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## Stress fracture of the second proximal phalanx of the foot in teenage athletes: Unrecognized location of stress fracture



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### ABSTRACT

**Background:** Adolescent athletes are a high-risk population for stress fractures. We report four cases of stress fractures of the second proximal phalanx, which had not been previously diagnosed as the location of the stress fracture of the foot, in teenage athletes.

**Case report:** All fractures were on the plantar side of the proximal phalangeal base, and the oblique images of the plain radiograph clearly depicted the fractures. Notably, three out of the four patients had histories of stress fracture of other locations. While three athletes with acute cases were able to make an early return to play with simple conservative management, the chronic case required surgical treatment for this rare injury.

**Conclusion:** Although a rare injury, it is important that clinicians be aware of this type of stress fracture, as a timely diagnosis can avoid the need for surgical treatment and allow an early return to play.

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### Introduction

Stress fractures commonly occur in the foot and ankle, due to the high stress associated with weightbearing on relatively small bones.<sup>1,2</sup> Adolescent athletes are a high-risk population for stress fractures, due to the rapid increase in the amount and/or intensity of their involvement in sports.<sup>3,4</sup> Early diagnosis and timely management are important for a successful clinical outcome and an early return to play.<sup>5</sup> Late identification may predispose the injury to non-union of the bone fragments and necessitate surgical intervention rather than conservative management.<sup>6</sup> However, the diagnosis of fracture is frequently missed, particularly in cases of uncommon locations.<sup>6</sup> While common locations of stress fracture in the foot include the metatarsal, navicular, and calcaneus, they can also occur in almost all tarsal bones, such as the cuneiform,

cuboid, and first proximal phalanx. Therefore, a high index of suspicion and early investigation are necessary. We report four cases of stress fractures of the second proximal phalanx, which had not been previously diagnosed as the location of the stress fracture, in teenage athletes. While athletes with acute cases were able to make an early return to play with conservative management, the chronic case required surgical treatment for this rare injury.

### Case reports

#### Case 1

A 15-year-old male soccer player presented with a one-week history of pain and swelling in the right second metatarsophalangeal joint. He had a history of lumbar spondylolysis two years before the onset of his foot pain. He had no relevant history of trauma or systemic musculoskeletal disease. Foot malalignment, such as cavus foot or flatfoot, was not observed on physical examination. No specific finding was noted on the radiographs of the foot at the first visit (Fig. 1A and B). However, the axial fat-

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**Fig. 1.** Case 1. A 15-year-old male soccer player. (A) Dorsoplantar and (B) oblique radiographs of the second metatarsophalangeal joint at the first visit are unremarkable. (C) Axial fat-suppressed T2-weighted magnetic resonance image shows high signal areas in the proximal phalanx and surrounding soft tissue (arrow).

suppressed T2-weighted magnetic resonance images exhibited high signal areas in the base of the second proximal phalanx, as well as in the surrounding soft tissue (Fig. 1C). Based on the clinical and radiographic findings, the lesion was diagnosed as a stress fracture of the second proximal phalanx.

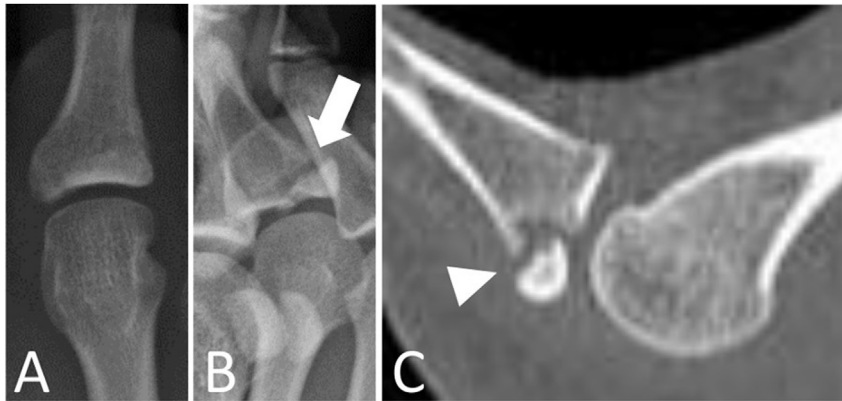
The patient was instructed to stop sports participation, although weightbearing and daily activities were not restricted. The pain and swelling were relieved by the follow-up visit after four weeks, and the patient gradually returned to play. The radiographs taken eight weeks after the first visit showed a clear fracture line and callus formation on the plantar side of the proximal phalangeal base (Fig. 2A and B). Three years later, the patient visited our clinic again for treatment of a stress fracture of the fifth metatarsal on the same foot. The radiographs showed complete healing of the second proximal phalangeal stress fracture (Fig. 2C).

