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Extracorporeal shockwave therapy for the treatment of scaphoid delayed union in a tennis player: A case report

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ABSTRACT

Operative procedures are considered the gold standard when treating delayed union or non-union of the scaphoid despite their considerable complexity and the risk of intraoperative complications. Although extracorporeal shockwave therapy has been reported as a non-invasive treatment option for non-union cases, only a few papers on delayed union or non-union of the scaphoid have been published. A 57-year-old man with delayed union of a scaphoid fracture was treated with extracorporeal shockwave therapy and showed complete bone healing with promising results two months after the start of treatment without undergoing surgery. This result indicated that extracorporeal shockwave therapy could be an option for treating delayed union of scaphoid fractures.

Introduction

Extracorporeal shock wave therapy (ESWT) is a non-invasive form of treatment that has been developed from extracorporeal shock wave lithotripsy in the field of urology [1]. In 1991, Valchanou et al. reported its effectiveness in treating various delayed unions and non-unions for the first time [2]. ESWT is reportedly effective for managing delayed union and non-union of various fractures, such as long bone and metatarsal fractures [3,4]. Surgical treatment is the gold standard for delayed union and non-union of scaphoid fractures, with only a few reports of successful outcomes after conservative treatment and low-intensity pulsed ultrasound (LIPUS) [5] and ESWT [4,6]. The choice of treatment for delayed union of scaphoid fractures remains controversial. Here, we report promising outcomes after using ESWT for delayed union of scaphoid fractures.

Clinical case

A 57-year-old man sustained an injury after falling on his left hand while playing tennis. Diagnosis at a previous hospital revealed "a sprained wrist." He visited our institution three weeks after the injury since his wrist pain did not subside. X-ray and computed tomography scans showed a fracture line at the scaphoid tuberosity (Fig. 1A, B), and MRI with short inversion time inversion-recovery showed a high signal intensity in the same area (Fig. 1C), leading to the diagnosis of a scaphoid tuberosity fracture (Herbert classification, type A1). We immobilized the wrist using a short thumb spica brace since the patient refused to have a cast fixed or undergo surgery. Three months after the injury, computed tomography (CT) showed no osteogenesis and absence of bone union at the fracture

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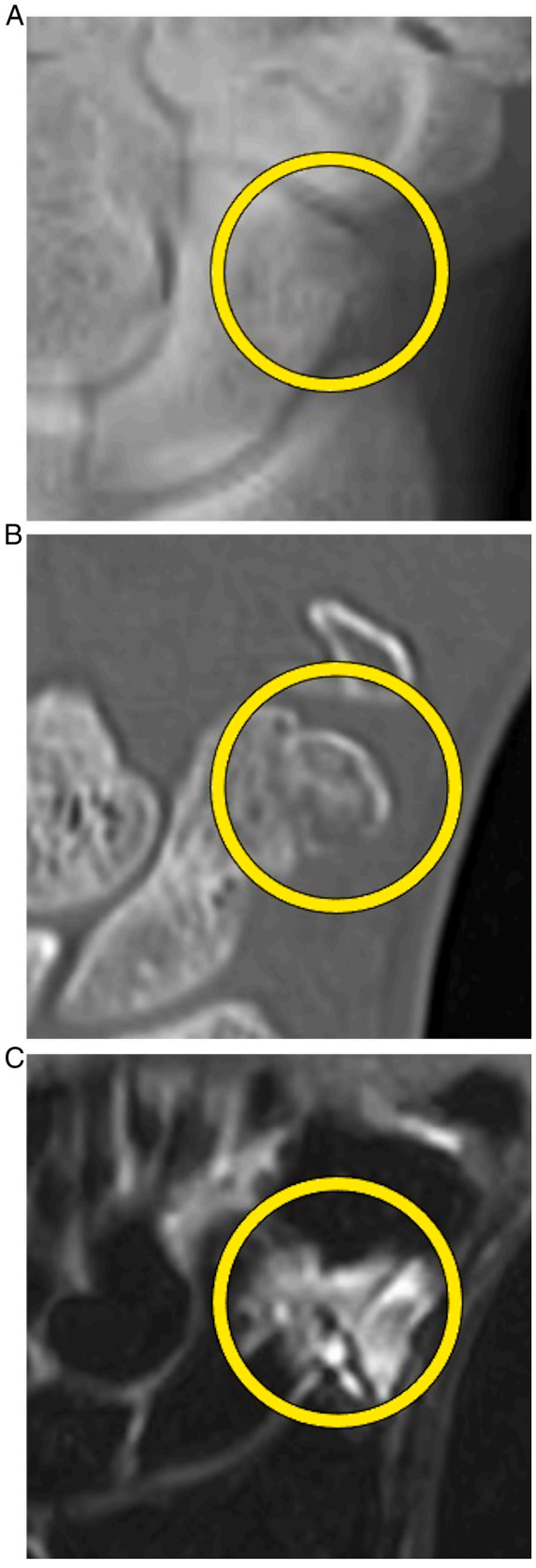

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Fig. 1. A, B: X-ray and CT findings on initial examination (3 weeks post-injury) showed a fracture line at the scaphoid tuberosity. C: STIR of MRI showed a high signal intensity in the same area.

site (Fig. 2). Thus, a delayed union was diagnosed.

