Non-Operative Treatment Of Comminuted Tongue-Type Fracture Calcaneum By Low-Level Laser Therapy Via Promotion Of Bone Healing And Re-Modelling

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Citation

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Abstract

Objective: The current clinical case series assess the use of low-level laser therapy (LLLT) in non-operative care of 7 patients with tongue-type fractured calcaneum with significant comminution who refused surgery without the need of bone-grafting with the aim of early rehabilitation with early ambulation with protected weight bearing

Materials and Methods: The patient cohort consisted of 7 consecutive unselected patients with tongue type calcaneum fracture all with significant degree of comminution. All the patients refused operation and prefer early fracture healing and ambulation with non-operative means.

Results: All patients on serial X-ray as well as CT scan checking not only had solid union of the significantly comminuted fracture, but all had good re-modelling of the buckling and increased width of the calcaneum bone. The calculated p value is statistically significant at $p < 0.01$

Conclusion: LLLT not only enhances fracture healing, it also has the power to help to re-model comminuted fractured calcaneum to spare the patient of operative intervention and at the same time allow early weight-bearing at a mean of 8 weeks, and help prevent unsightly widening of the os calcis bone.

INTRODUCTION

Fracture of the calcaneum tongue type with comminution is commonly treated by orthopedic surgeons with operative intervention with plate and screws as well as frequently require harvest of bone graft from the patient's pelvic bone. However, many a patient nowadays refuse operative intervention as they dislike the idea of surgical scars both at the heel as well as the pelvis. To add to this, albeit operative fixation of comminuted tongue-type fractured calcaneum, orthopedic surgeons frequently advise non-weight bear walking for 12 weeks.

The use of low-level laser therapy in promoting fracture healing of human fractures had previously been reported by the author [1] and also from clinicians in Taiwan [2]. This study represents the first ever study to assess the clinical use of LLLT in enhancing the re-modeling of comminuted tongue-type calcaneum fracture so as to allow early weight bearing without bone grafting, as well as prevention of widening of the breath of the os calcis.

As discussed by the author in his previous publications, advantages of the use of LLLT in fracture healing is manifold. Firstly, the procedure is non-invasive and spare the patient an operative intervention. Operative intervention in general not only involve higher cost, but also it leaves the patient a surgical scar, complications sometimes occur after os calcis operation such as skin necrosis, and donar site morbidity. In addition, a second operation is often required for removal of metallic implant in younger subjects. Secondly, the world literature on LLLT showed it is free of side effects, and have been in use in Europe over 30 years. Thirdly, LLLT administration does not involve higher cost, with the average cost of administration per session same as conventional physical therapy in the author's institute. It should be noted that conventional physical therapy machines do not have bio-modulation effects as does LLLT [3], and thus cannot in effect promote the process of fracture healing.

The author has shown previously in a published article in this journal that LLLT help re-model fractured distal radius[4], this article is the first ever clinical study to reveal LLLT help re-model even comminuted os calcis fractures

MATERIALS AND METHODS

The study population consisted of a series of consecutive unselected 7 patients with a mean age of 37 (range 33 to 41) presenting with both CT scan and X-ray confirmed tongue type os calcis fracture with communition. All of the patients had visited other medical units, all were being offered operative intervention but all 7 subjects strongly refused operation. All patients who enter the study after refused operative intervention consent to the use of LLLT as well as simple brace as the sole treatment modality. Exclusion criteria include history of fracture of the same affected bone, open fracture, sepsis and significant associated soft tissue injury.

The study represented a prospective clinical case series. LLLT of 810 nm wavelength emitting from GaAIAs semi-conductor laser device with 5.4 J per point, power density 20 mW/cm2 was employed. Irradiation was performed on alternate day basis. There was no control group in this study as seldom do patients present with bilateral os calcis fracture of their lower extremity. None of the patient consent to the idea of switch-over study where part of the treatment period was LLLT and part of the treatment being sham light source.

The end point of the current study was to assess the degree of healing at the 12 week mark if any that can be obtained after use of LLLT, as well as the time taken for the fracture to be stable enough for protected weight bearing walking. We also serially assessed the degree of overall satisfaction of the patient with the procedure by a score where 0 represents total dissatisfaction with the procedure, and 10 represented total satisfaction to be filled by the patient at the end of the treatment regimen which represented 12 weeks of LLLT treatment for the current study.

RESULTS

The study period spanned from 2016 to 2019 amongst patients attending wellness pain centre located in in Hong Kong. The male:female ratio among the study population was 6:1 in this study. The mean time for achievement of the fracture healing without any form of operation was 8.5 weeks (range: 7-10 weeks) The mean follow up was 12 months. All fracture proceeded to have solid bone healing besides proper re-modeling. The mean time taken for fracture to be solid enough for protected weight bearing was 8.5 weeks (range: 7-9 weeks)

As for the scoring of the degree of satisfaction, patients were offered brief guidelines of aspects they can take into consideration including: the ability of the procedure for symptom control, the power and appearance of the affected foot, the degree of pain, the activities of daily living, the ability to cope with activities of daily living The patients gave an overall score at the end of the LLLT treatment regimen. The mean score of satisfaction was 9 out of 10 at the end of the study period.

