CASE REPORT

Focused extracorporeal shockwave therapy for bilateral fatigue fractures of the proximal phalanges in the great toes : A case report

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Abstract : We report a case of a 14-year-old male sprinter with bilateral fatigue fractures of the proximal phalanges in the great toes. The patient and his guardian wished for an early return to sports; therefore, focused extracorporeal shockwave therapy (FSW) was administered instead of the traditional surgical treatment for bilateral cases. Four weeks after starting treatment, tenderness had disappeared, and he was able to return to sports. Computed tomography at 24 weeks after starting FSW revealed bone healing, and there was no recurrence of the fatigue fractures at the 48-week follow-up. The lesson learned from this case is that FSW offers a novel, less invasive treatment option for athletes with bilateral fatigue fractures of the proximal phalanges in the great toes who wish for an early return to sports without surgery. FSW has analgesic effects and promotes bone healing, resulting in optimal treatment outcomes. FSW should be considered a standard treatment option for this type of fracture. J. Med. Invest. 72 : 207-210, February, 2025

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INTRODUCTION

Fatigue fracture of the proximal phalanx in the great toe is uncommon, with Orava and Hulkko identifying only 2 cases among 369 fatigue fractures in the lower limb (1). This type of fracture causes pain in the metatarsophalangeal joint and is more prevalent in women, appearing on average at around 15.2 years of age (range 8–41 years) (2-8). Hallux valgus is a risk factor for fatigue fracture at this site (3). A bowstring effect created by the extensor hallux longus and the adductor tendons in hallux valgus leads to tension in the medial collateral ligament and the adductor tendons, which affect the proximal phalanx (4). This tension, combined with shearing forces, likely contributes to development of fatigue fractures (3). Such fractures are mainly observed in athletes who play sports that require frequent sprinting and jumping, such as track and field, basketball, and soccer (2, 3, 5-7).

Management of fatigue fractures usually involves conservative treatment. In cases where bone healing is delayed or uncertain, surgical interventions may be considered. Conservative treatment includes halting training, restricting weight-bearing on the affected limb, using a plaster cast, and prescribing insoles. In surgical interventions, internal fixation (3-6), tension band wiring (7), and corrective osteotomy (3) may be considered. When bone union is achieved, a phased return to physical activity is advised (2-8). The average time required to return to sports is 2.7 months for conservative treatment and 2.6 months for surgical interventions (9). In bilateral cases, ensuring sufficient rest can be difficult in patients (10), who often experience pain for a prolonged period (11) and take longer to return to competitive play (12), with several reports advocating surgical intervention in such cases (10, 11, 13).

Focused extracorporeal shockwave therapy (FSW) has been shown to have an analgesic effect (14) and to promote bone healing in cases of nonunion (15, 16) and fatigue fractures (17). This treatment may also be beneficial for fatigue fracture of the great toe. This report describes a case in which FSW was beneficial for an early return to sports and promotion of bone healing in a patient with bilateral fatigue fractures of the great toes.

CASE REPORT

The patient was a 14-year-old boy who had been participating in track and field for a year and training for 2 hours a day 6 days a week. Two months earlier, he had experienced pain in both great toes during training without any history of sprain or trauma. An orthopedic clinic initially diagnosed bilateral epiphysitis of the proximal phalanx of the great toe. The pain returned when he resumed jogging after 2 weeks of rest, prompting a referral to our hospital.

The patient reported being unable to run because of pain during dorsiflexion of the great toes and tenderness on the plantar side of both metatarsophalangeal joints. He had a past history of Sever's disease on the left side which had resolved, but there was no history of significant foot trauma. Plain radiographs revealed a fracture line at the medial base of the right proximal phalanx and sclerotic changes without a distinct fracture line at the medial base of the left proximal phalanx. The hallux valgus angle was 22° on both sides, indicating bilateral hallux valgus (18). The talus-first metatarsal angle was -7° for the right foot and -9° for the left foot, indicating bilateral pes planus (Figure 1) (19, 20). Axial computed tomography (CT) scans revealed oblique fracture lines from the proximal metaphysis to the proximal diaphysis in the proximal phalanx on both sides. Coronal images revealed a fracture line extending from the medial dorsal surface to the lateral surface of the plantar surface (Figure 2), similar to previously reported cases of fatigue fracture of the

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Figure 1. Plain radiographs of both feet obtained at the first visit. (A) Anteroposterior radiograph of the left foot showing sclerotic changes at the medial base of the proximal phalanx and a hallux valgus angle of 22°. (B) Anteroposterior radiograph of the right foot showing a fracture at the medial base of the proximal phalanx and a hallux valgus angle of 22°. (C) Lateral radiograph of the left foot showing a talus-first metatarsal angle of -9°. (D) Lateral radiograph of the right foot showing a talus-first metatarsal angle of -7°.

