THERAPEUTIC EFFECACY OF OZONE AND LOW LEVEL LASER IN TREATMENT OF DIABETIC FOOT ULCERS

By

Ali soliman hassan [a], omayma zakarya [b], wael mohamed al sheimy [c].

Nillie Ezz Eldin [D]

[a] Professor of Rheumatology and Rehabilitation, [b] Professor Of Rheumatology and Rehabilitation department, [C]Assistant professor of vascular surgery department, [d] assistant lecturer of Rheumatology and Rehabilitation department. Faculty of Medicine-Zagazig University

ABSTRACT

Back ground : Diabetes Mellitus is a syndrome characterized by disordered metabolism and high blood sugar (hyperglycaemia) resulting from either low levels of the insulin hormone or from abnormal resistance of cells to insulin's effects coupled with inadequate levels of insulin secretion to compensate.In wound care, ozone is considered as an anti-bacterial, anti-fungal and anti-viral agent. During the treatment an ozone generator produces ozone into a bag that surrounds the patient's leg ulcer. The treatment is administered three times per week for several weeks; there are many other methods of ozone administration as major and minor autohaemotherapy, rectal insufflations, direct intramuscular injection and intrarticular injection.Laser irradiation was able to significantly enhance the healing of diabetic wounds. And has a stimulatory effect on the fibroblast cells of the diabetic wounds. **Materials and methods**: It is a randomized controlled clinical trial. The number of patients was 60 patients. ***The calculation of the size of the ulcer*** was done by using the graph papers to document the ulcer′s perpendicular linear dimensions (typically in centimeters using graph paper); the maximum distance is length and perpendicular distance is width. And measure the progress of healing every month and record the percent of healing. The patients were randomized to 3 different groups of treatment (I treated by laser, II treated by ozone, and III treated by surgical debridement only). **Results***:* after treatment for 3 months by ozone and laser and surgical debridement many cases achieve complete healing at the laser and ozone groups in the second and third month but not in the third group **Conclusion:** Low-level laser therapy and ozone therapy could be a safe and effective method for treatment of diabetic foot ulcers. Clinical trials with higher sample size are proposed to more evaluate the efficacy of low-level laser therapy and ozone in treatment of this type of wounds.

Key words: ozone therapy, low level laser therapy, diabetic foot ulcer.

INTRODUCTION

Diabetes Mellitus is a syndrome characterized by disordered metabolism and high blood sugar (hyperglycaemia) resulting from either low levels of the insulin hormone or from abnormal resistance of cells to insulin's effects coupled with inadequate levels of insulin secretion to compensate. The characteristic symptoms are excessive urine production (polyuria), excessive thirst and increased fluid intake (polydipsia), and blurred vision; these symptoms are likely absent if the blood sugar is only mildly elevated [1]

The World Health Organization recognizes three main forms of diabetes mellitus: type 1, type 2, and gestational diabetes that occurring during pregnancy.[2]

Most forms are due to the beta cells of the pancreas being unable to produce sufficient insulin to prevent hyperglycemia [3]

There are many complications of diabetes; one of them is diabetic foot ulcer which is an open sore or wound that most commonly occurs on the bottom of the foot in approximately 15% of patients with diabetes. Of those who develop a foot ulcer, approximately 6% will be hospitalized due to infection or other ulcer related complication. *[4]*

Ozone is a molecule composed of three oxygen atoms. Created in the upper stratosphere as a result of solar ray

interactions with oxygen and thus forming the outermost layer of our biosphere.[5]

Ozone used in treatment of many diseases such as, Cancer, Atherosclerosis, HIV, Hepatitis, Rheumatoid arthritis, Allergy and Diabetes mellitus and its complications as diabetic foot ulcer. It has an important role in treatment of the wounds. It enhances the circulation by reducing the clumping or eliminates it and flexibility is restored, along with oxygen carrying ability. Oxygenation of the tissues increases as the arterial partial pressure increases, and viscosity decreases. [6]

In wound care, ozone is considered as an anti-bacterial, anti-fungal and anti-viral agent. During the treatment an ozone generator produces ozone into a bag that surrounds the patient's leg ulcer. The treatment is administered three times per week for several weeks; there are many other methods of ozone administration as major and minor autohaemotherapy, rectal insufflations, direct intramuscular injection and intrarticular injection. [7]

The term laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Laser light has the unique properties of monochromaticity (a single wavelength), collimation (travels in a single direction without divergence) and coherence (with all waves in phase). These properties allow laser light to penetrate the skin surface non-invasively [8]

