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Effect of Infrared Radiation on the Healing of Diabetic Foot Ulcer

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Abstract

Background: Diabetic foot ulcer is a worldwide health care concern affecting tens of thousands of patients. If these ulcers left untreated, they can create severe complications.
Objectives: This study was designed to examine the effect of infrared radiation on the healing of diabetic foot ulcer.
Patients and Methods: This clinical trial was performed on 50 patients referred to Dr. Ganjavian hospital in Dezful city, Iran, with diabetic foot ulcer degree 1 and 2 (based on Wegener Scale). Sample size was determined based on relevant studies of the recent decade. Patients were classified into the intervention and control groups (n = 25 in each group) in terms of age, gender, degree of ulcer, ulcer site and body mass index. In this study, work progress was evaluated according to the checklist of diabetic foot ulcer healing evaluation.
Results: The results of the current study showed that there was a statistically significant difference in healing ulcers ($P < 0.05$) and mean healing time ($P < 0.05$) between the two groups.
Conclusions: Using the infrared plus routine dressing is more effective than using merely routine dressing.

Keywords: Diabetic Foot Ulcer, Infrared Radiation, Routine Dressing

1. Background

Diabetes is one of the biggest global health emergencies from the 21st century. Every year more and more people live with this disease that can be as a result of life-changing complications (1).

The first world health organization's global report (2016) about diabetes shows that the number of adults with diabetes, almost from 1980 to 2014, has quadrupled. So that the number of people with diabetes increased from 108 million in 1980 to 422 million in 2014.This significant increase is greatly due to increase in type 2 diabetes and its associated risk factors, such as being overweight and obese (2).

An international diabetes federation (IDF) estimates 415 million adults are living with diabetes by 2040; this amount will be increased to 642 million. In addition to the 415 million people with diabetes, the IDF estimates that 318 million people have impaired glucose tolerance, and about 21 million women develop gestational diabetes (1, 3).

Diabetes is a major cause of blindness, kidney failure, heart attacks, strokes and amputations of lower limbs (2).

Diabetic patients can experience problems with poor circulation to the feet as a result of damage to the blood vessels. These problems increase the risk of ulcers, infections and amputations (1).

The current treatments for diabetic foot ulcer include controlling blood sugar, proper antibiotic treatments, tissues debridement, washing and regular dressings, necrosis, decreasing mechanical pressure, if possible and modifying blood circulation (4-6). The first objective in treating a diabetic foot ulcer is ulcer closure and helping accelerate this process. In this regard, Mester and his colleagues' studies about the effect of infrared radiation on treating different kinds of wounds, especially diabetic ulcers, indicate that more than 70% of these ulcers responded to this treatment procedure. Treating chronic foot ulcer is a medical problem (7). Various measures have been proposed for the treatment (8, 9) which include skin grafting (10, 11), temperature therapy (10, 12), and using infrared and electric stimulation; the last ones are the new methods being currently used and researched. These methods, which are

used to accelerate the treatment process, may replace current methods of treating foot ulcers in near future (10). Posten et al. also emphasized the positive effect of infrared radiation on different kinds of chronic ulcers in diabetic patients (13). Another study titled "The effect of local heat with tungsten generator of infrared treatment and accelerating the process of treatment of ulcers against environmental heat in chronic diabetic ulcers" indicated useful and meaningful treatment (14).

Kazemikho et al. study (2009) asserts that the low level laser therapy can be an effective and safe treatment method for foot ulcers caused by type 2 diabetes (15).

Also, Mokmeli et al. (2011) expressed that the low-level laser therapy promotes healing process of diabetic foot ulcers (16).

Treatment with infrared radiation is one of the new noninvasive and safe treatments in the field of caring after diabetic foot ulcers and learning this treatment method is easy for caregivers.

Therefore, diabetic foot ulcers can endanger life of thousand patients and restrict the ability of people to do their daily activities considerably. Hence, taking a suitable approach to treat the disease can play a key role in saving costs and time.

It must be mentioned that in relation to the treatment of diabetic foot ulcer, several studies have been conducted, which have had good and desirable results. However, these studies have been conducted with a small sample size and treatment with infrared radiation has been rarely used because it is a very expensive method.

Given that using of such machines requires expertise and also is expensive and costly, we used a tungsten infrared generator lamp, which is quite cheap and economical and applicable for most caregivers.

2. Objectives

This study was conducted to examine the effect of infrared radiation on diabetic foot ulcers.

