Low Intensity Laser Therapy (LILT) Versus Transcutaneous Electrical Nerve Stimulation On Microcirculation In Diabetic Neuropathy

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Abstract. Reduced microcirculation is a morbid element of neuropathy and one of the most common complications of uncontrolled diabetes. Many physical modalities have gained a considerable attention for enhancing cutaneous microcirculation in diabetic patients and prevent its serious complications. Accordingly, the present study was conducted to compare between the effect of low intensity laser therapy (LILT) and transcutaneous electrical nerve stimulation (TENS) on microcirculation in diabetic neuropathy. Thirty diabetic polyneuropathic patients ranged in age from 45-60 years participated in this study. They were randomly divided into two groups of equal number; patients in group (A) received LILT on plantar surface of foot with a dose of 3 J/cm^2 and wavelength (904 nm), while those in group (B) received TENS on lower leg for 30 minutes with frequency (2 HZ). Treatment was conducted 3 times/ week for 6 weeks. The cutaneous microcirculation was evaluated by Laser Doppler flowmetry at the baseline and at the end of treatment. Results revealed that group (A) showed statistically significant increase in the cutaneous microcirculation compared with group (B). So, it was concluded that LILT has to be more efficient than TENS in increasing cutaneous microcirculation in patients with diabetic neuropathy.

Keywords: Diabetes mellitus, microcirculation, low Intensity laser Therapy, transcutaneous electric nerve stimulation.
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INTRODUCTION

Diabetes mellitus (DM) comprises a group of common metabolic disorders that share the phenotype of hyperglycemia. It is the most common endocrine disorder and is classified as type 1 or Insulin Dependent Diabetes Mellitus (IDDM) and type 2 or Non- Insulin Dependent Diabetes Mellitus (NIDDM) on the basis of age of onset of disease and degree of insulin dependency [1]. The common identified causes of DM include complex interaction of genetics, environmental factors and life style choices. DM is the most leading cause of end- stage renal disease, non-traumatic lower extremity amputations, and adult blindness. With an increasing world wide, DM will likely contribute to be a leading cause of morbidity and mortality for the foreseeable future [2].

The economic and social costs of diabetes are many both for health care and loss of productivity. In developed countries, 10 % or more of the total health budget is spent on the management of diabetes and its complications [3].

Impaired skin microcirculation has a central role in the development of diabetic foot or foot ulceration which is a frequent complication of long standing diabetes mellitus. The prevalence of foot complication ranged from 10 to 30 % of all diabetics with a vital risk for gangrene and infections of both skin and bone with high mortality rates. Also macroangiopathy, diabetic polyneuropathy and infections are trigger factors for diabetic foot complications [4].

The microvascular complications of diabetes are the result of chronic hyperglycaemia, which causes vascular damage, increased vascular permeability, vascular leakage and oedema. Vascular tone is decreased by hyperglycaemia, resulting in increased blood pressure. Extracellular matrix accumulation also occurs, causing basement membrane thickening, which lead to occlusion and ischemia [5].

Diabetic sensory polyneuropathy is a major risk factor for the development of plantar ulceration because of the loss of protective sensation [6]. Beside that, Autonomic neuropathy gives rise to anhidrosis and dry fissured skin that leads to abnormal pressure distribution in the foot when standing or walking [7].

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Nowadays treatment of diabetes is directed to its complications because cardiovascular morbidity and mortality in patients with diabetes are caused by microvascular and macrovascular complications with clinical manifestations beginning 15- 20 years after the onset of diabetes[8]. And because, Foot ulceration is the most common component in the causal pathway leading to lower-extremity amputation among individuals with diabetes, Practical intervention strategies implemented to prevent the development of foot ulcers that could interrupt this pathway and thus prevent a large number of amputations in high-risk individuals [9].