The effects of low level laser therapy (LLLT) include wound epithelialisation, reduction of edema and inflammation, and re-establishment of arterial, venous and lymph microcirculation. Increased rates of ATP, RNA and DNA synthesis are also observed. Major changes seen in wounds treated with LLLT include increased granulation tissue, early epithelialisation, increased fibroblast proliferation, increased extracellular matrix synthesis and enhanced neovascularisation. [9]

Laser irradiation was able to significantly enhance the healing of diabetic wounds. And has a stimulatory effect on the fibroblast cells of the diabetic wounds.[10]

Debridement of necrotic tissue is an integral component in the treatment of chronic wounds since they will not heal in the presence of unviable tissue, debris, or critical colonization [11]

Undermined tissue or closed wound spaces will otherwise harbor bacterial growth [12]

Debridement serves various functions: removal of necrotic tissue and callus; reduction of pressure; evaluation of the wound bed; evaluation of tracking and tunneling; and reduction of bacterial burden [13]

Debridement facilitates drainage and stimulates healing. [14]

SUBJECT AND METHODS

Study design

It is a randomized controlled clinical trial

Informed consent was taken from the patients, after receiving adequate information about the study (the characters of the study, benefits and possible side effects)

Subject

The number of patients was 60 patients.

Adult patients of both sexes with a diagnosis of diabetic foot ulcer, may be with or with out signs of infection.

The patients either grade 1(superficial ulceration not infected) or grade 2 (deep ulceration exposing tendon or joint) in our study the tendon were exposed in some cases. According to the depth classification of Brodsky classification 1999.[15]

And the patients was classified into two grades either Grade A (no ischemia) or grade B (ischemia with out gangrene).According to the ischemia classification of Brodsky classification 1999, as shown in table (1)

They were collected from the inpatient clinic and out patient department of the vascular surgery department.

The exclusion criteria

We exclude the patients who had: severe septic conditions, hypersensitivity to the medications used renal failure

(serum creatinine more than 1.32mmol\l), pregnancy, cancer or other serious diseases, inability to cooperate with the requirement of the study, recent history of alcohol or drug abuse, current therapy of any immunosuppressive agents or anticonvulsant, concurrent participation in another clinical study or current treatment with investigational drug.

The calculation of the area of the ulcer was done by using the graph papers to document the ulcer's perpendicular linear dimensions (typically in centimeters using graph paper); the maximum distance is length and perpendicular distance is width [16]. The progress of healing was measured every month and records the percent of healing.

The patients were randomly classified in to 3 different groups of treatment.

Group I

It includes 20 patients treated by ozone. They were 11 female and 9 male

Group II

It includes 20 patients treated by low level laser therapy. They were 13 female and 7 male.

Group III

It includes 20 patients as a control group .It has 10 female and 10 male.

They were treated surgically by debridement only at outpatient clinic of the emergency surgery department, and the use of topical antibiotic with dressing.

Methods

1) All patients subjected to a clinical sheet to collect data for clinical evaluation.
2) Debridement was done to all cases at the start of the treatment only Then For each group:

Group I

20 patients treated with ozone (generated by the medozon apparatus) given three times per week for three months.

All cases treated locally by bag, in the local ozone treatment the lesion was covered by plastic bag sealed to the leg which was then put under vacuum in order to eliminate the air inside it, then the bag was filled with ozone at a concentration of 60 mg/l. The patient remained with the plastic bag for one hour then the bag was removed and the lesion covered with ozonated water as dressing.

7 cases of these 20 patients treated with rectal insufflation at concentration 60 mg/l using 5 syringes each filled with 50 ml of ozone. The other 13 cases that refuse to be treated rectally treated by subcutaneous injection of the ulcer edge and also injection of the ulcer bed at concentration 30 mg/l .The injection volume were according to the diameter of the ulcer, at each site of injection introduce 3-5 ml of the ozone.

Group II

20 patients all subjected to low level laser therapy to the ulcer. The infrared laser was applied by scanning method to the ulcer. It is applied for 8-10 minutes (980 nm; power: 200MW; 4-6 J/cm²). The treatment was applied for 3 months, 3 setting per week, with follow up every month to detect the improvement by measuring the diameter of the ulcer and detect the healing progression.

The patient lies comfortably on the bed, and eye goggle is given to the patient to protect the eyes from the hazard of the low level laser therapy.

Group III

20 patients as a control group all subjected to debridement only at the emergency surgery department. With topical application of antibiotic.

3) All patients were subjected to the investigations.