3. Patients and Methods

This clinical trial was performed on 50 patients referred to Dr. Ganjavian hospital in Dezful city, Iran, with diabetic foot ulcers degree 1 and 2 (based on the Wegener Scale) Sample size was determined based on relevant studies of the recent decade (14, 17-21). Patients were classified into the intervention and control groups (n = 25 in each group) in terms of age, gender, degree of ulcer, ulcer site and body mass index (BMI). Patients with diabetic foot ulcers degree 1 and 2 on finger, heel, foot and claw on the end limb, BMI of 18 - 35, age of 30 - 80 years, having full consciousness, oral nutritional and medication diet and having at least 5 years of diabetes were included in this study. Addicted and smoker patients and those who had diseases that can affect the healing process of ulcers like vascular diseases, lupus and rheumatoid arthritis were excluded from the study.

Before beginning the procedure, a written consent form was obtained from the participants. In this study, work progress was evaluated according to a checklist of diabetic foot ulcer healing evaluation. The applied method and procedure were also explained for both groups in summary.

Using the checklists, degree of ulcer, color, status of tissues around the ulcer and status of secretions of ulcer were evaluated and scored. Hence, the point 400 indicates healed ulcer and the lowest score of 50 indicates ulcer vanishing.

In a routine dressing method, firstly the ulcer and tissues around it were placed in sterilization tub for 20 minutes and then, it was dried by a sterile gauze and after putting a wet sterile gauze, it was dressed using the sterile method and the action was repeated twice a day and 7 days a week. In case of separation of dressing while changing linen and clothing of the patients or dressing getting wet due to high exudate, it was put again according to the mentioned procedure.

In treatment with infrared radiation using a 250W Lamp-tungsten generator, dressing was done twice a day. For this purpose, after washing the ulcer according to the mentioned method, before redressing of the patients, the ulcer was cured by infrared radiation once a day and 7 days a week according to studies in this field. For this purpose, a thermometer was placed on healthy skin around the ulcer to record temperature and ensure that its temperature has not exceeded 42°C. The distance of infrared source from the skin was equal to 30 cm and radiation duration was equal to 20 minutes. A radiation angle was selected perpendicular according to the Lambert cosine law, so that maximum radiation absorption and intrusion was gained and then, the wet dressing was done.

Patients were followed up for 4 weeks and 7 days a week and at weekend, a primary checklist was fulfilled again and separated scores were given to the ulcer in each week.

On the weekend, the last score (score of week 4) was compared to the first score (score of week 0) and status of the ulcer was defined as full recovery, partial recovery, no recovery and worsening.

Full recovery: In case that total scores of the ulcer were equal to 400 according to the checklist.

Partial recovery: In case that total scores of the ulcer were increased at least 30 times compared to the initial

score.

No recovery: The ulcer score was not changed compared to the initial score or was changed below 30 times.

Worsening: The score of ulcer was decreased 10 times compared to the initial score.

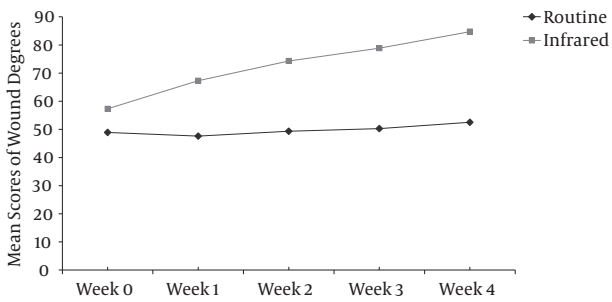
Using the SPSS 14 software, the demographic data and the repairing check list of foot ulcer (Table 1) were coded qualitatively and quantitatively, and inputted into computer. The data related to the check list were processed based on conventional pointing as five subsequent phases from the beginning, before intervention, week 1, week 2, week 3, and week 4, so that the process of repairing of each parameter can be analyzed. Also, to compare the quantitative and qualitative variables in two groups, an independent t-test and chi- square test were used, respectively. Also, t-test was used in both groups in different weeks.

4. Results

The mean age of the patients in the control group was equal to 53.36 (SD = 11.51) and the mean age of the intervention group was equal to 51.60 (SD = 8.71). Demographic information of both groups has been presented in Table 2.

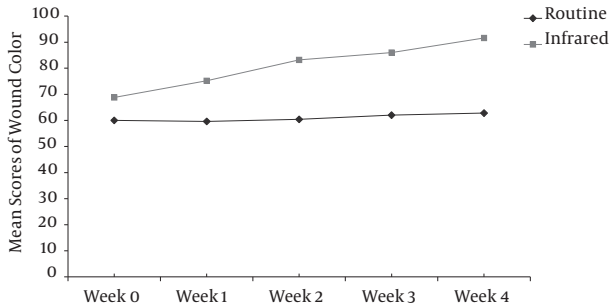
The total mean score related to the intervention group, which was 230.92 before the intervention (week 0), reached 338.76 after the intervention. In the control group, it reached from 196.92 before the intervention (week 0) to 209.92 at the end of week 4. Independent t-test showed no significant difference between the two groups before the intervention, while it showed a significant difference between the two groups at the end of the week four ($P < 0.001$). The results have been shown in Figures 1 - 5.