Low intensity laser therapy (LILT) is non invasive intervention that has an antiatherogenic, antioxidant, immunomodulating effects, and improved tissue microcirculation preventing the development of pathological vascular changes and improved myocardial contractility and performance capability [10]. In addition LILT has many beneficial effects that include enzymatic effect on acetylcholine esterase, absolute increase in microcirculation, stimulation of RNA, DNA, and ATP synthesis. It has proven to have a role in pain influence and inflammatory process in biotissues [11].

Transcutaneous electrical nerve stimulation (TENS) also was reported to have a clinical value for treatment of local ischemia. These effects may be the result of increased local blood flow which indirectly improves peripheral perfusion. Moreover it helps in increasing skin temperature and lowered systemic arterial blood pressure. Nevertheless the detailed haemodynamic effects of TENS are still incompletely understood and remain controversial [12].

So the aim of this study was to compare between the effect of Low intensity laser therapy versus Transcutaneous electrical Nerve Stimulation on microcirculation in patients with diabetic neuropathy.

MATERIALS AND METHODS

Thirty patients of both gender presented clinically with diabetic polyneuropathy were selected from out patent clinic of Cairo university hospital. Their average age ranged from 45-60 years. Inclusion criteria include: 1) all patients were type 2 diabetes according to the recommendations of the American Diabetes Association. 2) Patients suffering from neuropathy especially in lower limb as clinically evident. 3) The duration of illness ranged between 10-15 years of diabetes. 4) All patients with clinical history of glove stock hyposthesia, burning sensation, spasm of foot muscles, muscle weakness of lower limb.

Patients were excluded if they had history of pedal ulcer, amputation and/or arthritis, osteoporosis or fractures of any bones of lower limb, gross musculoskeletal problems, significant scar tissue or calluses on the feet or history of peripheral vascular diseases.

When the patients satisfied the inclusion criteria, they were randomly assigned into two equal groups. Group A (LILT group) received infrared laser therapy and Group B (TENS group) was provided Electrical stimulation with dual-channel TENS unit stimulator. The left leg was used as a control for all measuring variables. The local ethics committee approved the study protocol. The aim and methods of the study were explained to all patients before their informed consent was given.

Instrumentation

Visual Analogue Scale (VAS): It consists of 10 cm straight line for assessment of the patient's level of pain. Its validity and reliability have been have been tested.

Laser Doppler Flowmetry: is a noninvasive method of measuring the cutaneous circulation of blood flow on a microscopic level. It composed of a low-powered laser and probe that takes readings and sends results to an analyzer.

Laser device: (Italy ASA CO., Bravo style) the device emits both He-Ne and infra red laser in a mixed light. He- Ne wave length was 632.8 nm, continuous. Infra red wave length was from 780-905 nm, pulsed.

TENS device: Elettronica Pagani TENS unit dual channel with frequency: 10-300Hz, impulse: 10-350Ms, emission: 1.5-15.0 sec, pause: 0-15.0 sec, time: 0-30 minutes and amplitude: 0-75 MA.

Procedures

All assessment and treatment procedures were done at Faculty of Physical Therapy, Cairo University. All patients underwent the same evaluation protocol which included the following:

The level of pain was assessed by using VAS. The patient was asked to determine the level of his / her pain on 10 cm scale as (0= no pain) and (10= worst pain) by drawing a line corresponding to the intensity of pain. Assessment of pain was done before starting the program of treatment and after compliance of all treatment sessions.

Skin microcirculation measurements were performed under the heel and big toe by using Laser Doppler flow meter before and after the treatment program.

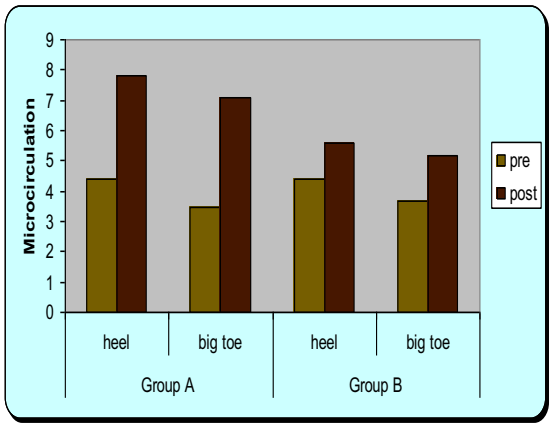

FIGURE 1. Skin microcirculation for group A and B before and after treatment.

