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Effects of Low-Level Laser on Wound Healing and Quality of Life in Foot Ulcers with Diabetic Neuropathy

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ABSTRACT

BACKGROUND: Diabetic foot ulcer was characterized by the infection, ulceration, or destruction of the deep tissues associated with neurological anomalies and to a greater degree of peripheral vascular disease in the lower limbs. Low-level laser therapy has a stimulating effect on cells, whereas high-energy radiation has an inhibiting effect. So, the application of laser to stimulate wound healing in cases of non- healing ulcers has been recommended. So, the purpose of the study was to know about the effects of low-level laser therapy on wound healing and quality of life in foot ulcers with diabetic neuropathy.

METHODOLOGY: A total of 30 patients fulfilled the inclusion criteria were assigned to two Groups by using a simple random sampling technique. The subjects are divided into 15 for each group. Group A received treatment with low-level laser therapy for 4 weeks, whereas Group B received conventional treatment.

RESULT: After a period of therapeutic intervention using the low-level laser therapy, it was noticed that there was an improvement in the wound reduction with a significant process of tissue repair. Where as in the control group there was no reduction of wound size is seen.

CONCLUSION: Group A shows more effectiveness in reducing wound size, considering to the low-level laser therapy seems to be an efficient method, viable, painless, and of low cost in tissue repair of ulcers in diabetic foot. The analgesic effect is significant for the reestablishment of these patients, preventing possible amputations and improving quality of life.

KEYWORDS: LOW- LEVEL LASER THERAPY, DIABETIC FOOT, DIABETIC FOOT ULCER

INTRODUCTION

Diabetic neuropathy is a type of nerve damage that can occur in people with diabetes. High blood sugar levels over time can injure nerves throughout the body, particularly those in the legs and feet, making diabetic neuropathy a common and serious complication of both type 1 and type 2 diabetes. It affects sensory, motor, and autonomic nerves and may cause a range of symptoms depending on the nerves involved. [1],[2]

Diabetic foot ulcers (DFUs) are a serious complication of diabetic neuropathy and a

leading cause of non-traumatic lower limb amputations. [3],[4] In people with diabetes, nerve damage (neuropathy) and poor blood circulation can make it challenging to feel injuries or allow wounds to heal effectively. Small injuries on the feet, when unnoticed or untreated, can lead to ulceration and infection, which can eventually require amputation if the infection spreads or if healing is insufficient. [5],[6],[7]

The prevalence of diabetes is indeed vast, with an estimated 425 million people worldwide affected, according to the International Diabetes Federation (IDF) [8]. India often referred to as the "diabetes capital of the world," has approximately 73 million people with diabetes, and this number is rising due to lifestyle and genetic factors. Among people with diabetes, around 15% are at risk of developing a foot ulcer at some point. Foot ulcers pose a significant risk for amputation, with statistics suggesting that between 6% and 40% of those with diabetic foot ulcers may eventually require amputation. This makes diabetic foot care a critical component of diabetes management, especially in countries with high diabetes prevalence, such as India. [9],[10]

Diabetic neuropathy, while not typically classified as a primary demyelinating neuropathy, does involve Schwann cell damage as a significant factor due to chronic hyperglycemia.[11] Schwann cells, which are crucial for maintaining axon health and the myelin sheath, are highly vulnerable to elevated blood sugar levels in diabetes. This Schwann cell injury disrupts the balance and mutual support between axons and Schwann cells, leading to axonal degeneration and, in severe cases, demyelination. The Classical Triad in Diabetic Foot Ulcers: Neuropathy, Ischemia, and Infection [12], [13]

Physiotherapy plays an important role in managing diabetic foot ulcers (DFUs) by enhancing blood circulation, reducing edema, and promoting healing. Several physiotherapy modalities have been shown to help in both preventing and treating DFUs. These approaches complement medical and surgical interventions by creating a more favorable environment for healing and restoring function. [14]

Each of these physiotherapy approaches aims to improve outcomes for patients with diabetic foot ulcers by:

- Increasing Blood Circulation: Improved blood flow to the ulcer site enhances oxygen and nutrient delivery, which is crucial for tissue repair.
- Reducing Edema: By reducing fluid accumulation in the feet, these therapies help relieve pressure and improve comfort.
- Promoting Cellular Regeneration: Modalities like LLLT, ultrasound, and electrical stimulation support cellular repair and collagen production, accelerating wound healing. [15]

Wound Healing Assessment

- Wound Size Measurement:
- Two-Dimensional Methods:

Traditional approaches, like manual planimetry, are widely used:

A transparent film is placed over the wound, traced, and superimposed onto a metric grid the wound area is determined by counting grid squares covered by the traced wound outline. This method provides reliable data for tracking wound healing progress. [16]

Impact of LLLT on Wound Healing:

Clinical Evidence:

- Hopkins et al. reported a 55% greater wound contraction in patients treated with LLLT compared to controls.
- Gupta et al. demonstrated significantly better reduction in leg ulcer surface areas with LLLT than in controls.[17]

NEED OF THE STUDY

Diabetic neuropathy is a highly prevalent condition with significant consequences, including pain and a substantial reduction in the quality of life (QOL) of affected individuals. It is a leading contributor to complications such as diabetic foot ulcers, which are associated with increased morbidity and mortality. Alarmingly, more

than 60% of all non-traumatic lower-limb amputations are attributed to complications from diabetic foot ulcers. Furthermore, approximately 15% of individuals with diabetes mellitus are likely to develop foot ulcers during their lifetime.

Therefore, this study aims to assess the effectiveness of low-level laser therapy in enhancing wound healing and improving the quality of life in patients with diabetic neuropathy-associated foot ulcers. This research will contribute to the existing knowledge base and may pave the way for improved therapeutic strategies in managing this debilitating condition.

AIM AND OBJECTIVES

The primary aim of the study is to evaluate the effectiveness of low-level laser therapy (LLLT) on wound healing and quality of life (QOL) in individuals with foot ulcers associated with diabetic neuropathy. The specific objectives are:

1. To assess the changes in wound healing following treatment with low-level laser therapy in individuals with diabetic neuropathy.
2. To evaluate the changes in quality of life (QOL) after treatment with low-level laser therapy in individuals with diabetic neuropathy.
3. To determine the overall efficacy of low-level laser therapy in improving wound healing and quality of life in subjects with diabetic foot ulcers.

METHODOLOGY

This experimental study was conducted with a total sample size of 30 participants, selected through simple random sampling. The study was carried out in Andhra Pradesh over duration. The inclusion criteria for this study encompassed both male and female participants diagnosed with chronic non-healing foot ulcers. Eligible participants were those with Meggitt-Wagner grade 1 diabetic foot ulcers who had not undergone any prior foot care interventions. On the other hand, the exclusion criteria ruled out individuals with pacemakers, pregnant individuals, those with cancer where metastasis was suspected, and individuals with labile epilepsy.

PROCEDURE

The procedure begins by ensuring that all participants meet the eligibility criteria. An orientation session is conducted to explain the purpose, procedure, and any potential discomfort associated with the study. Participants who are willing to take part provide written informed consent. After the orientation, the participants are randomly divided into two groups: Group A and Group B. Group A receives Low-Level Laser Therapy (LLLT) in addition to conventional therapy, while Group B receives only conventional therapy. [18]

To measure the ulcer area, impressions of the ulcers are taken on sheets of cello paper, which are then transferred onto graph paper for precise calculation. Measurements of the ulcer size are taken at two time points: Day 0 (baseline) and Day 15 (post-treatment). [19]

Group A (LLLT + Conventional Therapy):

Participants in Group A undergo LLLT treatment using a multidode cluster probe. The exposure duration is calculated based on ulcer size to deliver an energy dose of 2–4 J/cm² at 60 mW daily for 15 days. Both the ulcer floor and edges are irradiated during the sessions. Following the treatment, the ulcer is covered with a conventional moist dressing. [20]

Group B (Conventional Therapy Only):

Participants in Group B receive standard care, which includes daily wet saline or Beta-dine dressing, antibiotic treatment, contact cast immobilization, and slough excision when necessary. Additionally, participants in this group are educated about dietary intake, exercise, and proper foot care. [21]

The results of the ulcer size from Day 0 and Day 15 are recorded and compared for statistical analysis to evaluate the effectiveness of the treatments.

DISSCUSSION

This study evaluated the efficacy of low-level laser therapy (LLLT) combined with conventional therapy in promoting wound

healing and improving quality of life (QoL) in patients with diabetic foot ulcers and neuropathy.[22]

Thirty patients were divided into two groups: Group A (n=15) received LLLT alongside conventional therapy, while Group B (n=15) received only conventional therapy.[13] Group A (LLLT + Conventional Therapy): A multidode cluster probe LLLT device was used, delivering 60 mW daily for 4 weeks based on ulcer size.[23],[24] Ulcers were then covered with a moist dressing. Group B (Conventional Therapy): Treatment included daily wet saline or beta-dine dressings, antibiotics, contact cast immobilization, and slough excision as needed.

