

# INTRAMEDULLARY SCREW FIXATION FOR PROXIMAL FIFTH METATARSAL ZONE II AND III FRACTURES ON ATHLETE POPULATION: A SYSTEMATIC REVIEW

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## Abstract

*As the most prevalent fracture of the foot, the fifth metatarsal fracture has the incidence of 6.7 per 100.000 persons each year mainly in the high-risk population such as athletes. While most of the cases resolved over time with conservative management, the fifth metatarsal region is prone to the risk of non-union due to the poor blood supply. Early treatment should immediately be given for the fracture to improve significantly and rapidly. Currently, intramedullary screw fixation has become an emerging treatment to conventional plate fixation or K-wire in managing proximal fifth metatarsal fracture. Intramedullary screw fixation has demonstrated a minimally invasive approach with better outcomes and minimal complications. However, the review regarding the use of the approach in managing proximal fifth metatarsal zone II and III fractures in the athlete population is still scarce. The evidence as a base for recommendations to manage fifth metatarsal fracture thus limited. Therefore, this study is intended to review the summary and pitfalls of intramedullary screw fixation in the fifth metatarsal zone II and III in athletes to bring insight and improve the efficiency of the approach.*

**1. INTRODUCTION**

The annual incidence of metatarsal fractures is 6.7 per 100.000. Being the most common fracture in the foot, 30% of the metatarsal fractures are linked to the base of the metatarsal bone<sup>1</sup>. Athletes have the highest risk of sports injuries, due to twisting and inversion injuries. As stated by Albloushi et al. (2021), fractures are more prone in males by 10 times compared to female athletes<sup>2</sup>. This occurrence is attributed to heavy activities during sports, such as exceeding stresses in the foot during running, tackling, or jumping. The range of injury is hypothesized to play a role in the morbidity of metatarsal fractures<sup>3</sup>.

The classification of metatarsal fracture is based on Dr. Robert Jones in 1902. Lawrence and Botte further categorized the fracture into three zones. Zone I or Type I is the presence of an avulsion fracture located proximally from the fourth and fifth intermetatarsal articulation<sup>4</sup>. It is also called an acute proximal metatarsal fracture. Zone II or Type II is called Jones fracture which the fracture is located at the articulation level. Delayed union, or proximal metatarsal fracture is due to zone II fracture. Zone III is called diaphyseal stress' fracture, which is located at the distal articulation end, thus being called non-union proximal metatarsal fracture. Among all the zones, zone III possesses the greatest risk of a delayed bone union in more than half of the cases<sup>5-7</sup>. This may be attributed to the water-shed areas, which are locations where minimal vascularization and disrupted areas of the fracture commonly present. The condition in turn causes longer recovery duration to the extent of non-union<sup>2</sup>. Due to the morbidity, zone II and zone III fractures often have similar management<sup>1,8</sup>.

Management on metatarsal fractures are indicated based on the severity and zone of the fracture<sup>1</sup>. In athletes, specific fracture patterns need to be considered thus leading to difference in treatment. Surgical techniques such as the use of screws and plantar plate fixation are the options<sup>9,10</sup>. Although several studies have elaborated on the management of intratarsal fractures, the treatment of the other zones remains debatable<sup>2,11</sup>. Currently, intramedullary screw fixation, as an emerging minimally invasive approach to intratarsal fractures is the preferred treatment for the proximal fifth metatarsal zone II and III fractures despite the lack of evidence on treatment and prognosis. The aim of this study is to provide a summary of intramedullary screw fixation as the management of the proximal fifth metatarsal zone II and III fractures in athletes to elaborate on new insights for health practitioners and orthopedic surgeons.

**2. RESEARCH METHODS**

**Search Strategy**

This study is a qualitative systematic review. The data is obtained through electronic database search in Medline (PubMed), Scopus, Web of Science, and Google Scholar. The keywords are “Intramedullary screw fixation” AND “Fifth metatarsal fracture” AND “Athletes” using English and Bahasa Indonesia. Duplicates of the articles are removed. The selected articles are based on inclusion and exclusion criteria.