- **X-ray of feet.**
- **Doppler ultrasound of both legs:**
  1. The procedure is explained to the patient.
  2. The patient is fasting for 8-12 hours (avoid smoking also).
  3. The patient is asked to lie in supine position, after a 5-minute rest. A Doppler ultrasonic instrument (Nemio 20, TOSHIBA,

Tokyo, Japan) equipped with a 5-7.5 MHz linear array transducer was used to detect any abnormality in arterial blood flow.

4. The vessels are studied in the sagittal plane, and Doppler velocities are obtained using a 60° Doppler angle. Vessels are classified into 1 of 5 categories: normal, 1% to 19% stenosis, 20% to 49% stenosis, 50% to 99% stenosis, and occlusion. The categories are determined by alterations in the Doppler waveform as well as increasing peak systolic velocities (PSVs).

PSV	Stenosis Severity
Triphasic <100 cm/s	Normal
>30% increase in PSV	20% to 49%
Doubling of PSV	50% to 99%
No Doppler flow in artery	Occluded

Compared with normal arterial segment proximal to stenosis. PSV = peak systolic velocity.

5. Examining both legs arteries including: popliteal artery, anterior tibial artery, tibioperoneal trunk, peroneal artery, posterior tibial artery and dorsalis pedis artery.

- Planter pressure of the feet was reported by Zebris apparatus.

This apparatus has a plate on which the patient is stand and analysis of the stance is occurred either static or dynamic analysis. In our study we made static analysis.

This apparatus report the pressure in the feet at both the forefoot and the hind foot and detect the total pressure of each foot. Then compared with each other. This help to detect areas of the increased pressure and impending to be opened and cause an ulcer. Also this apparatus make analysis of the stance parameters as the width, height, angle, deg, horizontal deviation and the vertical deviation.

The report is then given to the patient at the end of the study, explain the areas increased pressure to help in designing the offloading (the diabetic foot shoe)

- Nerve conduction study to detect the degree of the nerve affection as a complication of the diabetes mellitus.
- Blood sample for biochemical analysis were obtained at the beginning of the study and 24 hours after the last ozone treatment for detection of the glucose level. The results from group I and group II was compared with the group III.

The main variables for follow up was the following:

a) Measurement of the area of the lesions under aseptic conditions,

At 0, 1, 2, 3 months. By using a graph paper

b) Qualitative clinical evaluation of the lesions.

- By physician , by inspection of the ulcer
- By the patient, by using the visual analogue scale.

2) Glucose levels, measured:

- At the beginning
- 24 Hour after the last treatment.

A good result was considered when there was decrease in the diameters of the ulcer.

RESULTS

This study is a randomized controlled clinical trial that was carried out on 60 patients all with diabetic foot ulcer that affect the soft tissue. They were collected from the inpatient and outpatient clinic of vascular surgery unit in Zagazig University Hospitals. The aim of the study was to evaluate the effect of ozone in treatment of diabetic foot ulcers after debridement, to evaluate of the effect of low level laser therapy in treatment of diabetic foot ulcers after debridement and Compare between the effect of both modalities and the patients who were treated with debridement only.

The duration of the study was from April -2007 to April-2009

Table 1 shows the degree of healing among the three groups; the percent is zero at the start of the trial in the three groups. After 1 and 2 months there were high significance of the percent of healing and there were early healing with ozone as appear in the values of the median and the range in the table as many patients in the ozone group achieve the complete healing of the ulcer in the second month and the rest (5 patients) involved in the third month, in comparison to the laser group in which (12 patients) involved in the third month. At the end of the third month there was high significance as there was no statistical analysis due to the difference in the number of cases involved in the third month.

Table (1): Shows the comparison of the healing percentage among the three groups at 0,1,2,3 months.

	0-month	1-month	2-month	3-month	P+
Laser					
Median	0.0%	55.5%	79.5%	97.0%	0.000
Range	0.0-0.0	30-100	59-100	89-100	
Ozone					
Median	0.0%	77.6%*	100.0%*	98.3%	0.000
Range	0.0-0.0	46-100	73-100	91-100	
Control					
Median	0.0%	0.0%	0.0%	0.0%	
Range	0.0-0.0	0.0-4.0	0.0-6.0	0.0-7.0	
Kruskal wallis-H		42.1	37.7	27.6	
P		0.000	0.000	0.000	

- *Means statistical change over time in the same group (done by Friedman's test).however in comparison between the 3 groups in the same month (done by Kruskal wallis-H test) there were statistical significant difference between the three groups.
- +means in the1st and 2nd month in comparison between the laser and the ozone groups (done by Mann Whitney test) showed statistical difference between the two modalities, in which the ozone is better in the percentage of healing than the laser group.

