

Proximal Fifth Metatarsal Fractures: Anatomy, Classification, Treatment and Complications

Chi Nok Cheung,¹ and Tun Hing Lui^{1,*}

¹Department of Orthopedics and Traumatology, North District Hospital, Hong Kong SAR, China

*Corresponding author: Tun Hing Lui, Department of Orthopedics and Traumatology, North District Hospital, 9 Po Kin Road, Sheung Shui, NT, Hong Kong SAR, China. Tel: +852-26837588, Fax: +852-26837576, E-mail: luithderek@yahoo.co.uk

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Abstract

Context: Fractures of proximal fifth metatarsal are one of the most common fractures of the foot.

Evidence Acquisition: A search of PubMed for studies on proximal fifth metatarsal fracture and Jones fracture focusing on the classification and management was performed. The reference list of the retrieved articles was searched for additional related studies.

Results: The vascular supply and soft tissue anatomy of the fifth metatarsal explains the increased risk of delayed union and non-union in fractures at the metaphyseal-diaphyseal junction. Lawrence and Botte classify proximal fifth metatarsal fractures according to their location: tuberosity avulsion fractures (zone 1), fractures at metaphyseal-diaphyseal junction extending into the fourth-fifth intermetatarsal joint (zone 2) and proximal diaphyseal fractures (zone 3). Zone 1 fractures are treated conservatively with functional immobilization and early mobilization with excellent outcome. For zone 2 and zone 3 fractures, acute forms can be treated conservatively but with a risk of delayed union time and time for return to function. Therefore, early surgical fixation with intramedullary screw is advised in athletic individuals. For cases presented with signs of delayed union and non-union, surgical treatment with or without bone grafting is recommended. Complications of these fractures and their management are discussed in this report.

Conclusions: Lawrence and Botte's classification of proximal fifth metatarsal fractures is recommended by experts, due to its implication on prognosis and treatment strategy. Zone 1 fractures should be treated conservatively due to their excellent healing potential. Early operative treatment is advised for zone 2 and zone 3 fractures, especially in the athletic group. Complications of delayed union, non-union and refracture should be treated by revision fixation and bone grafting.

Keywords: Metatarsal Bones, Fractures, Bone, Evidence-Based Medicine, Classification, Anatomy, Fracture Fixation

1. Context

Fractures of the fifth metatarsal are among the most common fractures of the foot (1). Many of these fractures are located proximally (2). The fracture of the proximal fifth metatarsal was first described by Sir Robert Jones in 1902 (3). Thereafter, different classification systems and management strategies were described in the literature. From Joseffson's series (4), proximal fifth metatarsal fractures usually occur during the second to sixth decades of life. Dameron (5) and Ekrol (6) observed that there is a male predominance in younger patients while a female predominance exists in older patients. These fractures are commonly a result of sport activities but can also happen in non-athletes (7-9).

The aim of this article was to review the pathoanatomy of proximal fifth metatarsal fracture, its classifications, treatment strategies, its complications and the management of the complications based on current evidence in the literature.

2. Evidence Acquisition

A review of the literature using PubMed, as the search engine for English articles on proximal fifth metatarsal fracture and Jones fracture, focusing on the classification and management was performed in July 2015. The following search terms were used: metatarsal fracture, fifth metatarsal fracture, Jones fracture, classification, management, operative treatment, delayed union and non-union. The reference list of the retrieved articles was subsequently searched for additional related studies.

3. Results

3.1. Anatomy

Understanding the anatomy of the proximal part of the fifth metatarsal is important because it explains the injury mechanism and the healing potential of different types of fifth metatarsal fractures, which affect the proper choice of management. The proximal fifth metatarsal includes, fractures from the proximal to the distal area, the

tuberosity, the metaphysis and the proximal diaphysis. It articulates with the cuboid bone proximally and the base of the fourth metatarsal laterally.

3.1.1. Soft Tissue Attachment

A cadaveric study by DeVries (10) showed that the lateral band of the plantar fascia attaches to the plantar-lateral aspect of the tuberosity, while the peroneus brevis tendon attaches to the dorsolateral aspect of the tuberosity and the peroneus tertius attaches to the dorsal metaphysis. These soft tissue attachments explain the injury mechanism and will be discussed later in this article.