**Selection Criteria**

All studies were assessed for eligibility. The inclusion criteria of the included studies were articles published in the last 3 years between 2019 and 2022, full-text articles, published in Bahasa Indonesia or English, and studied intramedullary screw fixation for the management of the proximal fifth metatarsal zone II and III fractures in a population of athletes. The exclusion criteria of the studies are articles that are not indexed by Scopus, editorials, reviews, and articles which did not report complete data on the variables of intramedullary screw fixation. PRISMA guideline is used for the selection. Finally, the articles are screened and synthesized into a qualitative systematic review.

**Data Extraction**

All the authors extracted the data from the articles. Author, year of study, published year, study design, treatment, outcome, and complication of the patients in the study were identified for qualitative analysis.

**3. RESULT**

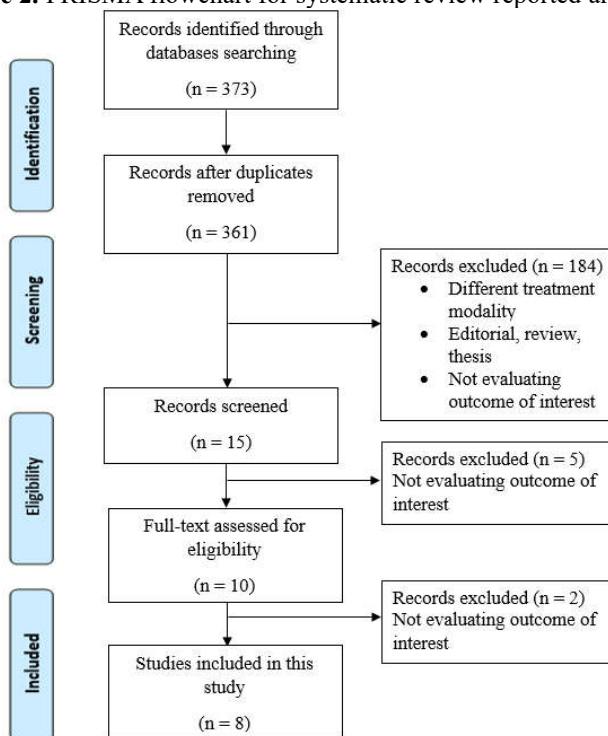
**Study selection and characteristics of included studies**

The literature search strategy and article screening process are based on PRISMA guidelines in Table 1 and Table 2. From all of the databases, we identified a total of 373 articles. Of these, 12 articles were removed due to duplicates, and 15 articles were screened. A total of 184 articles were removed with 127 articles had different treatment modalities, 52 articles were editorials, reviews, and thesis, and 15 articles didn't evaluate the outcome of interest of the systematic review.

**Table 1.** Literature Search Strategy

Database	Keywords	Results
PubMed	“Intramedullary screw fixation” AND “metatarsal fracture” AND “athlete”	1
Cochrane Library	“Intramedullary screw fixation” AND “metatarsal fracture” AND “athlete”	0
Google Scholar	“Intramedullary screw fixation” AND “metatarsal fracture” AND “athlete”	372

**Table 2.** PRISMA flowchart for systematic review reported articles



A total of 262 subjects were included in the study from the articles. All of the subjects are athletes from diverse sport classifications. The studies consisted of case series and cohort study with the outcomes measured by preoperative, postoperative, bone union mean time, return to sport mean time, correlation between other procedures and intermedullary screw fixation, and FAAM score reported of all the patients. In most studies, no complication is found (n = 6). The shortest time for bone union is 6 weeks and the longest 12 weeks. For return to sport mean time, the fastest period is 3.6 weeks and the longest period is 12.04 weeks.

