Case Report
Radial extracorporeal shock wave therapy in a patient with decubitus ulcer after spinal cord injury: a case report

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Abstract: Decubitus ulcer is a common complication in patients with spinal cord injury (SCI) that can be very difficult to treat. We report a case of a 51-year-old man with a right-heel decubitus ulcer after SCI. The ulcer initially covered an area of 4.8 cm × 4.5 cm and had a depth of 2 cm with denervation and hypoproteinemia. After surgical debridement of the wound, the patient received radial extracorporeal shock wave therapy (rESWT) as an alternative to skin flap transplantation to promote wound healing. The rESWT was administered at 10 Hz once or twice per week for 3 months, first from an R15 transmitter and later from a deep transmitter, with an increasing dosage of 2.0-3.5 bar given in 3000-6000 pulses. After 3 months of rESWT, the ulcer was completely healed. This case report demonstrates that rESWT can be an effective treatment option for patients with decubitus ulcers.

Keywords: Radial extracorporeal shock wave therapy, decubitus ulcer, spinal cord injury

Introduction
A decubitus ulcer is an area of localized damage to a tissue surface caused by prolonged pressure from compression or shear [1]. Decubitus ulcers are the most common complication associated with spinal cord injury (SCI), often occurring within a few days following SCI [2, 3]. Many factors contribute to decubitus ulcers in patients with SCI, including loss of motor function and pain and pressure sensation, poor nutrition, anemia, and other factors [4]. The treatment of decubitus ulcer is a major clinical challenge. Patients with decubitus ulcer are often subjected to long hospital stays and devastation of quality of life, resulting in a financial burden to family and society [3, 5].

Conventional therapies for decubitus ulcers include improvement of nutrition, removal of pressure, debridement, treatment of infection, application of dressings, and surgery [4]. Those therapies often fail to result in full healing of the wound, however, and sometimes they provide very little benefit.

Extracorporeal shock wave therapy (ESWT) is a safe, noninvasive, alternative treatment modality that has been used successfully in patients with various musculoskeletal problems, ischemic heart disease, and other conditions [6-8]. In contrast to conventional focused extracorporeal shock wave therapy (fESWT), radial extracorporeal shock wave therapy (rESWT) uses a type of pneumatically generated shock wave that disperses eccentrically from the transmitter without focusing the energy to a targeted spot [9]. Thus, rESWT can be applied to larger and more superficial treatment areas than fESWT. Different transmitters can be used to adjust the penetration depth and energy of rESWT [10, 11], making it possible to use rESWT in a wide variety of clinical situations. Although rESWT is used to treat many diseases and conditions, including carpal tunnel syndrome, hemiplegic shoulder pain syndrome, and muscle spasms, there are few reports of its use in patients with refractory decubitus ulcer [12-14]. Here, we report on a patient with intractable decubitus ulcer who achieved complete recovery after receiving rESWT.
A 51-year-old man presented to the department in March 2016. The patient had a 21 day history of right-heel decubitus ulcer after SCI of the first lumbar vertebra complicated with pelvic fracture due to trauma (Figure 1). The decubitus ulcer started as a blood blister that first appeared one day after the patient underwent internal screw fixation of a first lumbar vertebra fracture. After the surgery, the patient suffered from motor and sensory disturbance of the lower limbs. Within 10 days, the blood blister progressed to a ulcer that penetrated to a depth of 2 cm and covered an area of 4.8 cm × 4.5 cm. The patient was treated with iodophor disinfection solution and external application of traditional Chinese medicine at a local hospital, but the decubitus ulcer worsened in terms of its surface area and depth.

The patient was 173 cm tall and weighed 70 kg before the spinal surgery. Twenty-one days after the spinal surgery, the patient had lost 4 kg of body weight and had the following clinical parameters: white blood cell count 8.34 × 10⁹/L (normal range: 3.5-9.5 × 10⁹/L), neutrophil percentage 80.7% (normal range: 40-75%), platelet count 231 × 10⁹/L (normal range: 125-350 × 10⁹/L), hemoglobin level 130 g/L (normal range: 130-175 g/L), serum albumin level 30.7 g/L (normal range: 30.7-50 g/L), C-reactive protein level 61 mg/L (normal range: 0-8 mg/L), procalcitonin level 0.12 ng/mL (normal range: 0-0.05 ng/mL), and fasting glucose level 4.78 mmol/L (normal range: 3.9-6.1 mmol/L). Renal and liver functions were normal.

The standard treatment for intractable decubitus ulcer involves surgical debridement and skin flap transplantation. Accordingly, the necrotic tissue was surgically debrided from the patient’s right heel by a general surgeon. The wound bled little during the surgery. Because the survival of transplanted skin flaps depends on the local microvessel density and hemoperfusion [15], and the patient suffered from poor circulation and nutritional status and displayed neurological impairment of the lower limbs, we determined that implanted skin flaps might not heal sufficiently and might even become infected or necrotic.