Treatment procedures

Patients in group A received infrared laser (905 nm and 3 J/cm2) on the plantar surface of the right foot in continuous wave mode. A minimum power of 12 mW has been used and the distance between laser head and patient' foot was fixed at 30 cm. The patient was prone and the whole plantar surface of the treated foot was exposed to the light of scanner laser for 15 minutes.

Each patient received 18 treatment sessions at a rate of three sessions /week.

Patents in group B received electrical stimulation with dual-channel TENS unit stimulator and using pad TENS electrodes on the right lower leg for 30 minutes with frequency (2 Hz). The patient was prone and relaxed then fixed the stimulating electrode over the posterior tibial nerve down the popliteal fossa while the depressive electrode on the medial belly of gastrocnemius muscle. The intensity was increased until stimulus was felt but not painful, usually 10-15 mA. Each patient received 18 treatment sessions at a rate of three sessions /week.

RESULTS

Thirty diabetic patients (14 male, 16 female) aged from 45-60 years was participated in the study. Patient's characteristics were presented in table 1. There were no significant differences between the two groups regarding age, weight and height (P>0.05).

Figure1. shows skin microcirculation measurement values between group A and B at heel and big toe before and after treatment. The results revealed that microcirculation increased following treatment and there was a significant difference in microcirculation measurements between pre and post treatment at the heel and big toe of the right side for group A and group B.

TABLE 1. Demographic data: age, weight and height in group A and B **.**

Variables	**Group A N=15**	**Group B N=15**	**Comparison**		**S**
	Mean ±SD	Mean ±SD	T-value	P-value	
Age (yrs)	53.2 ±3.94	51.2 ±5.69	1.114	0.274	NS
Weight (kg)	80.53 ±5.8	84.0 ±7.64	0.025	0.980	NS
Height (cm)	165.2 ±6.14	167.5 ±4.98	0.420	0.677	NS

SD: standard deviation, P: probability, *: significant

TABLE 2. Comparison between mean values of skin microcirculation of right and left side for group (A).

Skin microcirculation	**Heel**				**Big Toe**			
	Pre		**Post**		**Pre**		**Post**	
Mean	Right	Left	Right	Left	Right	Left	Right	Left
SD	4.38	4.78	7.82	4.89	3.45	4.14	7.07	4.29
	1.32	2.01	2.38	1.93	0.94	1.62	2.15	1.79
t-value	1.06		5.61		1.98		5.93	
P-value	0.3		0.001*		0.06		0.001*	

SD: standard deviation, P: probability, *: significant

Table 2. revealed that there was a significant difference in skin microcirculation measurements value at the heel and big toe between the right and left side pre and post treatment for group (A).

Figure 2. demonstrated there was a significant difference in visual analogue scale score values between pre and post treatment of the right side for group (A) and group (B).

Table 3. shows that there was a significant difference in post treatment value of the skin microcirculation measurement values at the heel ang big toe between the right and left side for group B. **figure (3)** demonstrated the mean difference between both treatment groups. it was showed that there was a significant difference between group A and group B for microcirculation measurement values in favor to group A.

Table 4**.** demonstrates the mean difference between both treatment groups. it was showed that there was a significant difference between group A and group B for microcirculation measurement values and pain score in favor to group A.

TABLE 3. Comparison between mean values of skin microcirculation of right and left side for group (B).