Table (2): Shows the mean of number of settings among both laser and ozone groups
This table shows significance between both ozone and laser groups in the number of setting. It is less in number at the ozone group than the laser group.

	Laser	Ozone	t	P
X±SD	27.3+12.2	20.1+10.0	2.26	0.03

In this study there were changes in the pulses that were felt before start of the treatment. These changes occur only in the ozone group in which the number of patients with dorsalis pedis artery pulse became 1 after it was 0, and the number of patients with posterior tibial artery pulse became 5 after it was 3, the number of patients with anterior tibial artery pulse became 3 after it was 1. And the number of patients with posterior tibial+anterior tibial artery pulses became 10 after it was 8. These changes occur only with ozone not with the other two groups. As shown in table 3.

Table (3): Shows changes in felt pulses after treatment.

Felt pulses	ozone before treatment		ozone after treatment	
	No	%	No	%
-Dorsalis pedis pulse	0	0.0	1	5.0
-Posteriot tibial pulse	3	15.0	5	25.0
-Anterior tibial pulse	1	5.0	3	15.0
-Post tibial+Ant.tibial pulses	8	40.0	10	50.0

In our study there were significant difference in Doppler study before and after the treatment especially in the ozone group, as regard to peak systolic velocity, marked spectral broadening, loss of reversal of blood flow (the three major criteria), loss of the reversal of blood flow during diastole and the wave form (monophasic) which became biphasic but not reach the normal triphasic wave form after treatment. These findings were reported before the start of the treatment. Then at the end of the treatment all patients repeat the Doppler ultrasound study to both legs and there were changes in the findings that were reported in most patients of the ozone group. But not with the laser and the control groups. As shown in table 4.

Table (4): shows the number and percent of changes in Doppler ultrasound study before and after the treatment among the three groups.

Doppler ultra-sound finding	Laser N=20		Ozone N=20		Control N=20	
	Before	after	before	after	before	after
peak systolic velocities (Greater than100%)	17(85%)	17(85%)	16(80%)	5(25%)*	15(75%)	15(75%)
marked spectral broadening	16(80%)	16(80%)	17(85%)	6(30%)*	17(85%)	17(85%)
(turblance)	15(75%)	15(75%)	16(80%)	6(30%)*	16(80%)	16(80%)
loss of the reversal of blood flow during diastole	17(85%)	17(85%)	16(80%)	5(25%)*	16(80%)	16(80%)
significant arterial narrowing	15(75%)	15(75%)	15(75%)	4(20%)*	14(70%)	14(70%)
wave form (monophasic)						

***it means statistical significant changes (done by Mc Nemar's test)**

In our study the number of patients with retinal complications was 6; 1 in the laser group, 3 in the ozone group and 2 in the control group, as diagnosed by the ophthalmologist (**Non proliferative diabetic retinopathy**). In the ozone group those three patients were included in patients who received the rectal insufflation of ozone. After the end of treatment by ozone and laser, reexamination of the retina by the ophthalmologist was done in form of visual acuity and ophthalmoscopy. And there were marked improvement in the visual acuity and the exudates, intraretinal haemorrhage and other microvascular changes. This improvement was felt by the patients through the course of the treatment inform of improvement of the vision and became gradually clear. But there were no improvement in the other two groups. As shown in table (5)

Table (5): shows the improvement of retinal complications among the three groups

Retinal complications	Laser N=20		Ozone N=20		Control N=20		p
	before	after	before	after	before	after	
No	1	1	3	0	2	2	0.03
%	5.0	5.0	15.0	0.0	10.0	10.0	

Before ozone therapy ***after ozone therapy***

Before ozone therapy ***after ozone therapy***

Ulcer before laser therapy ***ulcer after laser therapy***

DISCUSSION

Diabetic ulcers are the most common foot injuries leading to lower extremity amputation. Family physicians have a pivotal role in the prevention or early diagnosis of diabetic foot complications. Management of the diabetic foot requires a thorough knowledge of the major risk factors for amputation. The most common risk factors for ulcer formation include diabetic neuropathy, structural foot deformity and peripheral arterial occlusive disease. A careful physical examination can identify patients at risk for foot ulcers and appropriately classify patients who already have ulcers or other diabetic foot complications. Patient education regarding foot hygiene, nail care and proper footwear

is crucial to reducing the risk of an injury that can lead to ulcer formation. [17]

This study was done at Zagazig University. In Rheumatology and Rehabilitation Department. The number of cases was 60 patients, collected from Vascular Surgery Department inpatients and out patient's clinics.

This study was carried out to evaluate the efficacy of ozone therapy and low level laser therapy on the diabetic foot ulcers.