Therefore, as an alternative to skin flap transplantation, we treated the wound with intermittent ultra short-wave and rESWT (STORZ MEDICAL AG, Switzerland). In the first week after the decubitus ulcer was surgically debrided, we treated the patient once with 3000 pulses of rESWT at 10 Hz and 2.0 bar intensity using an R15 transmitter with a 15-mm diameter. For the rESWT application, the ulcer areas were covered by plastic sterile wound dressings (Zhejiang Kanglidi Medical Articles Co., Ltd), and the transmitter was wrapped in one finger of a sterile plastic glove. The procedure was performed without local anesthesia. Transmission gel was applied between the appli-
rESWT in decubitus ulcer

The applicator was moved slowly around the wound area, including at least 3 cm of healthy tissue around the wound edge. After the first rESWT treatment, the patient displayed good growth of local tissue. Therefore, in the following week, we treated the patient twice with 4000 pulses of rESWT at 3.0 bar. After the first 2 weeks of rESWT, the wound area had a rich blood supply and was partly scabbed (Figure 2). Starting in the third week, to accelerate the wound healing process, we replaced the R15 transmitter with a deep transmitter (diameter, 15 mm) and continued treating the patient with 4000 pulses at 3.0 bar twice per week [11]. One month later, the peripheral areas of the ulcer had healed (Figure 3), so we increased the rESWT dose to 6000 pulses at 3.5 bar and 10 Hz applied twice per week. Three months after the start of rESWT, the decubitus ulcer was completely healed (Figure 4).

Discussion

The application of rESWT to a surgically debrided decubitus ulcer on the heel of a patient with SCI resulted in complete healing of the wound after 3 months. Lower-limb decubitus ulcer is reported as a common problem worldwide [16]. Poor healing of decubitus ulcer is a troublesome clinical problem. The management of ulceration may include both non-surgical and...
surgical approaches, depending on the clinical details of the case [17]. The deep tissue penetration and large surface area of the ulcer described in this case report would usually be indications for skin flap transplantation after surgical debridement of the wound. Surgical debridement left a large cavity that drained poorly, however, which increased the risk of infection and treatment failure. In addition, the patient had poor nutritional status and loss of sensory function in the distal tissues as a result of SCI, which greatly increased the risk of skin flap necrosis. Therefore, to promote wound healing, we decided to treat the patient with ESWT, a noninvasive and safe therapy.

ESWT is widely used to treat chronic soft tissue injuries and had beneficial effects in various preclinical and clinical studies [18, 19]. In one study, ESWT significantly reduced the size of digital ulcers and produced no adverse reactions in patients with systemic sclerosis [20]. In patients with deep-partial/full-thickness burns, ESWT played an important role as an adjuvant therapy and reduced burn-associated pruritus [21, 22]. Those clinical results suggest that the enhancing effects of ESWT on wound healing might make ESWT suitable for the treatment of decubitus ulcers. Indeed, there are some reports of beneficial effects of ESWT in the treatment of ulcers; however, those reports described only incomplete healing or excluded deep ulcers [23, 24].

ESWT is classified into fESWT and rESWT on the basis of the reflector design, which in part determines the pressure field and energy [12]. rESWT represents a breakthrough in clinical treatment because of its simplicity and safety. For instance, rESWT requires no anesthesia or image-guided location, and it lessens the risks of adverse reactions compared with fESWT by reflecting the pathology zone [24-26]. Decubitus ulcer is caused by local tissue hypoxia due to extrinsic pressure, friction, shear stress, and excessive moisture on the skin [27]. Because rESWT provides more superficial action over a larger surface area than fESWT, it might be more suitable for application in patients with external structure pathology such as decubitus ulcer [28]. Moreover, in rESWT, the transmitter can be moved during the application in order to achieve a wider range of management. By contrast, fESWT is fixed on one site. In general, the frequency of rESWT (1-22 Hz) is higher than that of fESWT (1-5 Hz). Therefore, if the same pulses are applied, rESWT can be performed in less time than fESWT, which tends to make patients more compliant. For all of those reasons, we decided to administer rESWT to our patient with lower-limb decubitus ulcer.

Although the surgical debridement left a large cavity, the decubitus ulcer was totally healed after 3 months of rESWT. We progressively increased the dose of rESWT according to the observed healing of the wound, eventually reaching a dosage of 6000 pulses at 3.5 bar given from a deep transmitter twice per week. Generally, the higher the dose, the greater the treatment effects, meaning that fewer sessions are required when higher doses are used [29, 30].

The effects of rESWT were excellent, but the exact mechanisms by which rESWT promotes healing of decubitus ulcers remain poorly understood. Shock waves might increase the expression of angiogenesis-related growth factors such as nitric oxide synthase (eNOS), vascular endothelial growth factor (VEGF), and proliferative cell nuclear antigen (PCNA) [31, 32]. Those factors would promote angiogenesis, leading to increased blood perfusion and reduced risk of ischemia, which is a major problem in ulcers [21]. One study found that shock wave therapy enhanced the migration of fibroblasts to wound areas [33], which suggests that shock waves modulate fibroblast recruitment and thus promote tissue remodeling [34]. Other reports showed that shock waves promoted the migration of circulating endothelial progenitor cells to chronically ischemic tissues [35], which suggests that shock wave therapy might accelerate decubitus ulcer healing by stimulating stem cells. Some studies showed that shock waves reduced inflammatory cell recruitment and cell apoptosis in wound areas [19, 34], which might contribute to faster healing. Beyond that, a threshold number of more than 1000 impulses was shown to reduce bacterial growth [36], suggesting that the application of shock waves might help to prevent or even cure infections. In our case study, the large, hypoproteinemic wound on the patient’s lower limb did not become infected, possibly as a result of shock wave therapy.

In conclusion, among the various therapies that can be used to treat decubitus ulcer in the
lower extremities, rESWT represents a safe, simple, and effective treatment option. A patient with decubitus ulcer of the lower limb after SCI was treated with surgical debridement and subsequent rESWT as an alternative to skin flap transplantation. The wound did not become infected after debridement and was completely healed after 3 months of rESWT. Thus, rESWT was a noninvasive and cost-effective alternative to skin flap transplantation for the treatment of a deep and large decubitus ulcer.

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Disclosure of conflict of interest

None.

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