The Internet Journal of Orthopedic Surgery
Volume 27 Number 1

Use of Low-Level Laser Therapy in Correcting Fracture Angulation of Pediatric Distal Radius Fractures Post-Casting

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Citation

D Ip. *Use of Low-Level Laser Therapy in Correcting Fracture Angulation of Pediatric Distal Radius Fractures Post-Casting*. The Internet Journal of Orthopedic Surgery. 2019 Volume 27 Number 1.

DOI: 10.5580/IJOS.54086

Abstract

Objective: The current clinical case series assess the use of low-level laser therapy (LLLT) in correcting residual fracture angulation of distal radius pediatric fractures that occur despite casting

Materials and Methods: The patient cohort consisted of 21 consecutive unselected patients with pediatric distal radius fracture all with various degrees of angulation despite initial close-reduction and casting done in government hospitals. All the parents of the patients refused operations and refused further manipulation of the painful wrist of their child. All subjects were given soft wrist braces, together with low-level laser therapy (LLLT) on alternate days for 8 consecutive weeks.

Results: All patients on serial X-ray checking not only had solid union of the incompletely consolidated fracture, but all had total or near total correction of their fracture angulation despite no manipulation performed. The calculated p value is statistically significant at $p < 0.01$

Conclusion: LLLT not only enhance fracture healing, it has the power to help correct fracture angulation to better re-model the partially healed and angulated pediatric fractures.

INTRODUCTION

Fracture of the distal radius is a common fracture in the pediatric population. However, many a times, despite initial close-reduction and casting and after the cast being taken off at 4-6 weeks, it is not uncommon to observe residual angulation of the fracture and represents a common clinical problem. Traditionally, many clinicians would either consider operative intervention in the face of residual angulation or ask the parents to accept the angulation. However, not every patient consent for operative intervention, but accepting the angulation can cause disability in the use of the fractured upper extremity of the child. In such scenarios, we as clinicians still need to seek ways to enhance bony re-modeling using non-invasive methodologies.

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 fractures in the pediatric age group.

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 operation for delayed union such as infection, failure of metallic implants. 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.

MATERIALS AND METHODS

The study population consisted of a series of consecutive unselected 21

patients with a mean age of 10 (range 8 to 12) presenting with radiologically confirmed residual fracture angulation after fractured distal radius with close reduction and casting done in government hospitals. All of the patients had had not less than 4 weeks of casting done in other medical units but there was residual mal-alignment and incomplete bony healing response on serial radiological assessments. All patients who enter the study refused operative intervention which represented the main pre-requisite for study entry and all consent to the use of LLLT as well as soft wrist brace as the sole treatment modality. Other 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 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 delayed union of the same bony construct of the extremity. None of the patient nor parents 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 re-modeling if any that can be obtained after use of LLLT. 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 8 weeks for the current study.

RESULTS

The study period spanned from 2015 to 2019 amongst patients attending two different medical clinics located in different areas in Hong Kong. The male:female ratio among the study population was 2:1 in this study. The mean time for correction of the fracture angulation without any form of manipulation was 6 weeks (range: 4-8 weeks) The mean follow up was 12 months. All fracture proceeded to have solid bone healing besides proper re-modeling.

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 limb, the degree of pain, the activities of daily living, the ability to cope with school work 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.

Table 1 below serve to summarize the characteristics of the patient population and the degree of fracture angulation. Fig 1 and 2 showed serial radiological appearance of one of the patients.

Table 1

Patient population demographics, fracture angulation, and clinical outcome

Location of Fracture and Age of Patient	Age of Fracture at presentation	Fracture Angulation before LLLT	Fracture Angulation after LLLT
Patient 1 [DR/10]	6 weeks	+15	0
Patient 2 [DR/9]	7 weeks	+20	+5
Patient 3 [DR/12]	5 weeks	-15	0
Patient 4 [DR/9]	4.5 weeks	-20	0
Patient 5 [DR/11]	6.5 weeks	+10	0
Patient 6 [DR/9]	8 weeks	-20	-5
Patient 7 [DR/10]	7 weeks	+15	0
Patient 8 [DR/12]	6 weeks	-10	0
Patient 9 [DR/8]	5 weeks	-15	0
Patient 10 [DR/8]	6 weeks	+15	0
Patient 11 [DR/12]	8 weeks	-20	-5
Patient 12 [DR/9]	7 weeks	-15	0
Patient 13 [DR/11]	4.5 weeks	-15	0
Patient 14 [DR/10]	6 weeks	+20	+5
Patient 15 [DR/12]	6 weeks	-10	0
Patient 16 [DR/8]	8 weeks	-20	-5
Patient 17 [DR/10]	7 weeks	-20	-5
Patient 18 [DR/9]	5 weeks	+15	0
Patient 19 [DR/12]	5 weeks	-15	0
Patient 20 [DR/11]	4.5 weeks	-20	0
Patient 21 [DR/10]	7 weeks	-15	0

Abbreviations: # means fracture DR means Distal Radius

\+ Angulation means Dorsal Angulated Fracture (in degrees)

\- Angulation means Volar Angulated Fracture (in degrees)

Figure 1

Young boy having volar angulation of the fractured distal radius, note the volar side fracture has not yet healed despite 5 weeks of casting

Figure 2

Distal Radius Fracture angulation corrected after LLLT, no manipulation of any kind was performed

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 [4], which in turn triggers a cascade of events stimulating ATP synthesis [5]; 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 [6], besides also producing local vasodilatation believed nowadays to be mediated via the nitric oxide pathway [7].

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 [8]. The same author Hirata also demonstrated that LLLT could stimulate BMPs-induced expression of type 1 collagen, osteonectin, and octeocalcin mRNA. Histological studies [9] also confirmed intense new bone formation surrounded by highly vascularized connective tissue indicative of increased osteogenic activity on LLLT exposure. Lastly, other authors [10] 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 clinical re-modeling of fractures in these fresh mal-aligned pediatric fractures.

CONCLUSION

The current prospective study of a clinical case series of patients presenting with fracture angulation of the distal radius in the pediatric age group despite casting indicated that low-level laser therapy if administered correctly can on the one hand augment the bone healing process, and on the other hand re-model the fracture so that for the very first time in clinical medicine, correction of mal-alignment can be achieved without the use of manipulative forces. All patients tolerated very well this non-invasive form of conservative management at an affordable costs comparable to conventional physical therapy.

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