#### Case 2

A 15-year-old male soccer player was referred to our clinic with pain and swelling in the right second metatarsophalangeal joint. He was initially diagnosed as having inflammation of the joint, and received physical therapy. The patient continued to play soccer and the pain persisted for 12 months. He had a history of spondylolysis six months before his first visit, and also had stress fractures in the bilateral tarsal navicular that were already under treatment. On physical examination, a flexible claw toe deformity of the second toe was noted. The radiographs of the second metatarsophalangeal joint revealed a fracture on the plantar aspect of the second proximal phalangeal base (Fig. 3A and B). Similar to Case 1, the fracture line was clearly depicted on the oblique image (Fig. 3B). On the sagittal images of computed tomography, the fracture fragment on



**Fig. 2.** Case 1. (A) Dorsoplantar and (B) oblique radiographs of the second metatarsophalangeal joint after eight weeks clearly depict the fracture line on the plantar side of the proximal phalangeal base and the callus formation (arrow). (C) Oblique radiograph three years after injury. The fracture is completely healed (arrowhead).



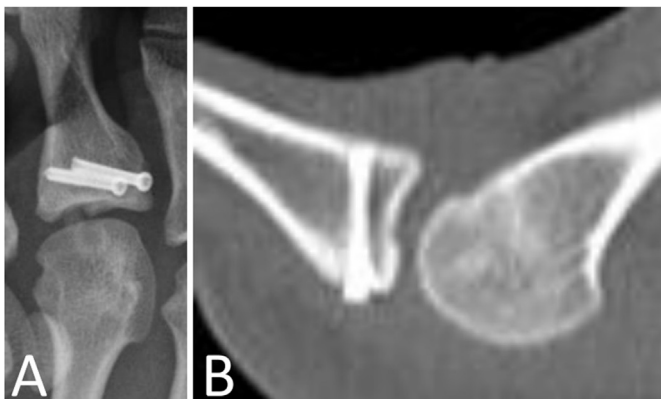
**Fig. 3.** Case 2. A 15-year-old male soccer player. (A) Dorsoplantar and (B) oblique radiographs of the second metatarsophalangeal joint at the first visit. The fracture line (arrow) is clearly shown on the oblique image. (C) Sagittal computed tomographic image exhibits a marginal sclerosis on the plantar fragment (arrowhead) and dorsal subluxation of the dorsal fragment.

the plantar side involved approximately 30% of the articular surface (Fig. 3C). The fracture margin of the plantar fragment had a bone sclerosis, suggesting the chronicity of lesion. From the clinical and radiographic findings, the lesion was diagnosed as a stress fracture of the second proximal phalanx.

The patient was instructed to refrain from participating in high-impact training, such as sprinting and cutting, for one month. This failed to alleviate the pain. Due to the long-standing pain and development of the claw toe deformity, internal fixation of the fracture was performed. A 3-cm longitudinal incision was made over the dorsal aspect of the second metatarsophalangeal joint. The joint capsule was incised and the fracture site was exposed. After debridement of the scar tissue between the fracture fragments using a curette, the fracture was fixed using two cannulated screws (Asnis micro 2mm, Stryker, Kalamazoo, MI, USA) with additional temporary fixation of the joint using two K-wires. Postoperatively, the patient was not allowed to bear any weight for four weeks. Then the K-wires were removed, and weightbearing with the heel was allowed. The patient started dorsiflexion exercise of the joint and weightbearing with the forefoot six weeks after surgery. The patient returned to full athletic activity after four months with no pain. At two years after surgery, the radiographs and computed tomographic images showed a union of the fragments (Fig. 4A and B). The claw toe deformity resolved postoperatively.

#### Case 3

A 13-year old male baseball player presented with a six-week



**Fig. 4.** Case 2. (A) Oblique radiograph and (B) sagittal computed tomographic image of the second metatarsophalangeal joint two years after surgery. The fracture is healed.