3.1.2. Inferior Healing Potential at Metaphysis-Diaphysis Junction

The blood supply to the fifth metatarsal metaphysis is by a network of arterioles entering the non-articulating surface of the tuberosity. The blood supply to the diaphysis is by the nutrient artery entering through the middle of the diaphysis, which gives longitudinal branches proximally and distally. This gives rise to a watershed area at the metaphysis-diaphysis junction, which accounts for the higher risk of delayed union and non-union of fractures in this region (11).

There are strong ligaments between the base of the fifth metatarsal and the cuboid and base of the forth metatarsal, which make this part of the fifth metatarsal relatively fixed (5, 12, 13). On the other hand, the diaphysis of the fifth metatarsal is relatively mobile. This difference in stability, also makes the metaphyseal-diaphyseal junction fractures biochemically more susceptible to delayed union and non-union (8).

3.2. Classifications

Fracture of the proximal fifth metatarsal was first described by Sir Robert Jones in 1902. Thereafter, different classification systems for the proximal fifth metatarsal fractures have been described. The term 'Jones fracture' is used inconsistently; some authors define it as a fracture at the metaphyseal-diaphyseal junction while others define it as a fracture at the proximal diaphysis. Therefore, using proper classification rather than the term 'Jones fracture' is recommended in describing proximal fifth metatarsal fractures.

3.2.1. Lawrence and Botte's Classification

The most commonly used classification was described by Lawrence and Botte in 1993 (14). It distinguishes three types of proximal fifth metatarsal fractures based on the mechanism of injury, location, treatment options and prognosis. Zone 1 fractures refer to avulsion fractures of

the tuberosity with or without involvement of the tarsometatarsal articulation. This is caused by forces by the peroneus brevis tendon or the lateral band of the plantar fascia during foot inversion. Zone 2 fractures refer to fractures at the metaphysis-diaphysis junction, which extend into the fourth-fifth intermetatarsal facet. This is caused by forced forefoot adduction with the hindfoot in plantar flexion. Zone 3 fractures refer to proximal diaphyseal fractures, distal to the fourth and fifth metatarsal base articulation. This is caused by acute excessive bearing of the region or chronic overloading as in stress fractures (Figure 1).

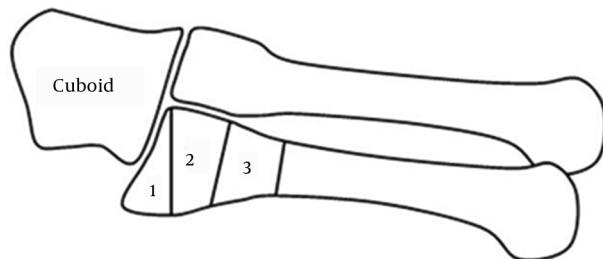


Figure 1. Lawrence and Botte's Classification of Proximal Fifth Metatarsal Fractures (Zone 1, 2 and 3)

Zone 1 fractures are the most common and usually lead to good outcomes with conservative treatment. Zone 2 and 3 fractures are prone to delayed union and even non-union, as explained previously, therefore require specific treatment strategies.

3.2.2. Torg's Classification

Torg (15) developed further classification for fractures at zone 2 and 3 for formulating a suitable treatment plan. Type I (acute) is a fracture with a narrow fracture line and no intramedullary sclerosis. Type II (delayed union) is a fracture with wide fracture line and intramedullary sclerosis. Type III (non-union) is a fracture with complete obliteration of the medullary canal by the sclerotic bone.

3.2.3. Isolated Proximal Fifth Metatarsal Fractures Versus. Lisfranc Injury

It is also important to assess clinically and radiologically for any evidence of Lisfranc injury over the medial column, because management of isolated proximal fifth metatarsal fracture and those associated with Lisfranc injury are completely different. In cases with Lisfranc injuries, management of compartment syndrome if any and early anatomical reduction and fixation of the Lisfranc joint and the other tarsometatarsal articulations are required. Delay in treatment of the Lisfranc component is associated with poor outcome including development of post-traumatic arthritis (Figure 2) (16).