In our study we use laser therapy and ozone therapy in treatment of diabetic foot ulcers, and this lead to marked improvement of the ulcer area as expressed by improvement in the percent of healing, this shown in table 1. There were marked improvement at the end of the second and third months noticed in both the laser and the ozone groups. More marked in the ozone group.

This is supported by that, the number of settings was significantly different between both ozone and laser groups. As shown in table 2.It is less significant in number at the ozone group than the laser group.

Many studies support our results about the treatment with ozone and laser as follow:

In a study done by using ozone therapy .This study concluded that ozone treatment in addition to conventional treatment was superior to conventional treatment alone in promoting the complete healing of diabetic foot ulcers. [18]

In other study that use ozone treatment in form of local application of bag and rectal insufflation. This study concluded that the healing of the lesions improved, resulting in fewer amputations than in control group. There were no side effects. These results show that medical ozone treatment could be an alternative therapy in the treatment of diabetes and its complications. [19].

A preliminary economic evaluation showed that the use of ozone therapy in the treatment of diabetic foot produced a decrease in treatment costs of about 25% compared to the use of antibiotics. Taking into account that the probability of hospitalization and the cost to health care is 3 to 5 times higher for diabetic patients than for non-diabetic patients and that epidemiological studies suggest that there will be 300 million diabetic patients in the year 2010 [20]

In a study that use low level laser therapy for treatment of patients with a diabetic foot wound. The study provides evidence that LLLT can accelerate the healing process of chronic diabetic foot ulcers, and it can be presumed that LLLT may shorten the time period needed to achieve complete healing. [21]

In a study that was done using laser in treatment of diabetic foot ulcer. It concluded that Low-level laser therapy could be a safe and effective method for treatment of diabetic foot ulcers. Clinical trials with higher sample size are proposed to more evaluate the efficacy of low-level laser therapy in treatment of this type of wounds. [22]

The first case of diabetic foot patient treated with low-intensity laser therapy reported in 1999 and proposed that this therapeutic method might constitute a useful side effect-free alternative treatment modality for the induction of wound healing of neuropathic ulcers in diabetic patients. Since then, some researches have been oriented to application of low-intensity lasers for treatment of diabetic foot ulcers. [23]

It was Said in a systemic review concluded that there is generally insufficient reliable evidence to draw conclusions about the contribution of laser therapy to chronic wound healing. [24]

The improvement in the pulse was noticed in the ozone group as reported in table 3, in which the number of cases with no pulses felt at the dorsalis pedis artery decreased from 20 to 19 cases, at the posterior tibial artery decreased from 17 to 15, at the anterior tibial artery decreased from 19 to 17.While in both the posterior

tibial and the anterior tibial arteries decreased from 12 to 10.

In a study that was done in 2002. [25] The patients included in this study were diagnosed with an ischemic or neuroinfectious diabetic foot, chronic venous insufficiency and subacute arterial ischaemia. They were treated by rectal insufflation of ozone. This study concluded that at the end of the treatment, platelet aggregation percentage was reduced in comparison with the initial values. This was evidence of decreased the incidence of vessel narrowing and decrease in the blood flow and lead to improvement of the pulse.

Non Invasive Doppler on both legs was done to all cases in our study at the start and at the end of the study. Improvement of the Doppler findings was noticed after treatment with ozone therapy in the ozone group only and not with the other two groups. This is reported in table 4, as regard the peak systolic velocity, marked spectral broadening, loss of reversal of blood flow (the three major criteria), and the other findings.

Doppler study supports the clinical experience of achieving improvement by using ozone therapy in peripheral ischemic syndromes. The systolic velocity had increased by 22% after sessions ($P = 0.001$) and by 15% 1 week later ($P = 0.035$), whereas the diastolic velocity had increased by 33% after session ($P < 0.001$) and by 18% 1 week later ($P = 0.023$). [26]

The effect of ozone on retinal disorders is confirmed in our study as shown in table (5) in which the three patients that were had retinopathy show improvement of vision that had been confirmed by ophthalmologist after the end of treatment by ozone using the rectal insufflation route.

In a study that was done on patients with retinal disorders [27] .The Patients were treated with ozone, by rectal insufflation. An ophthalmologic evaluation (visual acuity, direct and indirect ophthalmoscopy, retinophoto and fluorescein angiography) of the patients was performed at the beginning and at the end of every cycle of ozone therapy. In 72 % of the patients a visual improvement was achieved, with a slow disappearance of microaneurysm, intraretinal hemorrhages, hard exudates, microhemorrhages and retinal edema.