Figure 1. Comparison of the Mean Scores of Wound Degrees in Routine and Infrared Treatment



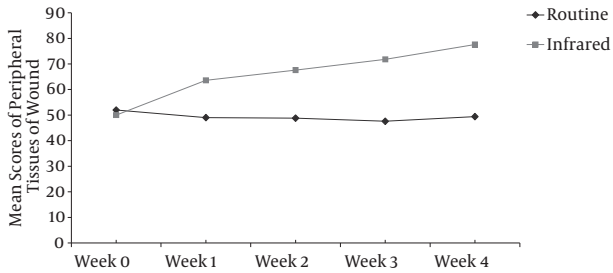
P < 0.001; there was a significant difference between the two groups (intervention and control) in different weeks.

Figure 2. Comparison of the Mean Scores of Wound Color in Routine and Infrared Treatment



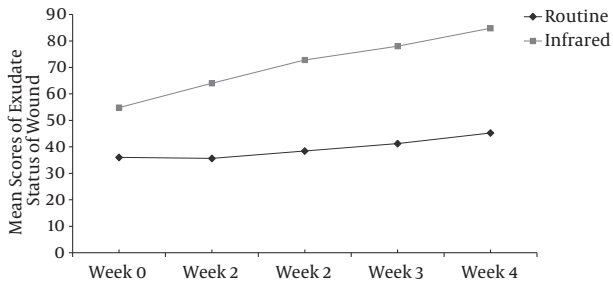
P < 0.001; there was a significant difference between the two groups (intervention and control) in different weeks.

Figure 3. Comparison of the Mean Scores of Peripheral Tissues of Wounds in Routine and Infrared Treatment



P < 0.001; there was a significant difference between the two groups (intervention and control) in different weeks.

Figure 4. Comparison of Scores of Exudate Status of Wound in Routine and Infrared Treatment



P < 0.001; there was a significant difference between the two groups (intervention and control) in different weeks.

5. Discussion

According to obtained results, infrared radiation can be more effective than routine dressing in healing of diabetic foot ulcers.

Table 1. Evaluation Checklist for Healing of Diabetic Foot Ulcer

Number	Parameters	Distribution of Points Between Each of the Components															
100	Ulcer degree	stages	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		100	100	90	90	80	75	65	65	55	50	40	40	30	25	15	15	10
100	Ulcer color	center	Fully healed			Red (granular)			yellow			necrotic			necrotic granular			
		50	50			40			30			20			10			
		labia	Fully healed			Red (granular)			yellow			necrotic			necrotic granular			
		50	50			40			30			20			10			
100	Peripheral tissue	color	normal			red			pail			cyanotic			-			
		25	25			20			15			10			-			
		heat	has			has not			-			-			-			
		25	0			25			-			-			-			
		edema	has			has not			-			-			-			
		25	0			25			-			-			-			
		sense	has not			Decrease			normal			-			-			
		25	0			15			25			-			-			
100	excretions	color	No excretion			serous			bloody			yellow			green			
		40	40			30			20			10			0			
		smell	has not			has			-			-			-			
		20	20			0			-			-			-			
		amount	no excretion			low			average			high			-			
		40	40			30			20			10			-			

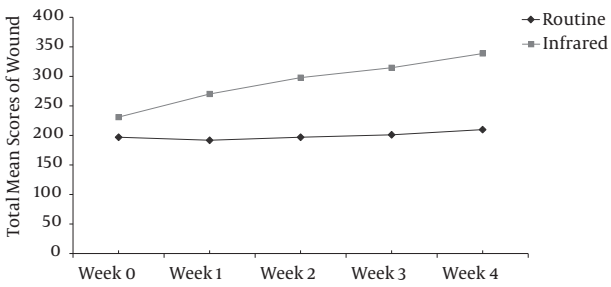
Total point (fully healed) = 400 (higher point = higher healing)

Table 2. Demographic Information of the Intervention and Control Groups

Variable	Intervention Group, Mean ± SD	Control Group, Mean ± SD	P Value
Age, y	51.60 ± 8.71	53.36 ± 11.51	0.54
BMI, kg/cm^2	27.26	25.24	0.68

Abbreviation: BMI, body mass index.