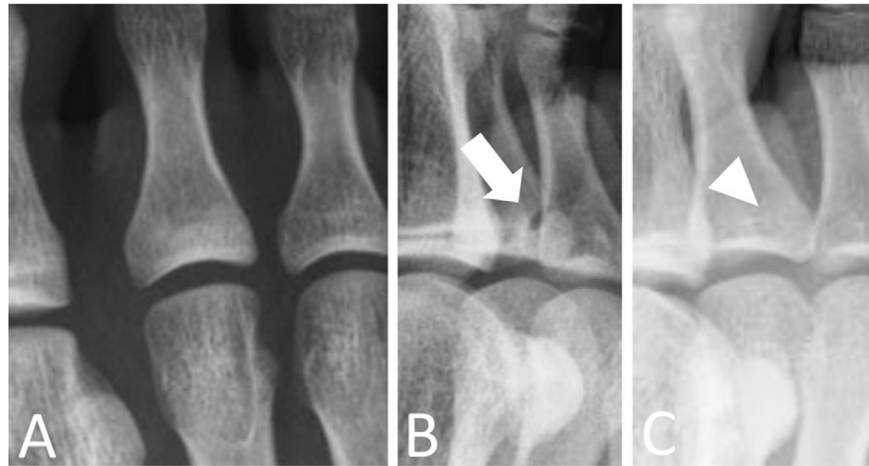
history of pain and swelling in the right second metatarsophalangeal joint with an insidious onset. He had a history of lumbar spondylolysis two years before the onset of his foot pain. Swelling and tenderness on the plantar side of the second metatarsophalangeal joint was noted on physical examination. The oblique radiograph of the second metatarsophalangeal joint showed a fracture on the plantar side of the second proximal phalangeal base (Fig. 5A and B). The patient was instructed to stop sports participation, while weightbearing and daily activities were not restricted. He was also prescribed a custom-made foot orthosis with a medial arch support and a metatarsal pad for unloading on the fracture site. The pain and swelling subsided at the follow-up visit after seven weeks, and the patient gradually returned to play. Four months after the initial visit to our institution, the patient returned to full baseball activity with no pain. The radiographs showed complete fracture healing (Fig. 5C).

#### Case 4

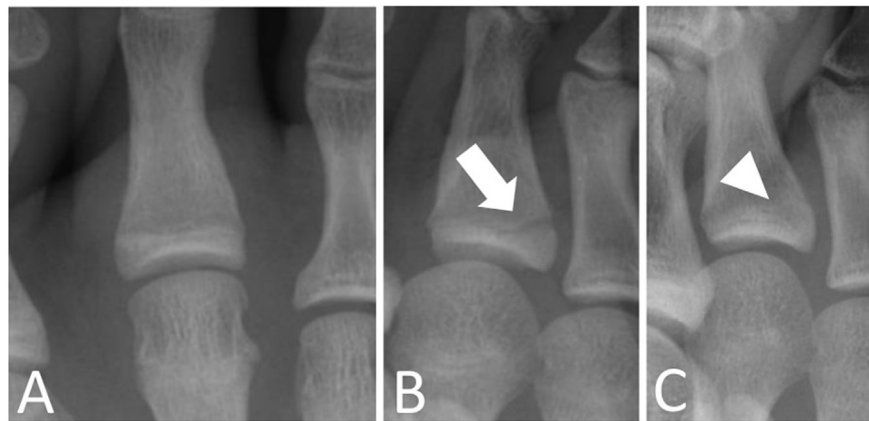
A 16-year-old male soccer player presented with pain and swelling in the right second metatarsophalangeal joint. The pain started one week before he visited the clinic. He had no history of stress fracture in other location, nor history of trauma or systemic musculoskeletal disease. Similar to the other three cases, the oblique radiograph of the second metatarsophalangeal joint clearly depicted a fracture line on the plantar aspect of the second proximal phalangeal base, although the fracture was not visible on the dorsoplantar view (Fig. 6A and B). The patient was advised to refrain from sports participation, and weightbearing and daily activities were not restricted. The pain and swelling were relieved by the follow-up visit after four weeks, and the patient gradually returned to play. The fracture healed on the oblique radiograph taken eight weeks after the first visit (Fig. 6C). The patient was able to return to full activity with no recurrence of pain.

#### Summary of four cases

Table 1 summarizes the characteristics of the patients we experienced. All four patients were teenage male athletes, and notably, three out of the four patients had histories of stress fracture of other locations. No patient had obvious foot malalignment on visual assessment. All fractures were on the plantar side of the proximal phalangeal base, and the oblique images of the plain radiograph clearly depicted the fractures. In three cases (Case 1, 3, and 4), the diagnoses were made in the acute phase of injury,



**Fig. 5.** Case 3. 13-year old male baseball player. (A) Dorsoplantar and (B) oblique radiographs of the second metatarsophalangeal joint at the first visit. The fracture is depicted on the oblique image (arrow), but not on the dorsoplantar image. (C) Oblique radiograph four months after the first visit shows fracture healing.



**Fig. 6.** Case 4. A 16-year-old male soccer player. (A) Dorsoplantar and (B) oblique radiographs of the second metatarsophalangeal joint at the first visit. Similar to the other cases, the fracture line is visible on the oblique image (arrow). (C) Oblique radiograph eight weeks after the first visit. The fracture is healed.

**Table 1**

Patient characteristics.