Medium-low energy-focused ESWT was performed at the fracture site using a DUOLITH® SD1 T-TOP ultra (Storz Medical AG., Tägerwilen, Switzerland). We performed ESWT once a week, three times, with each session consisting of 2500 impulses. The energy flux density (EFD) was set at 0.15 to 0.25 mJ/mm^2, depending on the patient's pain tolerance limit. A short thumb spica brace fixation was continued until the bone healed. As for the course of treatment, CT showed callus formation at the fracture site one month after starting shockwave therapy, and complete bone healing was observed in two months (Fig. 3A, B). Regarding clinical symptoms, the pain was assessed using the visual analog scale (VAS). The VAS score at the initial examination was 24 mm. It reduced to 8 mm within one month after irradiation and reached 0 mm two months later. No pain or limited range of motion was observed, and the patient was able to return to sports with full capacity.

Discussion

In this case, we treated a patient with a scaphoid fracture missed by a previous doctor using ESWT. The detection of scaphoid fractures is often delayed because they cause less pain and swelling compared to other fractures, and patients themselves tend to underestimate the pain. Nearly 25–50% of scaphoid fractures are reportedly missed during the initial diagnosis, which is performed using radiography alone [7,8]. Because 80% of the scaphoid is covered with cartilage and prevents callus formation, 5%–10% of fractures reportedly progress to pseudarthrosis without displacement. Delayed treatment has also been reported to increase the likelihood of non-union [5]. Surgical treatment is the gold standard for treating delayed scaphoid fracture union, and there are few reports of conservative treatment. In a meta-analysis of LIPUS for delayed union and non-union, with a treatment time of 20 min per day, the fusion rate was 78%, and the mean time required for fusion was 4 months [5].

Among non-surgical options, ESWT has emerged as a reliable and effective non-invasive modality for patients with delayed union or non-union [1]. In ESWT, the term EFD is used to indicate the output. Rompe et al. defined EFD into low (<0.08 m/mm^2), medium (<0.28 m/mm^2), and high (<060 m/mm^2) categories [9]. Initially, mechanical stimulation at high EFD in ESWT was demonstrated to interfere with bone tissue by causing hematoma, followed by revascularization with local cell proliferation [9]. This phenomenon, called closed bleeding, results from a cavitation effect caused by shock waves passing through the non-union focus. The bone structure and cortex/medulla ratio are important for the formation of cavitation bubbles. There is not enough space for cavitation bubbles to occur in the cortex, unlike in the medulla. Cavitation occurs when the shockwave reaches the medulla, which is 2.5 cm deep from the bone surface; however, no cavitation occurs at depths more than 2.5 cm regardless of the EFD. Because the clavicle is superficial and small in diameter, the tibia and femur have suitable cortex/medulla ratios, which are good targets for indicating ESWT. In contrast, the humerus and scaphoid have higher failure rates because of the predominance of the humerus in the cortex and the denseness of the

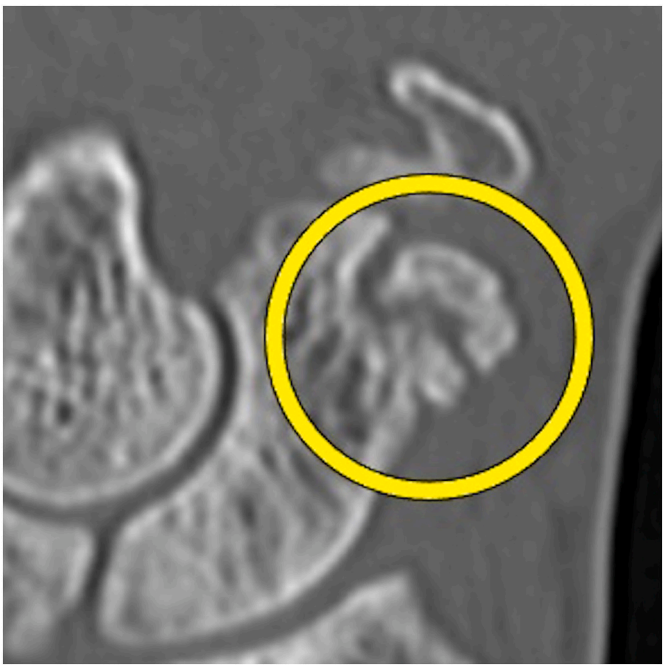

Fig. 2. CT performed three months after the injury showed no osteogenesis, and the bone union was absent at the fracture site.