Skin microcirculation	Heel				Big Toe			
	Pre		Post		Pre		Post	
Mean±SD	Right	Left	Right	Left	Right	Left	Right	Left
	4.41 ±2.12	4.38 ±2.48	5.6 ±2.06	4.44 ±2.46	3.68±1.67	4.06 ±1.8	5.18 ±1.79	4.17 ±1.79
t-value	0.04		2.41		1.87		3.56	
P-value	0.9		0.03*		0.08		0.003*	

SD: standard deviation, P: probability, *: significant

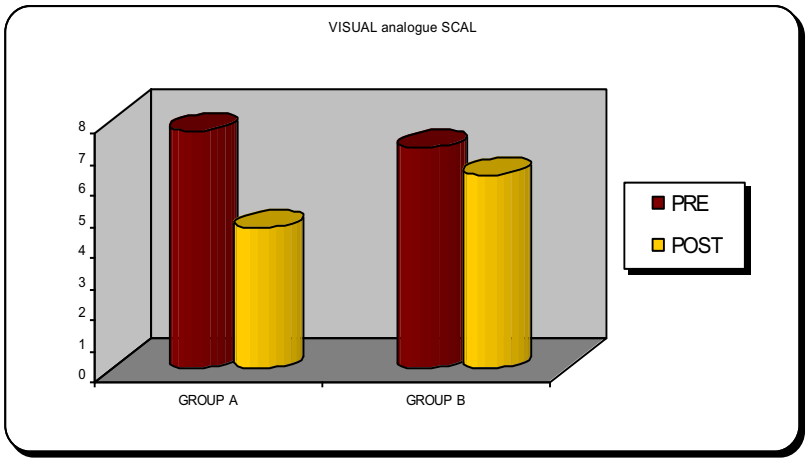

FIGURE 2. Comparison between visual analogue scale for group A and B before and after treatment.

TABLE 4. Mean value and significance of measured variables between group A and group B after treatment

Variables	Group A N=15	Group B N=15	T-value	P-value	S
Skin microcirculation	Mean ±SD	Mean ±SD			
Right side heel	7.82 ±2.38	5.6 ±2.06	6.081	0.0001	S
Right side big toe	7.07 ±2.15	5.18 ±1.79	2.60	0.014	S
Visual analogue scale (VAS)	4.533 ±0.255	6.267 ±0.20	5.276	0.0001	S

SD: standard deviation, P: probability, *: significant

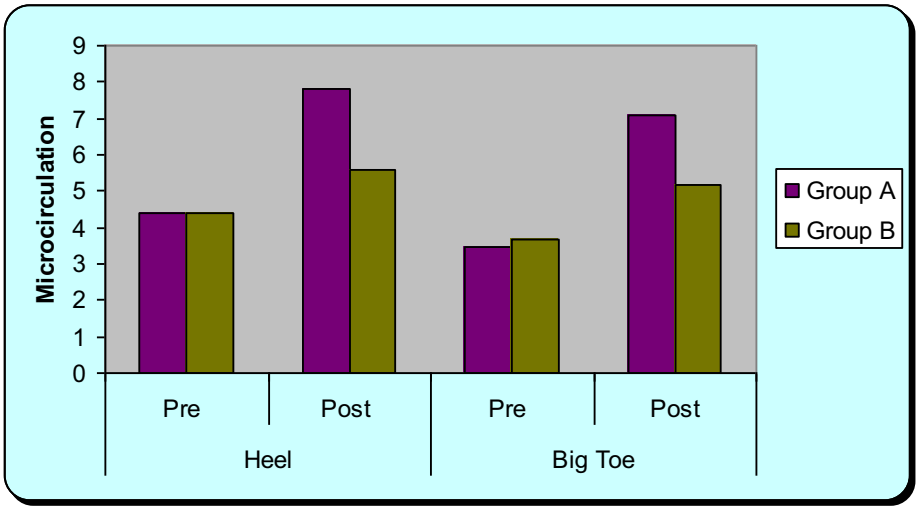

FIGURE 3. Comparison between group A and B before and after treatment

DISCUSSION

Patients with diabetic polyneuropathy are at very high risk for developing neuropathic ulcer on plantar surface of their feet that may lead to lower extremity amputation (LEA) and threaten the patient's life. [13]