Figure 2. A case of Proximal Fifth Metatarsal Fracture With Missed Lisfranc Injury That Resulted In Nonunion of the Fracture and Degeneration of the Lisfranc Joint

3.3. Treatment

3.3.1. Zone 1 Fractures

There is no controversy that non-displaced tuberosity avulsion fractures should be treated conservatively in view of their excellent healing potential. A meta-analysis of 187 tuberosity avulsion fractures from four studies in 2011 showed that there was no significant difference in union and refracture rates between different conservative treatment modalities (17). However, studies have shown that functional treatments with early weight bearing provide better functional outcome and earlier return to work than treatment by short leg cast with non-weight bearing walking (18-21). Therefore, functional treatments with orthopedic shoe, Jones bandage dressing or elastic bandage dressing are recommended.

Some authors suggested that fracture displacement of more than 2 cm and involvement of more than 30% of the cuboid-metatarsal articulation are indications for operative treatment of tuberosity avulsions (8). However, another study showed that functional treatment in this group of fractures gives good results compared to non-displaced and extra-articular fractures (15) (Figure 3).

3.3.2. Zone 2 and Zone 3 Fractures

Josefsson demonstrated over 95% union rate, satisfactory long-term result and satisfactory functional outcome with non-operative treatment by short leg cast immobilization (4). However, the main disadvantage was delayed union time and longer time to return to function. Eight out of the 44 patients in his study required secondary fixation surgery due to delayed union.

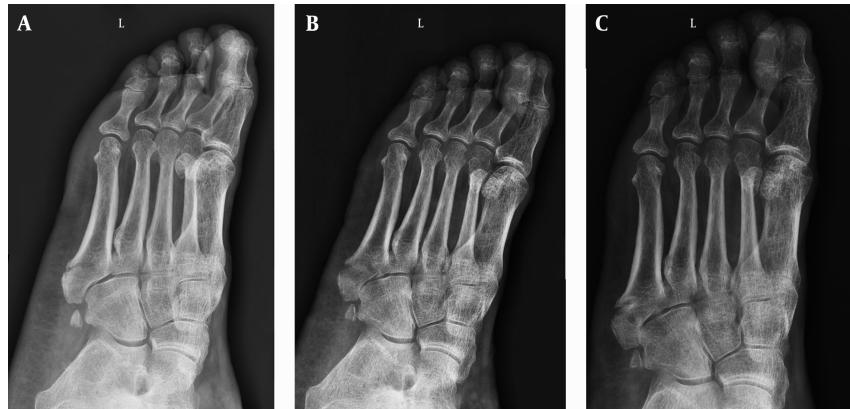
Torg suggested a treatment strategy according to his subgroups for the fractures at zone 2 and 3 (22). Type I fractures can be treated conservatively with non-weight bearing in a short leg cast for a period of 3 to 12 weeks (Figure 4). Type II fractures can be treated conservatively or operatively depending on the functional demand since most of these fractures heal eventually with conservative treatment but early surgical treatment may reduce the time of union and the time of immobilization. Type III fractures should be managed operatively.

Mologne performed the only randomized controlled study comparing the outcome of early intramedullary screw fixation versus casting for Type I fractures (23). Among the recruited 37 patients (18 patients with casting and 19 patients with screw fixation), he observed that non-operative treatment causes a relatively high rate of treatment failure (44%) and doubles the time to clinical union and return to sports.