No	Age	Sports	History of stress fracture at other location	Interval between onset and diagnosis	Diagnosis	Treatment	Bone union
1	15	Soccer	Spondylolysis Fifth metatarsal	1 week	MRI	Restriction of sports activity	+
2	15	Soccer	Spondylolysis Tarsal navicular	1 year	Radiograph	Surgery	+
3	13	Baseball	Spondylolysis	6 weeks	Radiograph	Restriction of sports activity, orthosis	+
4	16	Soccer	None	1 week	Radiograph	Restriction of sports activity	+

between one week and six weeks after the onset of pain. Non-operative management, including activity modification and foot orthosis, successfully led to pain relief and bone union in these cases. In the other patient (Case 2), the diagnosis was made after one year of persistent pain. Therefore, the patient had to undergo operative treatment to achieve bone union.

We obtained written informed consent from all patients and patients' parents, and the Research Ethics Committee of our institute approved this case report.

## Discussion

Almost all tarsal bones may be at risk of stress fracture.

Regarding the phalangeal bones, stress fractures of the first proximal phalanx have been reported.<sup>7,8</sup> Furthermore, stress reactions in the first distal phalanx and fifth proximal phalanx can be identified using magnetic resonance imaging.<sup>9</sup> However, to our knowledge, only one case of stress fracture of the second proximal phalanx has been previously reported.<sup>10</sup> Although a rare injury, it is important that clinicians be aware of this type of stress fracture, as a timely diagnosis can avoid the need for surgical treatment.

Nonoperative management methods, including activity modification and foot orthosis, were successful for the three acute cases. The patients returned to athletic activity within seven weeks without recurrence. The patient reported by Pitsis et al.,<sup>10</sup> who also had an acute injury, was managed with nonweightbearing for six

weeks followed by shoe orthosis, resulting in bone union. In the chronic case (Case 2), activity restriction failed to relieve the pain, and a claw toe deformity developed. Internal fixation of the fracture was necessary to achieve bone union. Moreover, it took four months for the patient to return to athletic activity after surgery. Again, treating physicians should be aware that stress fractures can occur in the second proximal phalanx. Furthermore, as is the case with high-risk stress fractures in other locations,<sup>1</sup> early diagnosis may be important for early return to play and to avoid surgical intervention.

The diagnosis was not difficult in these cases because the radiographs clearly depicted the lesion. Specifically, the oblique view of the radiographs of the foot clearly showed the fracture line on the plantar aspect of the proximal phalangeal base in three out of the four cases to confirm diagnosis. Similarly, in the case reported by Pitsis et al.,<sup>10</sup> the diagnosis was made based on the plain radiographs. In Case 1, MRI was useful for early diagnosis when the fracture was not visible on the plain radiographs. Other pathologies, including Freiberg disease, injury of the plantar plate, stress fracture of the second metatarsal shaft, and inflammatory joint disease, should be considered as possible causes of the pain in the second metatarsophalangeal joint. In our cases, careful imaging assessment led to a correct diagnosis.

Interestingly, three out of the four patients had a history of stress fractures at other locations, including the navicular, fifth metatarsal, and pars interarticularis (spondylolysis). This suggests that these patients might have had risk factors that predisposed them to multiple stress fractures. While excessive training<sup>11–13</sup> and high-impact activity<sup>13</sup> are widely recognized as risk factors for stress fractures, Korpelainen et al.<sup>14</sup> reported that pes cavus, leg-length discrepancy, and excessive forefoot varus were the anatomical risk factors for multiple stress fractures. Furthermore, there are numerous other risk factors, including low serum 25-hydroxyvitamin D levels,<sup>15,16</sup> high serum parathyroid hormone levels,<sup>15,17</sup> low bone mineral density,<sup>11,17</sup> poor physical condition,<sup>17</sup> and psychological stress.<sup>12</sup> Unfortunately, due to the retrospective nature of this report, we did not assess whether or not our patients had such factors.

A possible pathomechanism of the stress fracture is the following: the plantar plate, the primary stabilizer of the metatarsophalangeal joint against dorsal subluxation,<sup>18</sup> is attached to the plantar side of the proximal phalangeal base; repetitive traction forces are applied to the insertion site, with dorsiflexion of the joint during sports activity, which may cause stress fracture. However, the repetitive dorsiflexion of the joint alone may not fully explain the pathomechanism of this type of rare injury, and the cause might be other biomechanical factors. For example, similar avulsion-type stress fractures can occur at the base of the proximal phalanx of the hallux. The presence of hallux valgus is thought to be the predisposing factor because it increases the traction force at the plantar medial edge of the first proximal phalanx.<sup>7</sup> For fifth metatarsal stress fractures, protrusion of the fifth metatarsal head is associated with refracture after surgical treatment.<sup>19</sup> Further research is necessary to clarify the pathomechanism of stress fractures of the second proximal phalanx.

## Conclusion

In conclusion, we report four cases of stress fracture of the

second proximal phalanx. As simple conservative management was successful in the acute cases, the recognition and timely diagnosis of this injury help to avoid surgical intervention and allow an early return to play.

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## Conflict of interest

The author(s) have no conflicts of interest relevant to this article.

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