Measurements: Ulcer size was assessed using manual planimetry, where ulcer impressions were traced on cellophane and transferred to graph paper for area calculation. Measurements were taken at baseline (day 0) and after weeks. QoL was evaluated using the Diabetic Foot Scale post-treatment. Patients in both groups received education on diet, exercise, and foot care.[25]

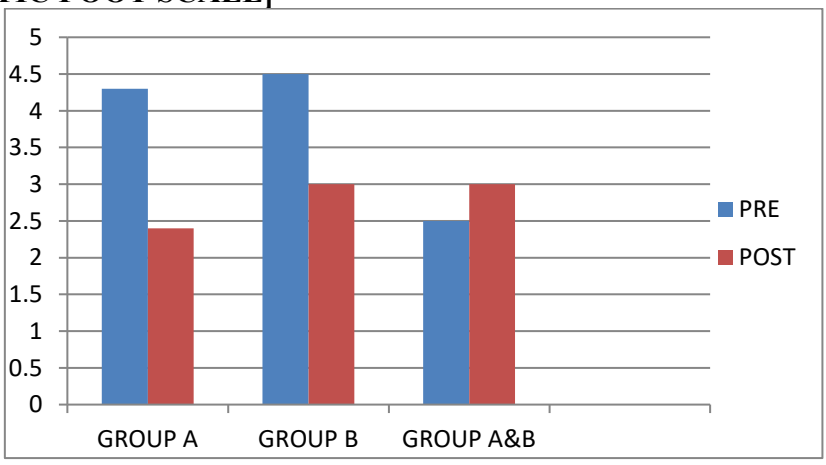
STATISTICAL ANALYSIS

Pre- and post-treatment ulcer sizes and QoL scores were compared.

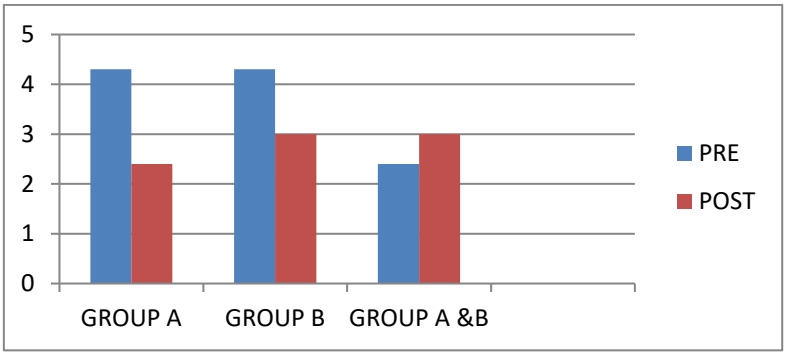
RESULTS:

TEST	MEAN	SD	T VALUE	P VALUE
DFS				
GROUP A				
PRE TEST	39.133333	1.807	17.548	<0.0001
POST TEST	19.733333	3.88		
GROUP B				
PRE TEST	33.2	2.178	11.508	<0.0001
POST TEST	3.8666667	2.160		
GROUP A &B				
PRE TEST	19.73333333	3.882	0.0013	
POST TEST	22.33333333	2.160		<0.0001
MP				
GROUP A				
PRE TEST	5.88666667	1.686	4.492	<0.0001
POST TEST	1.686	1.240		
GROUP B				
PRE TEST	6.7666667	1.562	6.345	<0.0001
POST TEST	3.46	1.240		
GROUP A &B				
PRE TEST	6.72666666667	1.562	6.345	<0.0001
POST TEST	3.46	1.240		

DFS [DIABETIC FOOT SCALE]



MANNUAL PLANIMETRY



Ulcer Size: Group A: Mean ulcer size decreased significantly from 39 cm² (pre-treatment) to 19 cm² (post-treatment). Planimetry measurements showed a reduction from 7 cm² to 4 cm². [26]

Group B: Mean ulcer size increased slightly from 19 cm² to 22 cm², with planimetry measurements decreasing from 5 cm² to 4 cm². [27]

Quality of Life: Group A exhibited significant improvements in mood, independent mobility, and resumption of daily activities, leading to better QoL compared to Group B. [28]

Pain Reduction: Group A reported reduced pain, consistent with LLLT's bio-modulatory effects. [29]

Mechanisms of LLLT: LLLT is a non-invasive, painless, low-cost therapy with minimal side effects. It promotes tissue repair by: Enhancing ATPase activity, altering erythrocyte membrane proteins, and modifying lipid bilayer structures, affecting membrane ion pumps. Stimulating neutrophil respiratory burst via protein tyrosine kinase and phospholipase C activation. Improving skin microcirculation in diabetic microangiopathy. Releasing growth factors from fibroblasts, accelerating tissue repair. Enhancing collateral circulation, microcirculation, and vascular smooth muscle relaxation. Increasing wound closure rates and tensile strength. [30]

CONCLUSION

LLLT combined with conventional therapy significantly reduced ulcer size and improved QoL in patients with diabetic foot ulcers compared to conventional therapy alone. The most notable reduction in ulcer size occurred within the first 15 days of LLLT. While promising, further research is needed to elucidate LLLT's mechanisms and optimize its clinical application

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