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REVIEW ARTICLE

# Decision Making in Management of Proximal Fifth Metatarsal Fracture: A Short Review

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## *ABSTRAK*

*Tulang metatarsal kelima adalah antara tulang kaki yang paling kerap mengalami patah. Pilihan perawatan sama ada melalui pembedahan ataupun konservatif masih dalam perbincangan. Sistem skor, model pilihan analisis dan sistem klasifikasi telah dibentuk untuk membantu membuat pilihan terbaik sama ada perawatan melalui pembedahan ataupun konservatif. Anatomi yang unik dan komplikasi pembedahan mempengaruhi strategi perawatan pembedahan. Oleh itu, artikel ini cuba melihat faktor-faktor yang mempengaruhi perawatan patah tulang metatarsal kelima.*

*Kata kunci: pilihan perawatan, tulang metatarsal, tulang patah*

## ABSTRACT

Fifth metatarsal bone fracture is one of the most commonest fractures of the foot. The decision for surgical or conservative approach is still inconclusive. Scoring system, decision analysis model and classification system are established to weigh between surgical and conservation approaches. Its unique anatomy and surgical complication influence decision on optimal surgical approach. Therefore, the present review attempts to look at factors that might influence decision making in management of fifth metatarsal fracture.

Keywords: bone fracture, decision making, metatarsal bones

## INTRODUCTION

The metatarsals are the intermediate long bones of the foot. Metatarsal fractures denote 5-6 % of fractures faced in the health care centres (Hatch & Rosenbaum 1994). Among five metatarsals, the first, second and fifth are frequently injured metatarsal bones

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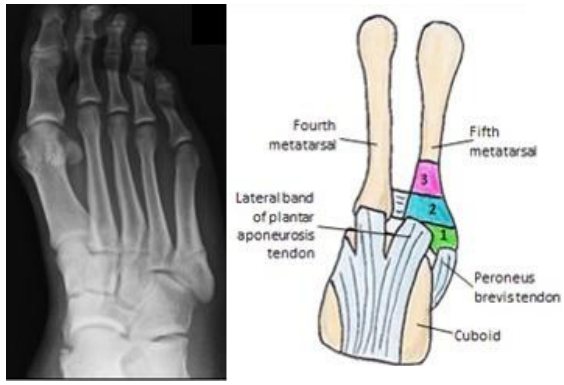


(a) (b)

Figure 1: a) Radiograph of fifth metatarsal fracture (Tan et al. 2016). b) Diagram of fifth metatarsal showing related tendons and fractures' zones

of the foot. However, the fifth metatarsal (5th MT) bone accounts for the highest incidences of fracture in any sports. With the increase awareness of sports in general population, the number of participants is increasing alarmingly.

The anatomy of the 5th MT reflects its fracture pattern. The 5th MTis located at the lateral side of the foot (Dameron 1975). This bone comprises base, a shaft, a neck and a head. The tuberosity is the expanded part of the base of the bone. Fractures of the base of the 5th MT are one of the most commonest injuries of the foot (De Lee 1996). The tuberosity of the 5th MT protrudes laterally, while the tendon of peroneus brevis and the lateral band of the plantar aponeurosis are inserted to the tuberosity (Figure 1). These strong ligaments make the proximal part of 5th MT fixed while it's distal part relatively mobile. Hence, in fracture, it creates instability and may predispose to poor fracture healing.

Increased motion results from increased contraction of the peroneus brevis tendon and lateral band of the plantar aponeurosis in acute inversion of the foot lead to the fracture of the tuberosity of the 5th MT bone. This type of fracture accounts for majority of proximal fractures (Theodorou et al. 2003).

Tuberosity of 5th MT receives blood supply from metaphyseal vessel that penetrates the non-articular surfaces. The proximal diaphysis of 5th MT receives blood from nutrient artery. In area just distal to the tuberosity, the longitudinal branches of the diaphysis artery join the metaphyseal vessel that gives rise to the watershed area. This creates an area that relatively has poor blood supply. Hence, it is associated with poor fracture healing and may complicate with delayed union or non-union (Smith et al. 1993).

Three different fractures occur in the base of 5th MT bones namely zone 1, zone 2 and zone 3. Zone 1 represents the fracture that occurs at the tip of the base (tuberosity) of 5th MT. This type of fracture is also known as avulsion fracture. Zone 2 fracture or Jones fracture occurs in between the base and the shaft of the 5th MT. Zone 3 fracture occurs at the distal to the shaft

of the 5th MT (Lawrence & Botte 1993) (Figure 1).

Depending on the type of fracture that occurs in the 5th MT bone, several non-operative and operative procedures were carried out. In addition, the outcomes and complications that arose from each therapeutic intervention were also widely discussed in the earlier studies (Kavanuagh et al. 1978; Sides et al. 2006; Kelly et al. 2001). However, the detailed benefits and impediments of both procedures related to 5th MT bone fracture were not reviewed, to date. Therefore, the present review attempts to look at the factors that might influence in decision making management of 5th MT fracture.