The data were collected from thirty patients of both sexes who divided into two groups: Group A (LILT group): received LILT on plantar surface of the foot and Group B (TENS group): received TENS on the lower leg. The patients were assessed for skin blood perfusion by laser Doppler flow meter and pain intensity by VAS. These measures were recorded for both groups two times, before starting the study (pre treatment) and after 6 weeks from initial assessment (post treatment).

After the application of physical therapy program to the both groups, post treatment measures between groups showed significant difference for all variables. There was a significant decrease in pain intensity, while there was a significant increase in skin blood perfusion in the right foot (treated foot) in comparison with the left one (non-treated foot). But, there was more significance difference in the (LILT or A group) than in (TENS or B group).

Rutkove (2002) documented that in patients with axonal peripheral neuropathies, treatment is usually symptom based with efforts towards reducing pain and dysesthesias. He added that if pain is an issue, physical therapists can assist with modalities as electrical stimulation, laser therapy; magnetic, etc. that may help to relief the pain. [14]

Other studies were preferable to use non-pharmacological modalities more than drug therapy as documented that numerous pharmacologic agents had been used to treat symptomatic peripheral neuropathy, but all of these drugs can be associated with adverse side effects [15]

Concerning pain relief Boykin, 2000 documented that, LILT was reported to have an anti-inflammatory effect by using 830 nm at energy density of 3.6 Joule/cm2 for two minutes. Therefore, LILT when applied to an inflamed peripheral nerve, prevent drop in action potential, delay degeneration of the surrounding muscles and accelerates regeneration. Evick et al. (2007) reported a significant improvement in nerve conduction velocity and sensory distal latency in the treated subjects by LILT with wave length 830nm and 3.6 J/cm^n. [16]

In a double blind, randomized study, 19 patients suffering from mild-to-moderate symptomatic diabetic neuropathy received LILT indicates that the laser therapy is a convenient, non-pharmacological option for primary or adjuvant treatment of painful diabetic neuropathy. [17]

In brief, the pain relief effect of LILT is scientifically based on a compound effect caused by the stimulation of laser light on the following: on peripheral nerves, on central nerves, on sympathetic nerves and on the blood. Also, it was reported that during the period of LILT treatment, patients with painful DPN do not need other types of physical therapies. [18]

Concerning the microcirculation, It was founded that regarding the inflammatory action, LILT acts on the prostaglandins synthesis, increasing the change of PGG2 and PGH2 into PGI2 (prostacycline). PGI2 is the main product of the arachidonic acid into the endothelial cells and the smooth muscular cells of

vessels walls that has a vasodilating and anti-inflammatory action [19].

It was reported that low-level light therapy (LLLT) has a positive biomodulatory effect on the repair of cutaneous wounds[20]. These were an agreement with Lorne et al., (2004) who reported that athermic laser irradiation was found to induce a significant increase in skin microcirculation, as measured by infrared thermography, in patients with diabetic microangiopathy [21].

The data of other studies showed a significant increase in skin circulation due to athermic laser irradiation in patients with diabetic microangiopathy and point to the possibility of inducing systemic effects [22, 23].

The results of the study agree with Nascimento et al., (2004) who indicate that LILT improved cutaneous wound repair and that the effect is a result of an inversely proportional relationship between wavelength and intensity, with treatment more effective when combining higher intensity with short wavelength or lower intensity with higher wavelength[24].

From the results of the present study and the previous studies, it can be proved that LILT had positive effect on pain and skin blood perfusion in DPN patients and it was very effective, safely and statistically highly significant.