**Table 3.** Summary of the included articles (n = 8)

Author (Year)	Study Design	N	Treatment Technique	Result	Complication
Baumfeld et al. (2020) <sup>12</sup>	Case series	27	Intramedullary screw fixation	<ul style="list-style-type: none"> <li>Preoperative - VAS = 6</li> <li>Postoperative - VAS = 0</li> <li>Postoperative - AOFAS = 99</li> </ul>	3 athletes had complications: <ul style="list-style-type: none"> <li>Granuloma (6<sup>th</sup> post-operative)</li> <li>Refracture</li> <li>Guidewire breakage</li> </ul>
Morimoto et al. (2021) <sup>13</sup>	Case series	37	Intramedullary screw fixation using the Herbert screw	<ul style="list-style-type: none"> <li>Bone union mean time = 10.1 weeks</li> <li>Return to sport mean time = 10.9 weeks</li> <li>No correlation between intraoperative plantar gap widening and bone union time (p&lt;0.05)</li> </ul>	Results obtained without complications
Watson et al. (2020) <sup>14</sup>	Case series	25	Intramedullary screw fixation <ul style="list-style-type: none"> <li>Partially threaded cannulated (n=10)</li> <li>Variable pitch headless compression screw (n=13)</li> <li>Solid (n=3)</li> </ul>	<ul style="list-style-type: none"> <li>Return to sport mean time = 3.6 weeks (1.5-6 weeks)</li> <li>FAAM activities of daily living = 94.9%</li> <li>FAAM sports subscale = 89.1%</li> <li>Percentage of preinjury daily function = 93.9%</li> <li>Percentage of preinjury sports function = 90.3%</li> </ul>	<ul style="list-style-type: none"> <li>Hardware removal (n=3)</li> <li>Refracture (n=1)</li> <li>Broken hardware (n=2)</li> </ul>
Bucknam et al. (2020) <sup>15</sup>	Case series	32	Intramedullary screw fixation	<ul style="list-style-type: none"> <li>Follow-up mean time = 24.2 months</li> <li>Patient satisfaction = 100%</li> <li>Bone union mean time = 10.8 weeks</li> <li>Return to sport mean time = 3.7 weeks</li> <li>Resumption of restriction-free activities = 13 weeks</li> </ul>	Results obtained without complications
Anastasio et al. (2022) <sup>16</sup>	Case series	51	Intramedullary screw fixation	<ul style="list-style-type: none"> <li>Preoperative - VAS = 5.4</li> <li>Postoperative - VAS = 1.4</li> <li>AOFAS = 59 (p&lt;0.0001)</li> <li>AOFAS = 186 (p&lt;0.0001)</li> </ul>	Results obtained without complications
Grant et al. (2020) <sup>17</sup>	Case series	30	Intramedullary screw fixation	<ul style="list-style-type: none"> <li>Bone union time = 6-12 weeks</li> <li>All patients had resolution of symptoms</li> </ul>	Results obtained without complications
Khurana et al. (2020) <sup>18</sup>	Case series	38	Intermedullary screw fixation	<ul style="list-style-type: none"> <li>Bone union time = 12 weeks</li> <li>Delayed union = 5 patients</li> <li>Plantar gap was associated with longer bone union duration (p=0.022)</li> <li>Ratio of postsoperative to preoperative apex height on anteroposterior and lateral views was correlated with plantar fracture gaps (p&lt;0.001)</li> </ul>	Results obtained without complications
Zazueta-Arnaud et al. (2022) <sup>19</sup>	Retrospective cohort	22	Intermedullary screw fixation	<ul style="list-style-type: none"> <li>Follow-up mean time = 23.54 months</li> <li>Bone union time = 12 weeks</li> <li>Return to sports mean time = 12.04 weeks</li> <li>FAAM score = 91.45 postoperative</li> <li>Preoperative - VAS = 8.81 (p&lt;0.05)</li> <li>Postoperative - VAS = 1.68 (p&lt;0.05)</li> </ul>	Results obtained without complications (after 24 months follow-up)

VAS = Visual Analogue Scale

AOFAS = American Orthopaedic Foot and Ankle Society Ankle Hindfoot Score

FAAM = Foot and Ankle Ability Measure

## DISCUSSION

Before describing the procedure of intramedullary screw fixation, it is important for the surgeons to visualize the anatomy of the proximal fifth metatarsal. The consideration includes the presence of vascularization which possibly resulted in watershed areas, as mentioned before, at the junction of metaphysis and diaphysis<sup>7</sup>. Delayed or non-union fractures can have a high-risk occurrence whenever there are watershed areas<sup>20</sup>. After the classification of fracture zones by Lawrence and Botte, zone II fracture is considered to be more often happen and severe than zone I. This is due to forefoot forced adduction at the condition of hindfoot plantar flexion. Zone III fracture also called diaphyseal stress' fracture, is a fracture where the heavy load, for example, stress, caused fractured proximal diaphysis. The Jones type is a helpful classification to provide the right treatment of the proximal fifth metatarsal fracture zone I and zone III<sup>20</sup>.