## SCORING SYSTEM, DECISION ANALYSIS MODELAND NEW CLASSIFICATION SYSTEM

Tahririan et al. (2015) established a scoring system, which can be used to weigh between operative and non-operative approaches in 5th MT fracture (Table 1). In this scoring system several factors were found to give weight towards surgical approach. These factors include type III fracture, fracture displacement more than 2 mm, weight of the patient more than 81 kg, female and the presence of diabetes mellitus as co-morbidities. The cut-off of point of the total score was 9, in which greater value favours surgical approach.

Decision analysis model developed by Bishop et al. (2015) reported operative fixation is the preferred management strategy for 5th MT fracture. This model was developed based on outcome probabilities and utilities. Outcome probabilities is based on data extracted from 19 studies on 5th metatarsal fracture that is one randomized controlled trial, one prospective case series, and 17 retrospective case series. Outcome utilities were based on patient preferences for various disease states obtained from 32 adults (25 women, 7 men) with no history of foot injury. The expected value for intramedullary screw fixation was 7.88 and non-operative treatment was 7.74 suggesting that operative treatment was a favourable approach. However, the expected values between operative and non-operative approaches were differed by only 0.3 on a 10-point scale, which may explain controversy surrounding decision making in the management of 5th MT fracture.

Table 1: Scoring system of fifth metatarsal fracture (Tahririanet al. 2015)

| Variable | Score |
|---|---|
| Gender (female) | 8 |
| Diabetes mellitus | 17 |
| Displacement greater that 2 mm | 19 |
| Weight (>81kg) | 2 |
| Type 1 fracture | -5 |
| Type 2 fracture | 0 |
| Type 3 fracture | 20 |

Attempts have been made to reclassify 5th MT fracture. Polzer et al. (2012) recommended 5th MT fracture to be classified as metaphyseal and meta-diaphyseal fractures based on prognosis and therapeutic consequences. Metaphyseal fractures are defined as fractures that do not extend beyond the distal end of the fourth-fifth intermetatarsal articulation, regardless of the number of fragments,

displacement or intraarticular involvement and it is recommended to be treated functionally. Meta-diaphyseal fractures defined as fracture just distal to the fourth-fifth intermetatarsal articulation and it is recommended to be treated with intramedullary screw fixation.

## NON-OPERATIVE OUTCOME

Displaced oblique spiral fractures of the 5th MT shaft showed excellent long-term functional outcomes when treated non-operatively with only two delayed unions and three non-union developed from 142 patients (Aynardi et al. 2013).

Fracture of 5th MT treated with removable walking boot and without weight bearing restriction had favourable outcome in which 24 (89%) out of 27 patients achieved clinical union at a mean of 8.0 ± 2.6 weeks with only one (4%) patient developed non-union (Marecek et al. 2016).

In one prospective, randomised clinical trial reported there was no significant difference in the outcome of patients with 5th MT fracture between the group of patients that received immobilisation treatment with below the knee cast and the group of patients who received symptomatic treatment with double elastic bandage (Akimau et al. 2016).

Furthermore, routine outpatient follow-up of 5th MT fracture has no added clinical value and can be discharged from the Emergency Department and allowed weight bearing as tolerated, provided adequate discharge advice is given (Ferguson et al. 2013).

## OPERATIVE OUTCOME

Systematic review comparing outcome between operative and non-operative approaches reported that surgical approach is recommended in 5th MT fracture in view of lesser non-union rate and lesser time needed for union. This review includes six relevant studies with a total of 237 patients in which 49% underwent surgical intervention and 51% treated non-operatively. In all studies, intramedullary screw was the surgical approach employed to patients. The rates of non-unions were lower in operative management ranging from 0% to 11%, in comparative with non-operative management ranging from of 11% to 50%. Time to union, return to sport and normal activity was significantly lower in surgical management compared with non-surgical approach. The rate of complications were higher in non-operative approach with 31% of patients needing surgery following conservative treatment compared to only 8.5% who needed repeat surgery in operative approach (Yates et al. 2015).

## FACTORS INFLUENCE INTRAMEDULLARY SCREWS FIXATION

The unique anatomy of the 5th MT in particular, its lateral curvature makes surgical technique inheritably challenging. Ideally, in intramedullary screw fixation it should be performed with the largest screw possible, both in its length and diameter in order to provide the best possible construct (Tan et al. 2016). It is a common problem

encountered during surgery when there is excessive screw length leading to lateral gapping and malreduction of the fracture (Tan et al. 2016). Considering lateroplantar curvature of 5th MT bone begins when its medullary canal starts to taper, it is recommended to keep the screw length less than 68% of the length of the 5th MT bone. This corresponds to the average straight segment length of the metatarsal bone which was 52 mm measured from its proximal end and it represented 68% of the overall length of the bone (Ochenjele et al. 2016). It is recommended to use lateral radiograph to estimate the length of the screw as distance from apex to the base is smaller in this view (DeSandis et al. 2016).