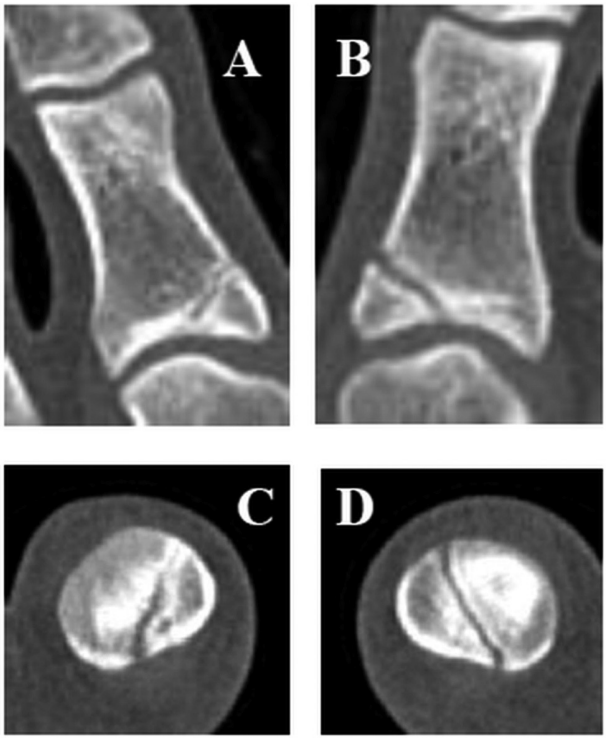

Figure 2. Axial and coronal computed tomography images of the proximal phalanx of the great toe on both sides obtained at the first visit. (A) Axial scan of the left side. (B) Axial scan of the right side. Oblique fracture lines between the proximal metaphysis and proximal diaphysis are seen. (C) Coronal scan of the left side. (D) Coronal scan of the right side. A fracture pattern extending from the medial dorsal surface to the lateral surface of the plantar surface can be seen.

proximal phalanx (10, 11). The epiphyseal lines were closed, which excluded phalangeal epiphysitis. Given the lack of a history of trauma and the imaging findings, we diagnosed bilateral fatigue fracture of the medial base of the proximal phalanx. We were concerned that conservative treatment in a bilateral case such as this one might result in inadequate rest and prolonged bone healing. Therefore, surgical treatment was considered to ensure bone healing. However, the patient was reluctant to undergo surgery, as he wished for an early return to sports so that he could compete at a high level in a competition 2 months later.

FSW was started using a multimodality shockwave system (Duolith SD1 T-Top ; Storz Medical, Tägerwilen, Switzerland) and custom-fitted shoe-insert insoles with arch support were prescribed to maintain foot alignment and correct mechanical stress distribution across the metatarsophalangeal joint. Depending on the patient's pain level, 2500 impulses were administered at either 0.20 mJ/mm² or 0.25 mJ/mm². This treatment was applied weekly and did not require local anesthesia. There were no adverse events, apart from transient mild redness at the site of application. The patient was advised to rest and avoid sports activities. No plaster immobilization or weight-bearing restriction was imposed. Four weeks after starting treatment, the tenderness in the metatarsophalangeal joints had resolved. Therefore, the fracture locations were identified by ultrasonography to determine the exact sites for application of FSW, with treatment adjusted every 2 weeks. At that time, the patient initiated a gradual return to sports, starting with light jogging, and we carefully monitored clinical symptoms to determine the pace of return to sports. Although MRI would have been useful for evaluating the bone stress response in order to guide the progression of loading, it was not performed in this case. No adverse symptoms developed, and he progressed to more intensive training. During competitions, he experienced only minor pain

with no decline in performance. No analgesics were required. He returned to full training and competed in the event after 8 weeks of treatment. By 15 weeks, his activity-related pain had resolved. After 24 weeks of treatment, he reported no pain, and plain CT scans showed that the fracture lines were becoming indistinct in both proximal phalanges (Figure 3A and B). At this time, FSW had been performed for 24 weeks and was completed on CT findings indicating progression of bone union. There is no established protocol regarding the frequency and duration of FSW irradiation. In the present case, the decision to complete treatment was made in reference to imaging findings. At the final follow-up 48 weeks after starting FSW, the patient remained pain-free with no recurrence of the fatigue fractures (Figure 3C and D).