Ozone therapy affects the retinal disorders in many ways. It increases the oxygen supply to the retina so protect from the neurosensorial cell degeneration and death [28], as lack of oxygen rapidly leads to peripheral and/or central loss of vision by degeneration of the neurosensorial cells. This is explained as follow, the *foveola* has the highest concentration of cones and is responsible for the visual acuity, i.e., for the detection of the finest details of any object. For its metabolic requirements, the *foveola* depends entirely on the choriocapillaries circulation because there are no retinal vessels and among the various tissues of the body, it has a far higher consumption of oxygen than the liver, the kidney and the brain. Thus it becomes understandable how the ozone affect the retinal disorder. [29]

In summary, ozone treatment of patients with diabetes suffering from diabetic foot ulcers. Ozone therapy could be a future alternative in the therapy of diabetes and its complications.

Further innovations in diabetes therapy are needed to improve treatment and its cost. Ozone therapy could provide a solution to diabetes
therapy.

Our work although was a mono method, and composed of treatment with laser or ozone, cure of all diabetic feet in about 2 months gives us hopes for opening new horizons in treatment of diabetic foot ulcers as already known to be refractory chronic ulcers.

However, more clinical and experimental studies are proposed
profile for treatment of diabetic foot ulcers in suffering patients.

REFERENCE

1. **Tierney L M, McPhee S J, Papadakis M A (2002).** Current medical Diagnosis & Treatment. International edition. New York: Lange Medical Books/McGraw-Hill, 1203-1215. ISBN 0-07-137688-7. Quoted from http://en.wikipedia.org/w/index.php
2. **-World Health Organization (1999):**Department of Noncommunicable Disease Surveillance (1999). Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications Quoted from: http://en.wikipedia.org/wiki/world_health_organization.
3. **-Rother, KI (2007):**"Diabetes Treatment — Bridging the Divide". N Engl J Med **356** (15): 1499-1501 Quoted from http://content.nejm.org/cgi/content/full/356/15/1499
4. **Oculus.Inc(2007)**: diabetic foot ulcer Quoted from http://www.oculusis.com/mexico/is/diabetic foot/diabetic foot ulcer.html
5. **-Gérard V. (2007):** Diabetic Wound Management: A Key Ingredient is Missing. Quoted from: http://www.triroc.com/ sunnen/ topics/diabetes.leg.htm
6. **-Dreddy(2006):** the story of ozone, ozone therapy is safest known therapy. Quoted from: http://dreddyclinic.com/contact.htm
7. **-Canadian Coordinating Office for Health Technology Assessment *(CCOHTA) (2002):*** Topical ozone therapy for the treatment of diabetic leg ulcer Quoted from (www.ccohta.ca)
8. **-Matic M., Lazetic B., Poljacki M., Duran V. and lvkov Simic M. (2003)** Low level laser irradiation and its effects on repair processes in the skin. Med Pregl. 56(3-4), 137..141.
9. **-Walash, (2005):** Low level laser therapy for diabetic foot wound healing. (Wound care) Quoted from http//www.goliath.ecnext.com/com2/summary_IIm
10. **-Houreld N. and Abrahamse H.(2006):** Frequency of helium-neon laser irradiation on viability and cytotoxicity of diabetic wounded fibroblast cells.Photomed Laser Surg. In Press (Manuscript 1095)
11. **-Falanga V.(2005):** Wound healing and its impairment in the diabetic foot. Lancet 366:1736-1743.
12. **-Schultz GS, Sibbald RG, Falanga V, Ayello EA, Dowsett C, Harding K, Romanelli M, Stacey MC, Teot L, Vanscheidt W(2003):**. Wound bed preparation: a systematic approach to wound management. Wound.Repair Regen 11(Suppl 1):S1-S28
13. **-Enoch S and Harding K (2003):** Wound bed preparation: the science behind the removal of barrier to healing. Wounds 15:213-229.
14. **-Edmonds M, Foster A, Vowden P (2004):** Wound bed preparation for diabetic foot ulcers. European Wound Management Association (EWMA). Position Document: Wound Bed Preparation in Practice, pp 6-11.
15. **-Brodsky JW. (1999):** The diabetic foot. In: Coughlin MJ, Mann RA, eds. Surgery of the Foot and Ankle. St. Louis: Mosby Inc; 895-969
16. **-Brown G S. (2007):** Reporting outcomes for stage IV pressure ulcer healing: a proposal,Adv Skin wound Care; 13:277-283.
17. **David G. and Lawrence A. (2000):** Diabetic Foot Ulcers: Prevention, Diagnosis and Classification. The American Family Physician. Quoted from:http//www.aafp.org/afp/980315ap/armstron.html
18. **Wainstein J, Feldbrin Z, Boaz M, Harman-Boehm I. (2011):** Efficacy of Ozone-Oxygen Therapy for the Treatment of Diabetic Foot Ulcers. Diabetes Technol Ther. [Epub ahead of print]
19. **Gregorio. M , Saied M, Silvia .M, Lamberto Re ,Attilia G, Eduardo C, Hector Á,José I, Olga S (2005) :** Therapeutic efficacy of ozone in patients with diabetic foot. European Journal of Pharmacology 523(151–161).