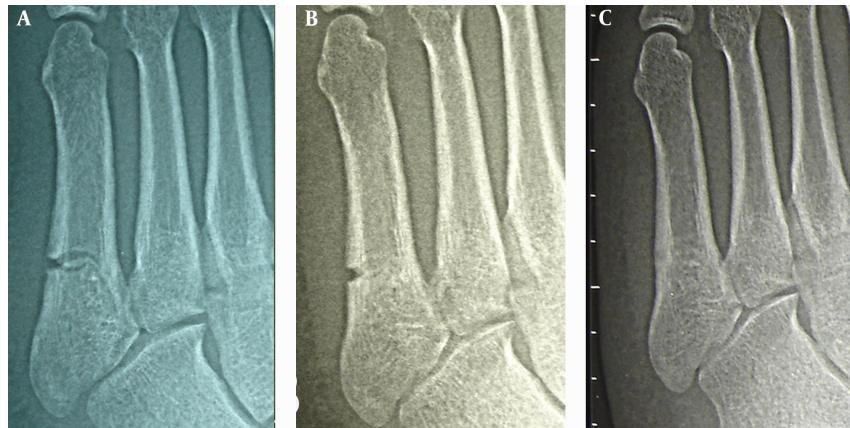
Rosenberg shared a similar opinion in his review paper on treatment for zone 2 and 3 fractures (24). He recommends conservative treatment with non-weight bearing in a short leg cast for six to eight weeks for acute fractures in the non-athletic group and surgical fixation in athletic patients for earlier union and return to function. For delay union and non-union cases, he recommends surgical treatment with or without bone grafting.

3.3.3. Operative Techniques

Different operation techniques were described in the literature including intramedullary screw, tension band wiring, differential pitch screw and percutaneous bicortical screw. Fixation with intramedullary compression

Figure 3. A Case of Lawrence and Botte Zone 1 Fracture That Was Treated Conservatively With Rocker Boot

A, injury film showing non-displaced fracture. B, radiograph taken six weeks after the injury, showing fracture displacement. C, radiograph taken nine months after the injury showing that the fracture had healed.

Figure 4. A Case of Lawrence and Botte Zone 3 Fracture Treated Conservatively With a Cast

A, injury film. B, radiograph taken nine weeks after the injury showed that the fracture healed with residual lateral cortical notch. The notch is a common radiographic appearance after the fracture heals. It takes a long time to disappear. C, radiograph taken 15 months after the injury, showed the notch disappeared.

screw with or without bone grafts is the most commonly reported technique (8). Reaming of the medullary canal before screw insertion is advised to ensure tight fit of the screw to the endosteum. A partially-threaded screw is used and all the screw threads must pass though the fracture line in order to achieve fracture compression. A cadaveric study by Shah showed that there is no correlation between the size of the screws and biomechanical advantage (25). A clinical analysis by Larson also showed that the screw diameter is not predictive of refracture or non-union (26). A larger screw may provide a better pull out strength but may also increase the risk of diaphyseal fracture during insertion. Porter reported a 100% union rate, high satisfaction and no refractures in a group of high physi-

cal demand athletic patients using 4.5mm cannulated intramedullary screw fixation (27). Similar excellent result was also demonstrated in a more recent study by Massada in 2012 (28).

Tension band wiring is an alternative operative treatment for proximal fifth metatarsal fractures. A recent study modified the tension band wiring technique with the use of two cortical screws and gave comparable outcomes to those of intramedullary screw fixation while the risks of sural nerve injury and neuralgia is reduced compared with the conventional tension band technique (12). Variable pitch tapered screw fixation and percutaneous bi-cortical screw fixation have been previously described but the clinical evidence at present is still limited (29, 30).

3.3.4. Post-Operative Rehabilitation

Post-operative rehabilitation (7, 23, 30) usually consists of immobilization with a short leg cast or plaster splint for one to two weeks, and then replacement with a walking boot. Patients are allowed to start progressive weight bearing from week four onwards. By six to eight weeks post-operatively, full weight-bearing walking is allowed and normal activities can be resumed. Some authors suggest extension of the initial period of cast immobilization and non-weight bearing to six weeks in case of stress fractures of the proximal diaphysis (12). Return to sports should only be allowed when there is radiological evidence of union and the patient is clinically asymptomatic (26). The rehabilitation plan must be accepted by the patient pre-operatively since pre-mature return to vigorous physical activity is believed to cause delayed union and refracture, especially in athletic patients (31).

3.3.5. Contraindications of Surgical Treatment

There is no evidence on specific contraindications of surgical treatment for proximal fifth metatarsal fractures. In general, surgical treatment is contraindicated in feet with vascular compromise, neuropathy or local infection. Diabetes mellitus itself is not an absolute contraindication providing that the vascular supply and protective sensation of the long extremities are still intact (32).