In a study by Baumfeld et al. (2020), fractures in zone II and III preferably to be managed by surgical approach rather than conservative treatment alone, and that intermedullary screw fixation is the current mostly preferred treatment for fifth metatarsal fracture in both zones. The study also found that VAS and AOFAS score improved significantly with intramedullary screw fixation procedure ( $p < 0.001$ )<sup>12</sup>. The complications are similar with other studies, mostly breakage of guidewire. Although there are existing complications, fracture healing is resolved in all the patients. Watson et al. (2020) also found that the athletes were safe if return to sport is needed, if there was no significant complication, which is often 4 weeks from injury. Uniquely, the return to sport was unaffected by the duration of surgery ( $p = 0.0172$ ), fracture healing ( $p = 0.734$ ), and the position of the soccer players ( $p = 0.614$ ). Another finding is there is association in the use of graft with the years of fracture<sup>14</sup>. The older the fracture is, the likelihood of graft use is greater ( $p < 0.05$ ). The delay in surgery may result in higher risk of the bone graft use by 1.015 times compared to short delay. Similarly, Anastasio et al. (2022) measured the VAS and AOFAS scores after intramedullary screw fixation. It is found that VAS and AOFAS scores improved significantly<sup>16</sup>.

The articles showed that intramedullary screw fixation in its role as a treatment of the fifth metatarsal fractures increased union time and decreased repeat fracture in athletes if compared to immobilization<sup>21-24</sup>. Other than that, the technique also showed faster athletes' sport return. In the study by Morimoto et al. (2021), no complications were found after surgery. Zazueta-Arnaud et al. (2022), Bucknam et al. (2020), Anastasio et al. (2022), Khurana et al. (2020), Anastasio et al. (2022), Bucknam et al. (2020), Grant et al. (2020) also found similar results<sup>13,15-19</sup>. The safety regarding postoperative outcomes was related to the skill of the surgeon. Screw insertion needs proper and precise procedure of screw entry into the fifth metatarsal which is curved. The surgeon must avoid the break of screw or excessive cortex penetration, metatarsalgia, peroneus brevis tendon rupture, sural nerve irritation, or reduction that is inaccurate in result with no complication<sup>7,19</sup>. Most of the studies showed that 12 weeks is the average time of return to sports after intermedullary screw fixation of the fifth metatarsal proximal for either zone II or zone III fractures. As mentioned by Zazueta-Arnaud et al. (2022), the patients' satisfaction and performance was normal, scored from FAAM-Sp Sports Subscale Score<sup>19</sup>.

In performing intramedullary screw fixation, it is quintessential to evaluate the osseous characteristics of the fracture<sup>11,25</sup>. Neglecting cortical quality, size, and shape can lead to complications in the surgery. A few techniques to reduce the incidence of complications are the use of screws with a larger diameter, threads' passage into the fracture site distally, pointed reduction forceps percutaneous placement, and evaluating the entry place and position into the medullary canal<sup>26,27</sup>. The right positioning is described as high and inside, showing that improper placement may result in refracture of the bones. The intramedullary screw fixation may be a treatment means with good result of osseous healing, weightbearing, and return to sport for high-level athletes if safety is always considered such as the previously mentioned<sup>28</sup>. Based on the studies, the refracture rate of intermedullary screw fixation was also low, despite the need of skilled technique<sup>4</sup>.

This study has several limitations. There is a lack of data on the screws' type, in which only one study specifically describes about the screw type. However, this systematic review has similar results between the articles. In the past five years, there are only case series studies and a few cohort studies that were found, hence the needs to conduct high level of evidence research such as case control or randomized clinical trial to specifically summarize the advantages and disadvantages of intramedullary screw fixation for proximal fifth metatarsal zone II and III fractures in athletes.

## 4. CONCLUSION

This review highlighted the advantages and disadvantages of intramedullary screw fixation as the procedure to proximal fifth metatarsal zone II and zone III fractures in athletes. The approach is generally safe with the consideration of surgeons' skill in order to achieve appropriate outcomes. This study is a basis for the application of intramedullary screw fixation and for further studies in metatarsal fractures.

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