20- **Bjork, S., (2001):** The cost of diabetes and diabetes care. Diabetes Res. Clin. Pract. 54 (1), 13–18.

21- **Kaviani A, Djavid GE, Ataie-Fashtami L, Fateh M, Ghodsi M, Salami M, Zand N, Kashef N, Larijani B.(2011):** A Randomized Clinical Trial on the Effect of Low-Level Laser Therapy on Chronic Diabetic Foot Wound Healing: A Preliminary Report.photo med laser surg. 29(2):109-14. Epub.

22-**Kazemi N-Khoo (2006):** Successful treatment of diabetic foot ulcers with low-level laser therapy. The international journal of clinical foot science. Volume 16,issue 4. Pages 184-187.

23- **Schindl A, Schindl M, Pernerstorfer-Schon H, Kerschan K, Knobler R, Schindl L. Diabetic neuropathic foot ulcer(1999):** successful treatment by low-intensity laser therapy. Dermatology;198(3): 314–6.

24- **Cullum N, Nelson EA, Flemming K, Sheldon T. (2001):** Systematic reviews of wound care management: (5) beds; (6) compression; (7) laser therapy, therapeutic ultrasound, electrotherapy and electromagnetic therapy.Health Technol Assess;5(9):1–221.

25- **Diaz-Llera, S., Gonzalez-Hernandez Y., Prieto-Gonzalez E. A., and Azoy A., (2002)**: Genotoxic effect of ozone in human peripheral blood leukocytes, *Mutat. Res.* **517**:13-20.

26- **Clavo B., Català L., Pérez J. L., et al. (2004):** Effect of ozone therapy on cerebral blood flow: A preliminary report, Evid. Based. Complement Alternat. Med., **1(3)**: pp315–319.

27- **Hernández R., Ramírez T., Guerrero M., Betancourt J., Rubio L. and Izquierdo N.(2009):** Ozone therapy in patients with diabetic retinopathy.medical applications of ozone: part 2 4th International Symposia on Ozone Applications.

28- **Seddon, J. M., Gensler G., Milton R. C., Klein M. L., and Rifai N., (2004)**: Association between Creactive protein and age-related macular degeneration, *JAMA* **291**:704-710.

29- **D'Amico, D. J., (1994):** Diseases of the retina, *N. Engl. J. Med.* **331**:95-106.

التأثير العلاجي للأوزون و الليزر في علاج قرح القدم السكري

مرض السكر هو اختلال في عملية الأيض و يحدث نتيجة نقص في هرمون الأنسولين أو عدم استجابة الخلايا للهرمون . يتميز السكر بكثرة إدرار البول ،زيادة في تناول السوائل،مع وجود زغللة بالعين.

أقرت منظمة الصحة العالمية ثلاثة أنواع من السكر،نوع(١)،نوع(٢) وسكر الحمل.

هناك أعراض جانبية كثيرة للسكر منها قرحة القدم السكري التي تحدث في ١٥% من مرضى السكر،٦% منهم عرضي للأعراض الجانبية للقرحة مثل العدوى بالبكتيريا وغيرها.

يتكون الأوزون من ثلاث ذرات أكسجين تتكون في الطبقات العليا من الغلاف الجوى.يستخدم الأوزون في علاج أمراض عديدة منها السرطان،تصلب الشرايين،الإيدز،الكبد الوبائي،الرثيان المفصلي،الحساسية،السكر وأعراضه الجانبية وأهمها قرح القدم السكري فهو يساعد في التئام الجروح حيث أنه له تأثير محفز للدورة الدموية و يزيد الأكسجين إلى الأنسجة كما أنه له تأثير مضاد للبكتيريا والفطريات والفيروسات. هناك طرق عديدة للعلاج بالأوزون منها عن طريق الحقن في الدم ،عن طريق الحقن في العضل، الحقن في المفاصل،أو الطريقة الموضعية. وكذلك الليزر يستخدم أيضا في علاج الجروح حيث أنه له خصائص منفردة تمكنه من اختراق الأنسجة دون فتحها.فهو يسرع من عملية التئام الجروح حيث أن له تأثير محفز على نمو الخلايا و يقلل من التورم و الالتهابات المحيطة بالجرح.