3.4. Complications

3.4.1. General Complications

Complications of proximal fifth metatarsal fractures include delay union, non-union and refracture (31). A low non-union rate of 0.5% -1% was reported in zone 1 fractures treated conservatively (20, 33). In contrast, non-union rate of zone 2 and zone 3 fractures treated conservatively is as high as 25 - 28% (23, 33, 34). Kavanaugh (35) also reported a high delayed union rate of 66.7% and a high refracture rate of 61.1% for zone 2 and zone 3 fractures.

For tuberosity, avulsion fractures failed conservative treatment; screw fixation with or without bone graft and excision of the extra-articular avulsion fragment are the treatment options (36). Lui described the technique of endoscopic assisted screw fixation and bone grafting, which avoids extensive soft tissue dissection, allows assessment of fifth metatarsal cuboid articulation and guides the desired position of screw fixation (37).

For fractures at zone 2 and 3, non-union and refracture could be treated with medullary curettage and inlay grafting or intramedullary screw fixation (38, 39). In case of revision in previous screw fixation, a larger diameter screw and re-reaming of the medullary canal is required (40). A case series by Sarimo (41) showed that tension-band

wiring as a secondary procedure for delayed union or non-union with prior unsuccessful conservative treatment or intramedullary screw fixation also give promising results. In his series, there was no delayed union, non-union or refracture upon follow-up.

Electrical stimulation with pulsed electromagnetic fields showed promising early results for proximal fifth metatarsal fractures, especially in cases of delayed union and non-union (42, 43). More studies on the effectiveness of this adjunctive are required.

3.4.2. Operation Related Complications

Other specific possible complications of surgical fixation include wound infection, rupture of peroneus brevis tendon, peroneal nerve irritation, sural nerve injury, impingement by prominent screw head, screw missing the medullary canal, iatrogenic fracture of the metatarsal bone and metatarsalgia (7, 44, 45). Wound infection and tendon or nerve injury can be avoided by careful soft tissue handling and using a low profile implant. Impingement by screw head can be prevented by adequate countersink of the cortex before screw insertion and can be managed by wearing more spacious shoes (7). Screws missing the medullary canal and iatrogenic fracture can be avoided by a proper surgical technique and careful choice of suitable implant (35, 40). One of the causes of post-operative metatarsalgia is fibrosis of the joints and tendons around the operative site. Lui reported a case of post-operative lateral foot pain successfully treated by arthroscopic arthrolisis and endoscopic tenolysis (46).

4. Conclusions

Proximal fifth metatarsal fractures are common. Knowing the anatomy is important for understanding the mechanism and prognosis of different types of fractures. The classification by Lawrence and Botte and that by Torg help to formulate appropriate treatment strategies accordingly. Fifth metatarsal fracture associated with Lisfranc injury must be distinguished from isolated proximal fifth metatarsal fracture because their prognosis and management are different.

Avulsion tuberosity fractures (zone 1) should be initially managed conservatively with functional treatment and early weight bearing since the union rate and functional outcome are good.

Zone 2 and zone 3 fractures are more prone to delayed union, non-union and refracture. For acute cases, conservative treatment with cast immobilization and non-weight bearing can be considered in the non-athletic group. While in the athletic group, early surgical fixation with intramedullary screw is advised for shorter union

time and time to return to sports. Tension band wiring, variable pitch tapered screw fixation and percutaneous bicortical screw fixation are other described surgical techniques. For cases of delayed union and non-union, surgical treatment with or without bone grafting is recommended. Post-operatively, the rehabilitation plan should be agreed and strictly followed by patients.

Complications of proximal fifth metatarsal fractures include delay union, non-union, refracture, soft tissue complications and implant impingement. Some of these could be prevented by careful soft tissue handling, proper surgical technique and suitable choice of implant. Symptomatic delayed union, non-union and refracture should be treated with revision intramedullary screw fixation and bone grafting. Arthroscopic or endoscopic assisted technique may provide a minimally invasive approach of the operative treatment.

Footnotes

Authors' Contribution: Chi Nok Cheung prepared the manuscript. Tun Hing Lui supervised the work of Chi Nok Cheung.

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