Figure 5. Comparison of Total Mean Scores of Wounds in Routine and Infrared Treatment



P < 0.001; Significant differences is between the two groups (intervention and control) in different weeks.

Common and dangerous complication of diabetes in this study that is a foot ulcer has been divided into several parameters for the purpose of investigation and analysis was done for each parameter independently. The results of the current study showed that in terms of degree of ulcer, color of ulcer, status of tissues around ulcer and secretions of ulcer in week 0, no significant difference was observed between the two groups, which can be due to the same conditions of caregiving as a result of hospitalization. However, in the first week after intrusion, changes in degree of ulcer, color of ulcer, secretions, tissues around the ulcer and total score of the ulcer showed a significant difference between the intervention and control groups. The difference was also existed in week 4 about the mentioned parameters. The results from a significant difference between scores of ulcer status in both groups have been in consistence with a study of Gerald Petrophsky et al. (2007). In this study, ulcers were investigated for 1 month and obtained results from the intervention group were significantly different from the control group in benefit of using infrared radiation (14). A study of Mahmudi (2004) has had also similar results (P = 0.08) (22). However, in a study conducted by Korzendorfer (2008), the two groups showed no significant difference in different weeks (P < 0.05) (23).

Infrared may accelerate ulcer healing through preventing infection and keeping ulcer surface sterile and dehydrating it. It has been reported that antibiotic medicines can control ulcer infection and accelerate its healing, which can be compared to the effect of infrared (18, 24).

Table 3. Frequency Distribution and the Recovery Percentage of Patients Based on Routine and Infrared Treatment

Recovery Status	Statistical Index	Routine	Infrared	Total Sample	P Value
Full recovery	Frequency	1	4	5	P < 0.001
	Percentage	4.0	16.0	10.0	
Partial recovery	Frequency	7	21	28	P < 0.001
	Percentage	28.0	84.0	56.0	
Worsening	Frequency	5	0	5	P < 0.001
	Percentage	20.0	0.0	10.0	
No recovery	Frequency	12	0	12	P < 0.001
	Percentage	48.0	0.0	24.0	
Total	Frequency	25	25	50	-
	Percentage	100.0	100.0	100.0	

Effect of infrared on collagen fibers indicates that in the day 10 after injury, the amount of this variable would be increased significantly. The finding is one of the most important findings of studying infrared radiation. This is because collagen fibers can make the ulcer site to be similar to the initial tissue before the injury and can also prevent creation of white and malformed scarring.

Some scholars believe that the best treatment for cutaneous wounds is using infrared radiation and in this regard, two scholars named Donald and Highland have used infrared radiation for cutaneous wound healing and have obtained desirable results and found that infrared radiation cannot cause prolongation and the chronic healing inflammatory process (18, 25).

Therefore, the diabetic foot ulcer can endanger life of thousand patients and restrict the ability of people to do their daily activities considerably. Effect of infrared on ulcer healing through reduction of inflammation has caused acceleration of the ulcer. On the other hand, increase in blood flow and oxygen to the wound site can be done through dilating blood vessels, which can affect capacity of fibroblasts, increasing the synthesis of collagen fibers and enhancing wound strength because of increase in collagen content (18, 26).

In a study under the title of "comparing the effect of three methods of nursing cares by themselves and along with ultrasound and laser (infrared) for pressure ulcer treatment", it was found that infrared lasers are more effective than conventional nursing actions to treat ulcers (19).

Studies in the field of the effect of infrared on chronic wound healing indicated that more than 70% of the wounds responded to emphasized the effect of infrared on healing types of wounds, especially diabetic ulcers (13, 27). The results of Malm et al. study showed no significant effect of infrared radiation on chronic wounds (28). On the other hand Kajagar et al. in their study (2012) assert that a low-level laser therapy, as an adjunct to usual therapy in the treatment of diabetic foot ulcers, is useful (29).

In this regard, Mao et al. (2016) also expressed that the combination of a low-level light therapy and topical coenzyme Q10 is a secure and comfortable method (30).

According to a high prevalence of the diabetic ulcer, and delay in healing it, using a method to decrease ulcer healing duration compared to the routine and conventional treatments is recommended. Studies in this field have been usually on a few numbers of patients and have used infrared laser generators that are extremely costly and working with them needs profession.

Although the results of the Mao et al. study showed that a low-level light therapy and topical coenzyme Q10 could increasingly promote wound healing (30), obtained results from some other studies have been inconsistent.

Therefore, performing the study using an infrared tungsten lamp generator is necessary that is cost- effective and is familiar for majority of nurses.