Figure 1 and Figure 2 show the CT scan images after 3-D reconstruction of the fracture os calcis of one of the patients and Figure 3 showing the result of bone-remodeling at 8 weeks.

Figure 1

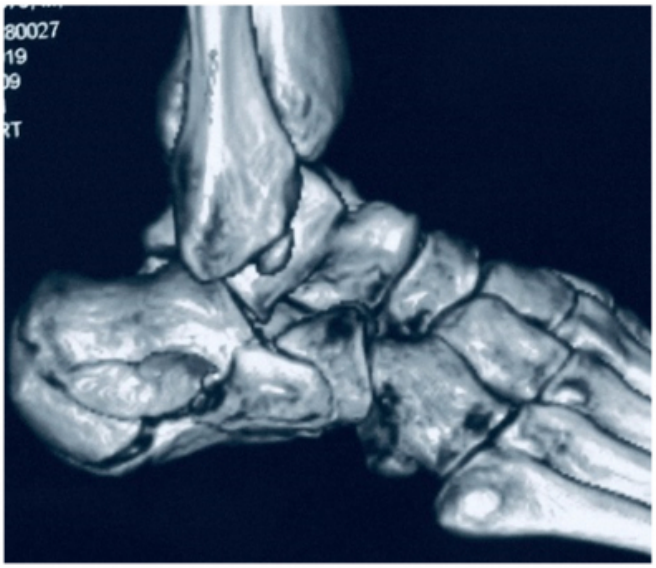
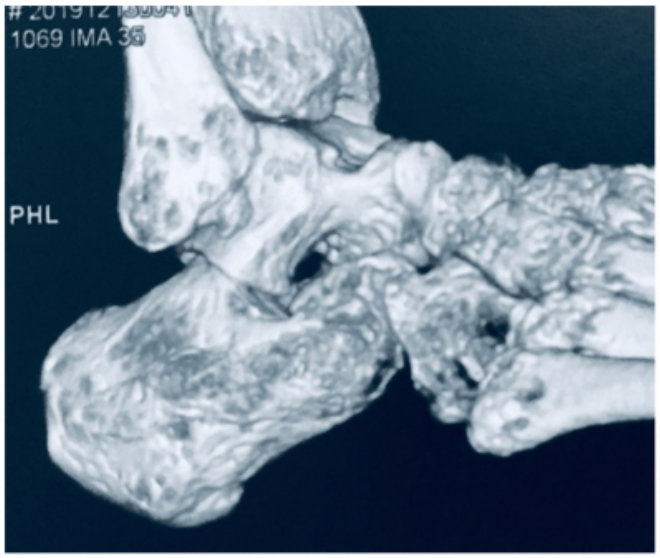


Figure 2

Figure 3



DISCUSSION

Low-level laser therapy (LLLT) involves directing near infra-red lights to tissues with a view to improve healing and reduce pain in the field of Orthopedics. The main mechanism of LLLT involves its biochemical and circulatory effects, viz: the incident radiant energy of LLLT is being absorbed by the cell's chromophore and this process usually involves the Cytochrome system [5], which in turn triggers a cascade of events stimulating ATP synthesis [6]; thus in this way the laser energy is transformed to cellular energy in the form of ATP and this aid in healing the injured body's cells which are usually under oxidative stress. In addition, other LLLT actions include inducing an increase in DNA repair gene expression [7], besides also producing local vasodilatation believed nowadays to be mediated via the nitric oxide pathway [8].

As far as the role of LLLT in fracture healing is concerned; in the past decade, abundant laboratory animal studies had elucidated the possible mechanism whereby LLLT enhances bone healing. The mechanism involved is manifold, including the induction of osteoblast formation and differentiation via increase in bone morphogenic protein BMP2-induced phosphorylation of the Smad 1/5/8 pathway [9]. The same author Hirata also demonstrated that LLLT could stimulate BMPs-induced expression of type 1 collagen, osteonectin, and octeocalcin mRNA. Histological studies [10] also confirmed intense new bone formation surrounded by highly vascularized connective tissue indicative of increased osteogenic activity on LLLT exposure. Lastly, other authors [11] also demonstrated improvement in the mineralization process via enhanced IGF-1 and BMP production.

The author is not aware of any previous clinical studies on the use of LLLT in assessing not only the enhancement of fracture healing, but also the enhancing of re-modeling of even significantly comminuted tongue-type os calcis fractures.

CONCLUSION

The current prospective study of a clinical case series of patients presenting with communited tongue-type os calcis fracture revealed that low-level laser therapy if administered correctly can, on the one hand, augment the bone healing process without recourse to bone-grafting; and on the other hand re-model the fracture so that for the very first time in clinical medicine, correction of fracture communition can be achieved without the use of operative intervention. All patients tolerated very well this non-invasive form of conservative management at an affordable cost comparable to conventional physical therapy.

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