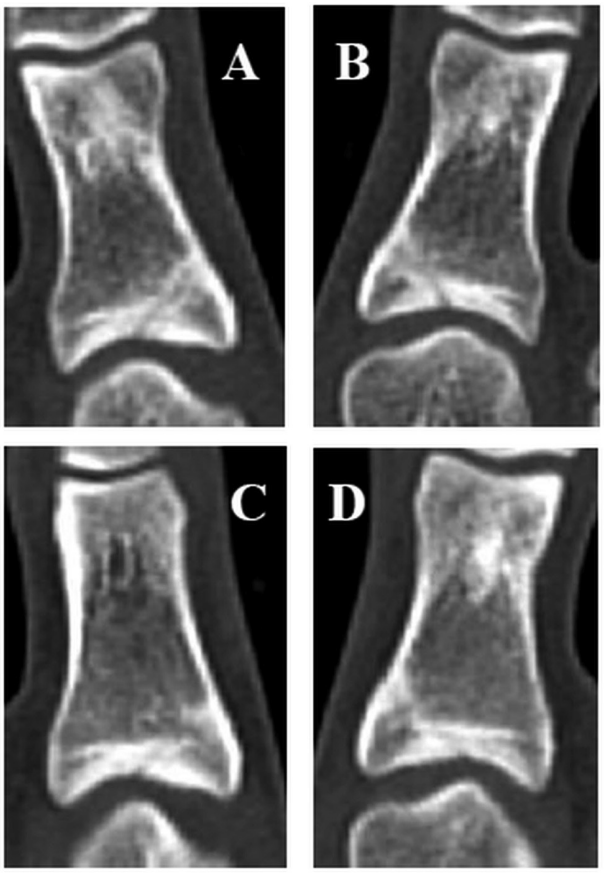

Figure 3. Axial computed tomography images of the proximal phalanx of the great toe on both sides obtained after (A, B) 24 weeks and (C, D) 48 weeks of focused extracorporeal shockwave therapy. (A) Left and (B) right sides both show obscuration of the fracture lines in the proximal phalanges. (C) Left and (D) right sides show no recurrence of the fatigue fractures.

DISCUSSION

We learned an important clinical lesson from this case. FSW was effective for rare bilateral fatigue fractures of the proximal phalanges in the great toes, resulting in an earlier return to sports and bone healing compared with typical conservative and surgical treatments. This favorable outcome was aided by the analgesic effects and bone-regenerating properties of FSW.

This case demonstrated the potential of a novel treatment option for rare bilateral fatigue fractures of the proximal phalanges in the great toes. Moretti *et al*. and Taki *et al*. reported successful outcomes using FSW for fatigue fractures of the lower limbs and trunk that were resistant to conventional conservative and surgical treatments (17) (21). Our findings suggest that FSW may also be effective for proximal phalanx fatigue fractures, especially in rare bilateral case. Four cases of bilateral fatigue fractures have been reported ; 3 underwent surgical treatment, and 1 received conservative treatment. The 3 cases underwent surgical treatments required 8 (10), 12 (11), and 24 weeks (13), respectively, to return to sports, while the case treated conservatively took 22 weeks due to prolonged pain in one toe (12). Therefore, surgical treatment has been somewhat predominant in bilateral cases, with the disadvantage of requiring a gradual return to sports following bone healing. In this case, less invasive FSW allowed the patient to return to sports within 4 weeks of starting treatment and to achieve bone healing at follow-up. This new treatment option for bilateral cases is significant, as it facilitated an earlier return to sports and bone healing compared with traditional treatments.

FSW contributed to successful clinical outcomes through its analgesic effect and promotion of bone healing. The analgesic effect is attributed to the induced degeneration of free nerve endings (22) and a reduction in pain-transmitting substances (23), resulting in an early return to sports without deterioration of performance, even before complete fracture healing. In this case, the analgesic effect led to the disappearance of tenderness at the fracture sites 4 weeks after starting treatment, and there were no recurrences thereafter. Regarding the promotion of bone healing, Delius *et al*. noted that FSW induce periosteal detachment and trabecular microfractures with hemorrhages, thereby stimulating fracture healing (24). Moreover, Wang *et al*. reported that the mechanism of FSW first stimulates the early expression of angiogenesis-related growth factors, including eNOS (endothelial nitric oxide synthase), VEGF (vascular endothelial growth factor), and PCNA (proliferating cell nuclear antigen), and then induces neovascularization that enhances blood supply, increases cell proliferation, and ultimately leads to tissue regeneration necessary to repair tendon or bone tissues (25). The patient returned to sports after the resolution of tenderness at the fracture site, which indicated early symptom relief. Although it did not appear that complete bone union had occurred at this stage, the analgesic effects of FSW enabled a safe return to sports activities. While there was a risk of recurrence due to continued athletic stress, the bone regeneration promoted by FSW provided sufficient healing potential to overcome this risk. This was confirmed by CT at 6 months after starting treatment, which revealed bone healing. Although insoles may help distribute stress across the metatarsophalangeal joint, their ability to achieve bone union when used alone remains a matter of debate.

In summary, we reported on an athlete with rare bilateral fatigue fractures of the proximal phalanges in the great toes who had undergone FSW and achieved an early return to sports and bone healing. FSW is a novel treatment option for such fractures, which have been managed mainly through surgery. Characterized by its analgesic effects and promotion of bone healing, FSW is less invasive than traditional surgery and could be particularly beneficial for athletes who prefer to avoid surgery and for those who may face a prolonged recovery time before resuming their sports activities.

DECLARATION OF COMPETING INTERESTS

The authors declare no conflicts of interest.

STATEMENT OF INFORMED CONSENT

The patient is not identifiable by the information presented in this report. The patient and his guardians provided oral informed consent for publication of this case report.

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