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Evaluation of AO Titanium Locking Plate and Screw Fixation for Isolated Unstable Metacarpal and Phalangeal Fractures

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Abstract
Arbeitsgemeinschaft-osteosynthesefragen (AO) mini-fragment screws and plates, when used in properly selected cases, can provide rigid fixation, allowing early mobilization of joints and hence good functional results while avoiding problems associated with protruding K-wires and immobilization. This study was conducted at government medical college after getting permission from hospital ethics committee, includes 30 patients of which 20 were males and 10 were females. The average age was 30.4 years. Twenty fractures were fixed with miniature plates and 10 with interfragmentary lag screws. The right hand was involved in 22 cases. There were 15 metacarpal, 9 proximal phalangeal, and 6 middle phalangeal fractures. The distribution of the above fractures was as follows: thumb ray 7, index ray 9, middle ray 3, ring ray 6, and little ray 5. Mechanism of injury included fall(11), direct blow(3) and traffic accident(16).There were transverse(7), oblique(11), spiral(6), intraarticular(4), and 2 were comminuted. All the fractures were closed. These patients were evaluated post operatively for 3,6 months and one year. All of them presented improvement in their clinical and functional parameters regarding the variables of range of motion (ROM), visual analog scale (VAS) score, Grip strength value(%) and DASH (Disability of the Arm, Shoulder and Hand) score. All the patients achieved improved quality of life and returned to work, with significant decreases in their DASH questionnaire scores (14-2). There was an improvement in pain, with decreases in their VAS scores (2-0). This technique provides a highly rigid fixation, which is sufficient to allow early mobilization of the adjacent joints, thus helping to achieve good functional results.

Keywords: *AO Screws and plates, unstable, metacarpal, phalangyeal, fracutes and fixation.*

Introduction

Metacarpal and phalangeal fractures account for 17.2%–21.3% of all fractures in adults and >30% of all hand injuries[1,2]. In most cases, favorable clinical outcomes can be obtained with conservative treatment. However, treatment of markedly displaced, irreducible and rotational fractures can be challenging for surgeons and can lead to impaired function and restricted range of motion.

Improvement of materials and techniques has enabled surgeons to choose many methods for fixation of hand fractures. The various techniques available to treat unstable phalangeal and metacarpal fractures include: (1) percutaneous Kirschner-wire (K-wire) fixation, (2) external fixation, and (3) open reduction with internal fixation using various techniques and devices[1]. Because these methods of treatment have their advantages and disadvantages, there is uncertainty regarding what is the best way to treat hand fractures. In clinical situations, the choice of fixation technique depends on: (1) the location and geometry of the fractures, (2) associated injuries, (3) patient factors, and most importantly, (4) the preference and experience of the surgeon. The operative goal is to achieve adequate reduction and rigid fixation that will allow early digital mobilization in order to avoid permanent deformity and stiffness[3].

AO mini-fragment screws and plates, when used in properly selected cases, can provide rigid fixation, allowing early mobilization of joints and hence good functional results while avoiding problems associated with protruding K-wires and immobilization[4-5]. Hence the study was conducted to evaluate functional outcome of AO mini-fragment screws and plates fixation for isolated unstable metacarpal and phalangeal fractures

Material and Methods

A fracture was considered as unstable if it was irreducible, if acceptable reduction could not be maintained, and/or motion at the adjacent joints could not be started without loss of reduction.[6] Certain fracture patterns like displaced transverse, long spiral and short oblique fractures as well as displaced articular condyle fractures with >25% articular surface involvement were recognized as inherently unstable and were selected for surgery if they met the above criteria for instability.

The operations were performed with tourniquet hemostasis under brachial plexus block or local anesthesia and a longitudinal dorsal approach was used. The fracture line was exposed by retracting the extensor tendons bilaterally for metacarpal fractures and by an extensor tendon-splitting incision for phalangeal fractures. After elevating the periosteum, the fracture site was exposed and the fracture reduced and stabilized with an AO miniplate using appropriately sized screws (1.2–2.0 mm). Postoperative immobilization was not required in patients without tendon or nerve impairment. In patients who had undergone tendon or nerve repair, immobilization was achieved with external fixation with a plaster cast for 3 weeks. Passive motion was started on the second postoperative day and active movement in the third postoperative week. Patients were allowed to resume activities of daily living only after bony union had been observed on follow-up plain radiographs.

Patients underwent follow-up examinations at 1 week, 3 months, 6 months and 1 year postoperatively. The variables assessed included total ROM of the finger, grip strength and Quick-DASH scores. Total ROM of the finger is expressed as the sum of movement range in each joint: metacarpophalangeal (MP) joint (normal, 0_–85_), proximal interphalangeal (PIP) joint (0_–110_) and distal interphalangeal (DIP) joint (0_–65_)[7] Using a Jamar Hydraulic Hand Dynamometer the grip strength of the involved finger was measured by having the patient squeeze the handle of the dynamometer maximally. The grip strength of the corresponding finger in the contralateral, uninjured hand was measured and grip strength calculated as a percentage of that of the contralateral hand[8]. DASH disability/symptom score range of responses was from 0 to 100, higher scores indicating greater patient disability[9]. At each follow-up evaluation, pain during daily activities was assessed using a VAS scale, 0 indicating no pain and 10 the most severe pain. SPSS for Windows, Version 16.0 (SPSS, Chicago, IL, USA) was used for analysis and modeling of the data.