CONCLUSION

Low intensity laser and TENS have proven to be effective and non invasive modalities to prevent many complications of diabetic polyneuropathy especially that related to microcirculation; also they have great effects on decreasing pain in these cases.

The results of the current study proved that LILT was more significant in decreasing pain intensity and increasing skin microcirculation than TENS. More studies must be done in this field because diabetes and its complications are still the serious problems that should be taken into consideration to prevent these serious complications.

REFERENCES

1. Ahmed K, Muhammad Z, Qayum I. *J Ayub Med Coll Abbottabad* .**21**(2),76-79 (2009).
2. Powers R. Diabetes mellitus. Cecil textbook of medicine 17th ed WB Sandars Company 2001
3. Frykberg RG, Armstrong DG, Giurini J, Edwards A, Kravette M, Kravitz S. *J Foot Ankle Surg*. **39** (2000).
4. Lawall H, Amann B, Rottmann M, Angelkort B . *VASA* , **29** (3) 191-7 (2000).
5. Morello CM. Etiology and natural history of diabetic retinopathy: an overview American journal Health-Syst pharm 2007; 64 suppl 12 (s3-s7)
6. Young MJ, Breddy JL, Veves A and Boulton A J. *Diabetes Care*. **17**, 557-560 (1994).
7. Leonard D.R., Farooqi M. H. and Myers S. *Diabetes care* . **27**,168-172 (2004).
8. Fuchsjager MG, Pleiner J, Wiesinger GF, Sieder AE, Quittan M, Ruhr MJ, Francesconi C, Seit HP, *Diabetes Care* **25**,1795-1801 (2002).
9. Boulton A ., *Am J Surg* . 187(5 A), 17-24(2004).
10. Basford R, Sheffield G and Harmsen S . *Arch Phys Med Rehab* . **80** (6), 647-652 (1999).
11. Kujawa J, Zavodnik L, Zavodnik I, Bryszewsaka M. *Lasers Surg Med*. **21** (6), 351-355
12. (2003).
13. Richard E L., Luiz E F., *Wound Repair and Regeneration*. **16**(1), 65–69 (2008).
14. McGuire J and Nawoczenski D . West Indian Med J **50**(1) 35-38 (2001).
15. Rutkove SB. Peripheral neuropathies. In frontera WR and Silver JK (eds), essentials of physical medicine and rehabilitation. Hanley and Belfus, Inc. (2002) 122: 658-663.
16. Wunderlich RP, Peters EJ, Bosma J and Armstrong DG. *South Med J*. **91** (10) 894-898 (1998).
17. Evick D, Kavuncu V, Cakir T, Subasi V and Yaman M. Photomed. Laser Surg. **25** (1), 34-39 (2007).
18. Forst T, Nguyen M, Forst S, Disselhoff B, Pohlmann T, and Pfutzner A. *Diabetes Nutr Metab*.**17** (3),163-8.(2004).
19. Zoran P and Bratislav C. *Facta Universitstis, Medicine and Biology* **13** (1),11-14, (2006).
20. Chen LY and Mehta JE. *J Cardio Vasc Pharmacol.* **32**, 57-61, (1998).
21. Mendez TM, Pinheiro AL, Pacheco MT, Nascimento PM, and Ramalho LM. *J Clin Laser Med Surg.* **22**, 19-25, (2004).
22. Lorne H, Mylan N, Eduardo T, Khin T, Sven G and Vera B . *Diabetes Care*. **27**, 921-924 (2004).
23. Schindl A, Heinze G, Schindl M, Pernerstorfer H and Schindl L. *Microvasc Res.* **64** (2), 240-246 (2002).
24. Boykin J. The nitric oxide connection: Hyper baric oxygen therapy, becaplermin and diabetic ulcer management. *Adv Skin Wound Care* **13**,169-174 (2000).
25. Nascimento PM, Pinheiro AL, Salgado MA, and Ramalho LM. Photomed Laser Surg. **22**(6),513-8 (2004).