إزالة النسيج التالف احد طرق العلاج الجراحي،حيث أن وجود النسيج التالف يعوق عملية التئام الجرح و يعمل على نمو البكتيريا.

و قد كان الهدف من هذا البحث:

١. تقييم تأثير العلاج بالأوزون علي قرح القدم السكري.
٢. تقييم تأثير العلاج بالليزر علي قرح القدم السكري.
٣. المقارنة بين الطريقتين السابقتين والعلاج الجراحي.

وقد اجرى البحث على ستين مريضا مصابون بقرح القدم السكرى وقد تم جمعهم من العيادات الخارجية و القسم الداخلي لوحدة جراحة الأوعية الدموية بمستشفيات جامعة الزقازيق. وقد تم علاج المرضى جراحيا بواسطة إزالة النسيج التالف عند البدء فى الدراسة.

و قد تم تقسيم المرضى إلى ثلاث مجموعات:-

المجموعة الأولى:-

شملت ٢٠ مريضا وقد تم علاجهم با للأوزون بالطريقة الموضعية ثلاث مرات أسبوعيا لمدة ثلاثة أشهر.و هناك ٧ حالات تم علاجهم عن طريق الحقن الشرجى و ١٣ حالة تم علاجهم بالحقن الموضعى.

المجموعة الثانية:-

شملت ٢٠ مريضا وقد تم علاجهم با لليزر ثلاث مرات أسبوعيا لمدة ثلاثة أشهر.

المجموعة الثالثة:-

كمجموعة ضابطة.وشملت ٢٠ مريضا.وقد تم علاجهم جراحيا

وقد تم متابعة وتقييم جميع الحالات كل شهر بقياس أبعاد القرحة لمدة ثلاثة أشهر متتالية وتم مقارنة التحسن مع المجموعة الضابطة.

وقد تم أخذ التاريخ المرضى الكامل لهؤلاء المرضى مع معرفة جميع الفحوصات التى تم عملها

وقد تم تسجيل تاريخ بداية القرحه فى القدم مع معرفة مدة حدوث مرض السكر.و الطرق اللتى اتبعت لمتابعة القرحه وعلاجها والتحسن الحادث بحالة القرحه وايضا تم تسجيل الاعراض الجانبيه الأخرى لمرض السكر.

من هذه الدراسه نستخلص الآتى:

أن علاج قرح القدم السكرى بواسطة كلا من الأوزون و الليزر كان أكثر فاعلية من العلاج الجراحي و قد كان التحسن فى التئام القرحه فى مجموعة الأوزون أكثر فاعلية وسرعة من العلاج بالليزر.

فى النهايه ننصح بما يلى:

١-العنايه بالقدم السكرى هامه جدا لتجنب حدوث قرحة بالقدم.

٢-زيادة الوعى بمعرفة أضرار مرض السكر هامه جدا لتجنب حدوثها، مما يساعد فى التشخيص والعلاج المبكر.

٣-عند حدوث قرحة القدم السكرى ليس من الصائب علاجها جراحيا كأول قرار ولكن لابد من اعطاء فرص لطرق أخرى للعلاج تساعد على التئام الجرح مثل العلاج بالليزر أو الأوزون.

٤-العلاج بالليزر والأوزون يساعد على التئام قرحة القدم السكرى ولكن هناك بعض الملاحظات:

- أثناء العلاج بالأوزون لوحظ سرعة الالتئام مع ظهور الجرح بصوره صحيه أفضل مع وجود تحسن بالدوره الدمويه وذلك بواسطة الفحص الظاهري و بعد المتابعة بالدوبلر.
- لوحظ مع المرضى الذين تم علاجهم بالحقن الشرجي للأوزون أعراض نقص مستوى السكر فى الدم وقد تم قياس السكرللمرضى بعد انتهاء جلسة الحقن الشرجى وجد أنه منخفض.
- لوحظ مع المرضى الذين تم علاجهم باليزر أن القرحة عرضه للحدوث مره أخرى.
- لوحظ أن العلاج بالليزريستغرق فتره زمنيه أطول من الأوزون.

بعداتمام هذه الدراسه نوصى بالآتى:

١-اعطاء الفرصه لطرق أخرى للعلاج بدلا من قرار البتر.

٢- التعاون مع الأقسام الأخرى خاصة قسم جراحة الأوعية الدموية لأن الهدف الأساسى العلاج الآمن للمريض.