Accurate diametre of the screw is crucial as under sizing leads to instability of the fixation leading to failure of fixation, while oversizing increases risk of iatrogenic fracture (Scott et al. 2015; Granata et al. 2015). It is reported that 4.5 mm cannulated screw is the narrowest screw diameter that can provide adequate fixation, considering a cadaveric study that reported the mean dorsal to plantar and medial to lateral diameter of the 5th MT bone as 6.475 ± 1.54 (range 4 to 12) mm and 4.6 ± 0.85 (range 3 to 6) mm respectively (Scott et al. 2015). Radiographic study of 199 patients suggested screw size greater than 4.5 mm may provide optimum reduction considering coronal diameter of the isthmus of 5th MT bone was greater than 4.5 mm in 81% of males and 74% of females (Ochenjele et al. 2015). It is recommended to use anteroposterior radiograph to estimate diameter of the screw as the canal shape is elliptical and was smaller in this view (DeSandis et al. 2016).

Bicortical purchases of the screw may increase the strength of the fixation. It is reported that all patients treated with bicortical screw fixation for displaced zone I and zone II fractures healed with radiological union achieved at 5.33 ± 1.03 and 6.59 ± 1.84, respectively (Mahajan et al. 2011). Screws positioned at proper angle and perpendicular to the fracture line may help achieve bicortical purchase. In order to achieve this, an imaginary line connecting tuberosity of the 5th MT bone and third metatarsophalangeal joint can be used to position the leading guide wire. These anatomical landmarks can be assessed during surgery when the patient is put in lateral position with the hip joint neutral in position, knee joint flexed to an angle of approximately 15 and the ankle positioned in slight plantar flexion (Wang et al. 2016). In order to maintain the proper position of the screw during its placement, it is recommended to incorporate percutaneous reduction and stabilization of the fracture using pointed reduction clamp prior to screw fixation, which was reported to prevent iatrogenic displacement and gapping at the fracture site (Tan et al. 2016) (Figure 2).

Options for screws in 5th MT fractures are diversed in type and size. A study comparing between groups of patient treated with traditional screw and screw designed specifically to be used in 5th MT fracture reported there was no significant difference in fracture union between the two groups. However, group with traditional screw was associated with increased number

Figure 2: Point reduction clamp is used to prevent displacement and gapping (Tan et al. 2016)

of adverse events including implant failures, intraoperative fracture and symptomatic hardware (Metzl et al. 2013).

Complications associated with 5th MT fracture include non-union, delayed union and failure of fixation. Failure of fixature presents as refracture, malreduction and symptomatic hardware (Yates et al. 2015).

Refracture following operative treatment was reported in 7.3% cases which occurred within eight months. Failure occurred in patients treated with smaller diametre of cannulated screw suggesting proper selection of screw size may reduce risk of refracture especially in athletes (Granata et al. 2015).

Pre-treatment of non-union with pulsed electromagnetic fields (PEMFs) at non-union site together with open reduction and internal fixation significantly shortened union time to 8.9 weeks in comparison to 14.7 weeks for group without PEMF (Streit et al. 2016).

## OTHER SURGICAL METHODS

Mini-hook plate has been designed so that its hook provides compression force, rotational stabilization and grasping effect of the comminuted fragments. It is an effective alternative surgical hardware for zones I and II 5th MT fractures with displaced or comminuted small fragments. Fracture union with mini hook plate was reported at a mean of 54 ± 11 days (range, 38-74 days) and returning to premorbid daily activities at a mean of 74 ± 10 days (range, 63-98 days) (Choi et al. 2013).

Locking compression plate (LCP) distal ulna hook plate was designed for fractures of distal ulna. Due to the similarity in anatomical structure between distal ulna and proximal 5th MT bone, this plate was used in 5th MT fracture. In a study involving nineteen patients, it was reported that this LCP distal ulna hook plate is suitable to be used in osteoporotic, comminuted and tuberosity avulsion (zone 1) of 5th MT fractures with average union achieved at 7.4 weeks (Lee et al. 2014).

Headless compression screw is a self-drilling screw that provides excellent holding power and compression effect to the fracture site. In a study involving 60 athletes treated with headless

compression screw reported less adverse events and fast recovery with mean time to start running at 6.3 weeks (range, 3-12.7 weeks) and full activity following surgery at 11.2 weeks (range, 6-25 weeks) (Nagao et al. 2012).

Plate fixation was recommended in laterally bowed 5th MT of comminuted fracture with union achieved at mean of 56.8 days (range, 30-92 days). However, one third of the studied patients required reoperation for plate removal (Kadar et al. 2015).

Among competitive athletes, patients with metatarsus adductus angles, 5th MT lateral deviation, prominent 5th MT styloids and high fourth-to fifth intermetatarsal are recommended to perform bone graft as it is reported to be associated with reduced risk of complications (O'Malley et al. 2016; Tsukada et al. 2012).

## CONCLUSION

Several factors may influence decision making in the management of 5th MT fractures. Outcome of previous studies, surgical technique, surgical method and appropriate hardware may influence approach in this fracture.

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