Results

This study includes 30 patients of average age 30.4 years, includes 20 males and 10 females. Twenty

fractures were fixed with miniature plates and 10 with interfragmentary lag screws.

Table 1: Fracture location

Fracture location	No of patient
Metacarpal	15
proximal phalangeal	9
Middle phalangeal	6

Table 2: Distribution of fracture

Distribution of fracture	No of patient
thumb ray	7
Index ray	9
Middle ray	3
Ring ray	6
Little ray	5

Table 3: Fracture cause

Fracture cause	No of patient
Road accidents	16
Falling	11
Direct blow	3

Table 4:

Type of fracture	No of patient
Transverse	7
Oblique	11
Spiral	6
Intra articular	4
comminuted	2

Table 5: Clinical outcome

Clinical variable	Mean
after 3 months	
TROM	221
VAS	2
Grip strength value	76%
Quick-DSAH	14
after 6 months	
TROM	241
VAS	0
Grip strength value	94%
Quick-DSAH	4
after 1 year	
TROM	243
VAS	0
Grip strength value	97%
Quick-DSAH	2

All of them presented improvement in their clinical and functional parameters and there were improvements in their results regarding the variables of range of motion (ROM), visual analog scale (VAS) score, Grip strength value(%) and DASH (Disability of the Arm, Shoulder and Hand) score. All the patients achieved improved quality of life and returned to work, with significant decreases in their DASH questionnaire scores. There was an improvement in pain, with decreases in their VAS scores.

In comparing the clinical and functional results with those of the unaffected side (range of motion, DASH and VAS), we observed that there was no statistically significant difference between the values analysed, which showed that functional recovery of the fingers affected had been achieved.

All fractures had united consistently.

The complications like 2 cases of superficial wound infection, one case of deep infection and one cases of residual deformity attributed to fracture comminution. The case of deep infection was treated by antibiotics and implant removal at three months when radiological union was demonstrated. The implant was removed in 12 cases, which included 8 mini-plates and 2 interfragmentary lag screws. In one case, the indication for removal was deep infection while the rest had local tenderness over implant. In all other cases, the implant was removed after six months.

Discussion

Intramedullary fixation has been a classical procedure for treating metacarpal and phalangeal fractures; various techniques and types of instrumentation have been proposed to improve postoperative functional recovery and ROM. These include various forms of Kirschner wire pinning[10], extramedullary fixation with plates and screws[11], and external fixation[12].

In recent years, fixation with *Arbeitsgemeinschaft für Osteosynthesefragen* (AO) titanium locking plate and screws (ATLPS) has been used to treat unstable metacarpal and phalangeal fractures and has yielded favorable clinical outcomes. In the literature, several studies have reported satisfactory results with internalfixation of unstable metacarpal and phalangeal fractures using AO mini-plates and screws[4,6,10]

Omokawa *et al.*[13] conducted a prospective study to evaluate clinical results of miniature titanium plate for open reduction and internal fixation of unstable metaphyseal fractures of the metacarpal and phalangeal bones With 55 patients and a minimum follow up of 1 year, 5 patients developed complications, including fracture redisplacement, collapse or absorption of the condylar head and superficial infection; and the objective outcomes were reasonable. Trevisan and co-workers[14] used AO mini-plates and screws to treat low severity metacarpal and phalangeal fractures and achieved fracture reduction in 94.6% of patients; however, by the final check-up approximately half the patients had developed one or more complications.

A biomechanical study by Fyfe and Mason[15] to evaluate the rigidity of various modes of internal fixation showed that AO mini-plates and screws and IO wiring produced much stronger stabilization than K-wires. A similar study by Black[16] concluded that dorsal plating with or without lag screws provided significantly more stability than K-wires/IO wiring. Agarwal[17] in a more recent prospective review of 20 hand fractures treated with a new ultra low profile plating system, in which 0.6-mm-profile-height plates were used for both metacarpals (11 cases) and phalanges (9cases), reported very favorable results, with no incidence of plate failure.

A study to compared the clinical and radiologic outcomes of AO titanium locking plate and screw (ATLPS) and anterograde intramedullary (AIM) fixation for treating unstable metacarpal and phalangeal fractures. At 3-month follow-up, all clinical outcomes were significantly better in the AIM than ATLPS group except for VAS pain scores. However, at 6-month follow-up, the differences were no longer significant, indicating similar results for both types of fixation. Patients in the AIM group developed significantly more complications[18]. Fujitani et al. compared the outcomes of AIM with those of a low-profile miniplate for treatment of fifth metacarpal neck fractures and found that total ROM of the fifth finger was better in the AIM group at 3 months but not at 6 months[19]. In a study by Ozer et al. of treatments for extra-articular metacarpal fracture, slightly greater total ROM was observed in the AIM group than in the plate-and-screws group however, this difference was not significant[20].

There was a case of finger stiffness, required surgical revision and post operative rehabilitation. This mobility deficit is attributable not only to the extensive surgical incision, but also to the extensor apparatus and adhesions to the adjacent joint. Page and Stern In their study encountered extensor tendon rupture and other complications that they attributed not only to the non-locking design of the plates, but also to the frequent use of plates in open phalangeal fractures. In some studies malunion requiring revision was encountered, head necrosis, neurologic and extensor ligament complications, plate loosening or breakage were noted [21,22, 23].

Therefore, AO titanium lacking plate and screw fixation may be a better alternative for those who require immediate mobility and return to previous work, especially manual workers with specialized skills.

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