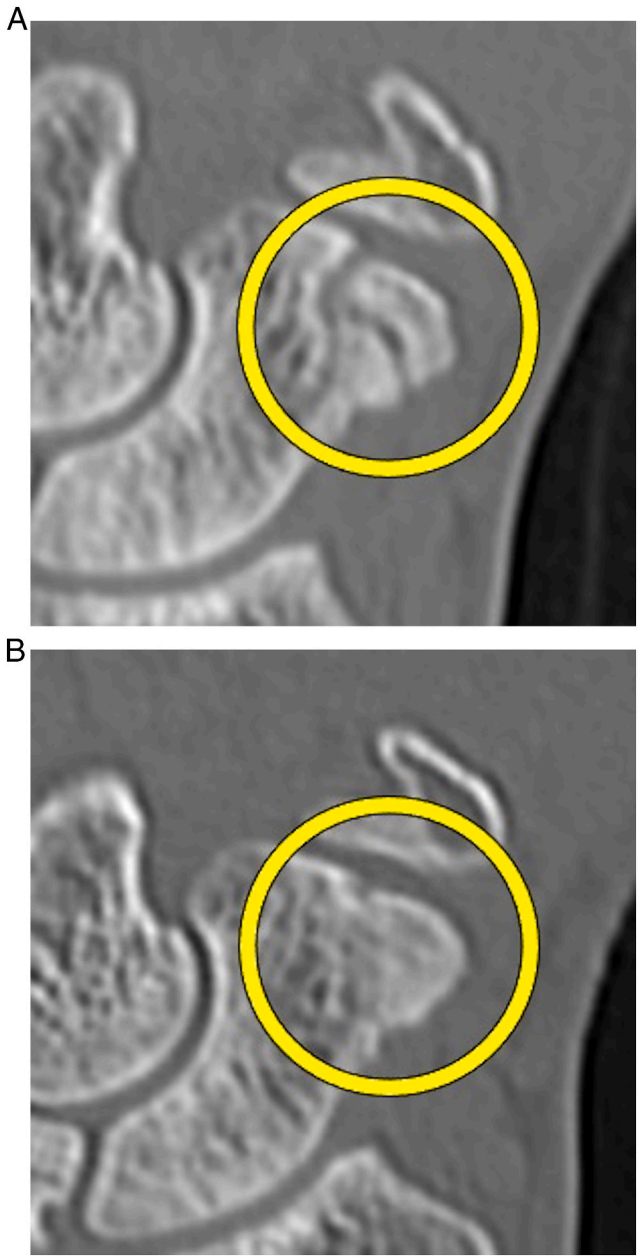

Fig. 3. A, B: CT showed callus formation in the fracture site one month after starting irradiation, and complete bone healing was observed in two months.

medulla, and because the scaphoid bone has a biased cortex/medulla ratio favoring the former [6].

Currently, a working mechanism called "mechanotransduction" has been proposed to explain the treatment. The tensile and shearing forces delivered by shockwaves (medium-low EFD) to the cells and the extracellular matrix (ECM) messengers activate different genes. The osteogenic factors, NO, bone morphogenic protein 2 (BMP -2), transforming growth factor-beta (TGF-β), as well as a neoangiogenic factor, vascular endothelial growth factor, are locally induced. This results in callus formation and subsequent ossification. Medium-low EFD irradiation has a revascularizing biological effect as against a mechanical rupturing effect of high EFD [3,6]. These effects are important in delayed union and non-union foci with very poor capacity, for example, the scaphoid. In other words, medium-low EFD is now considered desirable for delayed union and non-union of the scaphoid, and good results were obtained in this case.

The only study in English literature on the treatment of scaphoid non-union using ESWT was reported by Notarnicola et al. [6] All stable type A fractures were targeted as the initial fracture type; 58 cases were treated using ESWT, while 60 cases were treated using surgery. The irradiation protocol for the ESWT group was EFD 0.09 (0.05–0.12), with 4000 impulses, at 72-h intervals. As a fixation

method, sling fixation was performed between each session, and thumb spica cast fixation was performed for 60 days after the session ended. The ESWT group reported a bone union rate of 75.9% at 2 months and 79.3% at 6 months. No significant difference was observed in the surgery group (76.7% at 2 months and 78.3% at 6 months). In our case, after starting shockwave therapy, the pain at the fracture site disappeared almost entirely at an early stage, and complete bone healing was achieved within two months without any complications.

Conclusion

ESWT is a non-invasive treatment that does not require hospitalization and can be performed in only three visits. Patients with delayed union of scaphoid fractures without instability can be treated using ESWT with a short thumb spica brace alone, without a cast. This approach is physically burdensome for patients and can significantly improve patient satisfaction. In conclusion, we suggest that ESWT is a promising treatment for delayed union of scaphoid fractures.

Meeting presentation

This case was presented at Japanese Society of Clinical Sports Medicine 32nd Annual Meeting, Tokyo, 2021.

Ethics approval and informed consent

The patient provided informed consent for the publication of the report and associated images.

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Declaration of competing interest

None.

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