis of 11,000 fractures seen in a private practice of orthopaedic surgery, 1937-1956. J Bone Joint Surg Am., 40 (5): 1169–75.
4. **Stanton JS, Dias JJ, Burke FD (2007):** Fractures of the tubular bones of the hand. J Hand Surg Eur., 32 (6): 626–36.
5. **Burkhalter WE, Reyes FA (1984):** Closed treatment of fractures of the hand. Bull Hosp Jt Dis Orthop Inst., 44 (2): 145–62.
6. **Swanson AB (1970):** Fractures involving the digits of the hand. Orthop Clin North Am., 1 (2): 261–74.
7. **Melone CP (1986):** Rigid fixation of phalangeal and metacarpal fractures. Orthop Clin North Am., 17 (3): 421–35.
8. **Wong H, Lam C (2008):** Treatment of phalangeal and metacarpal fractures: a review. J Orthop Surg., 10 (1): 42–50.
9. **Geissler WB (2006):** Cannulated percutaneous fixation of intra-articular hand fractures. Hand Clin., 22 (3): 297–305.
10. **Alan E (2013):** Freeland GW. Percutaneous Mini Screw Fixation of Phalangeal and Metacarpal Fractures. In: Capo JT T V, editor. Atlas of Minimally Invasive Hand and Wrist Surgery. 4th ed. New York: Inform a Healthcare USA, Inc., Pp: 45–54.
11. **Crosby CA, Wehbé MA, Mawr B (1994):** Hand strength: normative values. J Hand Surg Am., 19 (4): 665–70.
12. **Kreiger N, Kelsey JL, Harris C *et al.* (1981):** Injuries to the upper extremity: patterns of occurrence. Clin Plast Surg., 8 (1): 13–9.
13. **Moberg E, Stener B (1953):** Injuries to the ligaments of the thumb and fingers; diagnosis, treatment and prognosis. Acta Chir Scand., 106 (2-3): 166–86.
14. **Rajesh G, Ip WY, Chow SP *et al.* (2007):** Dynamic treatment for proximal phalangeal fracture of the hand. J Orthop Surg (Hong Kong), 15 (2): 211–5.
15. **Hill C, Riaz M, Mozzam A *et al.* (1998):** A regional audit of hand and wrist injuries. A study of 4873 injuries. J Hand Surg Br., 23 (2): 196–200.
16. **De Jonge JJ, Kingma J, van der Lei B *et al.* (1994):** Phalangeal fractures of the hand. An analysis of gender and age-related incidence and aetiology. J Hand Surg Br., 19 (2): 168–70.
17. **Feehan LM, Sheps SB (2006):** Incidence and demographics of hand fractures in British Columbia, Canada: a population-based study. J Hand Surg Am., 31 (7): 1068–74.
18. **Butt WD (1962):** Fractures of the hand. I. Description. Can Med Assoc J., 86: 731–5.
19. **Nalbantoğlu U, Gereli A, Cilli F *et al.* (2009):** Open reduction and low-profile plate and/or screw fixation in the treatment of phalangeal fractures. Acta Orthop Traumatol Turc., 43 (4): 317–23.
20. **Gupta R, Singh R, Siwach R *et al.* (2007):** Evaluation of surgical stabilization of metacarpal and phalangeal fractures of hand. Indian J Orthop., 41 (3): 224–9.
21. **Roth JJ, Auerbach DM (2005):** Fixation of hand fractures with bicortical screws. J Hand Surg Am., 30 (1): 151–3.
22. **Büchler U, Gupta A, Ruf S (1996):** Corrective osteotomy for post-traumatic malunion of the phalanges in the hand. J Hand Surg Br., 21 (1): 33–42.
23. **Lisa PD (2004):** Intraarticular Injuries of the Metacarpophalangeal and Carpometacarpal Joints. In: Richard A A-PC, editor. Hand Surgery. Philadelphia: Lippincott Williams & Wilkins, Pp: 176–91.
24. **Pun WK, Chow SP, So YC *et al.* (1989):** A prospective study on 284 digital fractures of the hand. J Hand Surg Am., 14 (3): 474–81.
25. **Ikuta Y, Tsuge K (1974):** Micro-bolts and micro-screws for fixation of small bones in the hand. Hand, 6 (3): 261–5.