



Treatment of Non-healing, Post-traumatic Wound with High Frequency Ultrasound of 10 MHz: A Case Report

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Case Report

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ABSTRACT

We present a case of a non-healing, post-traumatic wound, which as an alternative to reconstructive surgical intervention, was successfully treated with a non-invasive, high-frequency ultrasound of 10 MHz.

Keywords: Post-traumatic wound; non-healing; non-invasive treatment; high frequency ultrasound; 10 MHz.

1. INTRODUCTION

The treatment of post-traumatic wounds can often be a complex problem for doctors, especially if they develop into the chronic wounds. In such cases, aesthetically and functionally satisfying results can often only be achieved using plastic reconstructive surgery. Whereas the reconstruction of soft tissues can be crucial in order to save the patient's extremities, such interventions are often performed without regard to any subsequent consequences and complications. Open fractures are considered to be particularly problematic because of the potential contamination of the wound. They often cause soft

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tissue and bone infections, which can lead to the partial loss of extremities, with significant limitations in the patients' quality of life.

A reliable, therapeutic alternative solution to reconstructive surgery for the treatment of such wounds, during their transition from acute to chronic wound conditions, does not currently exist. Here, we report a case of a non-healing, post-traumatic wound, which was successfully treated with a high-frequency ultrasound of 10 MHz.

2. MATERIALS AND METHODS

2.1 Epicrisis

A 12-year-old, male patient with a complex, third degree, luxated, comminuted fracture of the ankle after a kart-race accident on 15.07.2011. After immediate care at the place of accident - including repositioning, splinting and analgesic sedation - the patient was transported to a children's surgery department of a maximum care hospital, where he was immediately operated upon. Intra-operatively, the entire joint bands of medial ankle were completely ruptured. The soft tissue was strongly contused and the wound was contaminated by soil. The talus demonstrated multiple shears (Fig. 1). The ligament and nerves as well as the blood vessels were structurally continuous. After intubation anesthesia, the wound was cleansed and the bone fragments were readapted.



Fig. 1. Post-traumatic wound on the day of accident, 15.07.2011

Subsequently, the open repositioning and reconstruction of the capsular-ligamentous complex were carried out using sutures with layer-by-layer wound closure. The intra-operative investigation as well as the post-operative x-ray and CT check showed the correct axial repositioning with the restoration of the articular surface and the readaptation of the multiple bony fragments as far as was possible. This was followed by a further immobilization with a splint.

The initial wound healing process was normal. Three days later, the initial signs of an infection could be seen, with increasing, progressive demarcation. This resulted in a 12x5 cm necrotic zone developing from the medial malleolus up to the Achilles tendon.

Throughout the duration of hospitalization, the patient received antibiotics as well as the local application of antiseptic. Ten days later the patient was released from hospital with a splint and the above-described necrosis. Over the next nine days, the extent of the necrosis intensified – the necrotic area deepened and spread further. In the case of further wound depression or the progression of necrosis, a skin graft would have been needed. The state of the soft tissue was deemed critical by a plastic surgeon consultant.

To avoid surgical intervention, an interdisciplinary decision was made to remove the necrosis (Figs. 2 and 3) and to treat the wound daily with high-frequency ultrasound of 10 MHz in combination with local antiseptic therapy. This decision was based on present case studies as well as on Wellcomet GmbH's pilot study into treatment of *Ulcus cruris* of Kruglikov and Kruglikova (2011), which have demonstrated a rapid wound-healing process, when this technology has been applied to chronic wounds.



Fig. 2. Before the removal of necrosis, 04.08.2011

2.2 Treatment Protocol

Biophysical background for the treatment of chronic wounds with 10 MHz ultrasound as well as with double-frequency ultrasound is the simultaneous modulation of the activity of matrix metalloproteinases (MMPs) and heat shock proteins (HSPs) in the wound. This topic was analysed and referenced in detail in our article Kruglikov and Kruglikova (2011). Detailed description of treatment protocol for chronic wounds with application of these ultrasound waves was presented in the same article. Comparing to this treatment protocol, we applied in this present case of the acute wound, during its transition into the chronic condition, only the 10 MHz ultrasound, since this ultrasound has very limited penetration depth (approximately 3mm), which may be important by acute wounds. The ability of this ultrasound to modulate significantly the production of HSPs and MMPs was investigated in different experiments referenced in Kruglikov and Kruglikova (2011).

Treatments were done with the commercially-available LDM[®]-MED machine (Wellcomet GmbH, Karlsruhe, Germany). The ultrasound intensity was controlled by the digital, ultrasound power meter UPM-DT-10 (Ohmic Instruments Co., USA). Altogether, 29 treatments were delivered pragmatically in outpatient settings. Initially, therapy took place five times a week and then every two days, from the 23rd session. This schedule was connected with relatively short-termed modulation of MMPs and HSPs, which was demonstrated in our preliminary *in vitro* experiments (references in Kruglikov and Kruglikova, (2011). After eight sessions, the treatments ceased for five days. After 22 sessions treatment

stopped for 14 days and, after 26 sessions, for seven days. All interruptions were requested by the patient and his parents and were connected with outpatient art of the treatment. Every interruption was allowed by plastic surgeon consultant.

The following parameters were used: ultrasound frequency – 10 MHz; pulsed 1:2, intensity – initially 1.0 W/cm^2 and from the third treatment – 1.2 W/cm^2 ; treatment time – approximately 20 minutes (from the 15th treatment this was approximately 10 minutes due to the significant reduction of the wound surface). During the treatment both the whole wound and the surrounding tissue at least 3 mm from the wound edges were treated uniformly. Sterile US gel was used as a coupling medium; there was no direct contact of the ultrasound applicator to the wound. The control investigation was done one and four weeks after the last treatment. All treatment results were photo-documented in a standard manner.

3. RESULTS

Figs. 3-8 show a dynamic regression of the wound as the treatment progresses.

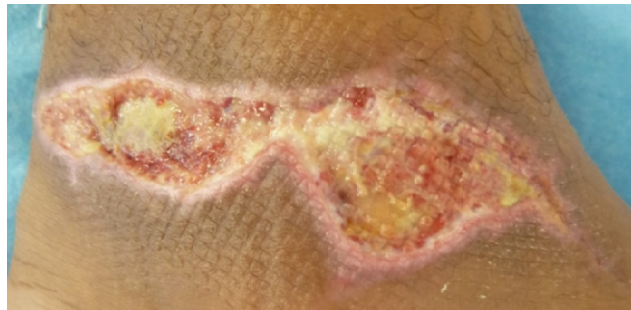


Fig. 3. Before the 1st treatment, 05.08.2011

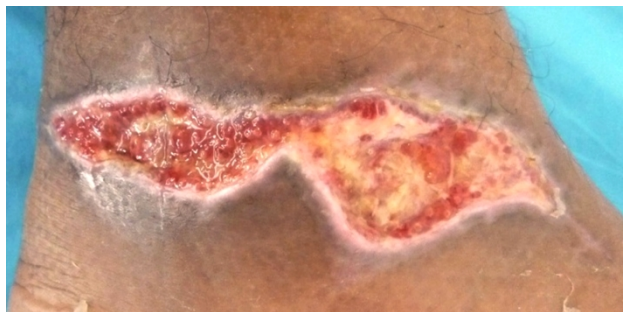


Fig. 4. Before the 5th treatment, 11.08.2011



Fig. 5. Before the 8th treatment, 16.08.2011



Fig. 6. Before the 18th treatment, 05.09.2011



Fig. 7. Before the 24th treatment, 26.09.2011



Fig. 8. Before the 29th treatment, 12.10.2011

Even after the 1st session, the strong granulation of the wound could be clearly observed. In the further course of treatment, the size of the wound surface from the edge to the inside markedly decreased and the granulation layer on the wound floor was developed (Figs. 4-6). These local measures managed to almost completely close of the wound after 22 sessions. During the pause in treatment that followed, the wound demonstrated further spontaneous positive signs of healing (Fig. 7). The last seven treatments were provided merely as a supportive measure.

4. DISCUSSION

Application of the pulsed ultrasound with conventional frequencies of 1 and 3 MHz for the healing of chronic wounds is well known. The results are however very contradictive, the needed treatment time is very long (sometimes over 3 months) and the healing is dependent on the wound surface (detailed discussion in Kruglikov and Kruglikova (2011)). This method is normally not applied to the acute traumatic wounds even during their transition into the chronic condition.

We present here for the first case report concerning the application of a very high frequency ultrasound of 10 MHz in attempt to close the very big, acute traumatic wound with a bad healing prognosis during its transition into the chronic condition. Regular application of this ultrasound could clearly and very rapid improve the state of the wound even without any significant supportive medical care. Comparing with the critical necrotic state of the wound before the first session (Figs. 2 and 3), the wound condition was significantly improved already after 7 sessions (Fig. 5), and the wound was almost closed after one month (Fig. 6), demonstrating to this moment the strong spontaneous healing dynamics. This saved the patient further operations, with their possible complications and the development of stigmatizing scars as well as additional hospitalisations.

Whereas this case was treated pragmatically, we believe the regularity of the treatments, especially during the early period of the treatment course, is of main importance for treatment results. This phenomenon was also observed by some patients with *Ulcus cruris*, which could not be treated daily or at least every two days and consequently demonstrated the delayed healing dynamics comparing to other patients with similar wound conditions (Kruglikov and Kruglikova (2011)). We can hypothesis that normalisation of the wound state during some critical time can significantly improve the healing process.

The treatment was free of both pain and side effects and was accepted well by the patient. Pigmentation on the wound edge was of a post-inflammatory nature and could be neither avoided nor later improved by these treatments.

Whereas the results presented here support our hypothesis that a very high frequency ultrasound of 10 MHz can positively improve the healing of the acute wound during its transition into the chronic state, no final recommendations for the treatment schedule and possible limitations of this method (e.g. the initial state of contamination, dependence on CRP and CBC values, and so on) can be provided. The randomised, controlled study will be needed to make the strict statistical evaluation.

CONSENT

All authors declare that written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

COMPETING INTERESTS

The treatments in this case study were carried out using Wellcomet GmbH's LDM[®]-MED machine.

REFERENCE

Kruglikov, I., Kruglikova, E. (2011). Dual treatment strategy by venous ulcers: Pilot study to dual-frequency ultrasound application. *J Cosm Derm Sci Appl*, 1(4), 157-163.

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