Recovery duration was considered just for ulcers with full recovery and only 1 ulcer (4%) from the routine group and 4 ulcers (16%) from the infrared group were healed during 4 weeks. Hence, healing duration is the same in both groups. However, according to a high percentage of partial recovery in the infrared group and a high percentage of no recovery and worsening in the routine group, it would be better to repeat the study in longer time interval to obtain more exact results. It is worth noting that the limitations of this study was time limit and the strengths of this study was a high percentage of partial recovery in the infrared group as well as low expense of infrared radiation for patients with diabetic foot ulcers.

In general, it could be found that if sterile points are observed in diabetic foot ulcers and also nutrition and medicine diet and proper technique of infrared radiation are observed, infrared radiation can be useful for ulcer healing and can cause effective sterile dressing of diabetic foot ulcer and ulcer healing without scarring.

5.1. Conclusions

The findings of the current study show the positive effect of the infrared radiation on ulcer healing compared to the routine dressing method.

Considering that treatment methods of the diabetic foot ulcers are costly and these ulcers cannot easily be cured, using the infrared lamp generator for healing this wound is recommended due to low expenditures and easy application for the patients. In general, this method prevents wasting of time, costs and resources.

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References

1. International Diabetic Federation . Diabetes atlas. 7 ed. Brussels: IDF; 2015.
2. WHO . Global report on diabetes. Geneva: World Health Organization; 2016.
3. International Diabetic Federation . Atlas: About 415 Million Adults Worldwide Have Diabetes. 3. Brussels: IDF; 2015.
4. Steed DL. Clinical evaluation of recombinant human platelet-derived growth factor for the treatment of lower extremity diabetic ulcers. Diabetic Ulcer Study Group. *J Vasc Surg.* 1995;**21**(1):71–8. [PubMed: 7823364] discussion 79-81.
5. Larijani B, Heshmat R, Bahrami A, Delshad H, Mohammad K, Heidarpour R, et al. Effects of intravenous Semelil (ANGIPARSTM) on diabetic foot ulcers healing: A multicenter clinical trial. *DARU J PharmaSci.* 2008;**16**(Suppl. 1):35–40.
6. Bahrami A, Kamali K, Ali-Asgharzadeh A, Hosseini P, Heshmat R, Gharibdoust F, et al. Clinical application of oral form of ANGIPARSTM and in combination with topical form as a new treatment for diabetic foot ulcers: A randomized clinical trial. *DARU J Pharma Sci.* 2008;**16**(Suppl. 1):41–8.
7. Mester E, Mester AF, Mester A. The biomedical effects of laser application. *Lasers Surg Med.* 1985;**5**(1):31–9. [PubMed: 3982191].
8. Bennett SP, Griffiths GD, Schor AM, Leese GP, Schor SL. Growth factors in the treatment of diabetic foot ulcers. *Br J Surg.* 2003;**90**(2):133–46. doi: 10.1002/bjs.4019. [PubMed: 12555288].
9. Edmonds M, Bates M, Doxford M, Gough A, Foster A. New treatments in ulcer healing and wound infection. *Diabetes Metab Res Rev.* 2000;**16 Suppl 1**:S51–4. [PubMed: 11054889].
10. Larijaani B, Foruzande F. Diabetic Foot Disorders. Iran: Diabetes Magazine Diabetes and Lipid of Iran; 2003. pp. 93–103.
11. Gentzkow GD, Iwasaki SD, Hershon KS, Mengel M, Prendergast JJ, Ricotta JJ, et al. Use of dermagraft, a cultured human dermis, to treat diabetic foot ulcers. *Diabetes Care.* 1996;**19**(4):350–4. [PubMed: 8729158].
12. Armstrong DG. Infra-red dermal thermometry: stethoscope for the diabetic foot special edition. special edition ed. An International Forum on wound care; 2002. p. 15.
13. Posten W, Wrone DA, Dover JS, Arndt KA, Silapunt S, Alam M. Low-level laser therapy for wound healing: mechanism and efficacy. *Dermatol Surg.* 2005;**31**(3):334–40. [PubMed: 15841638].
14. Petrofsky JS, Lawson D, Suh HJ, Rossi C, Zapata K, Broadwell E, et al. The influence of local versus global heat on the healing of chronic wounds in patients with diabetes. *Diabetes Technol Ther.* 2007;**9**(6):535–44. doi: 10.1089/dia.2007.0231. [PubMed: 18034608].
15. Kazemi kho NA, Khamse MI, Hashim D, baghyan F, Hajizadeh M, Akrami SM. The effects of low level laser therapy in the treatment of diabetic foot ulcers grade 2 and 3 [in Persian]. *Iran J Diabet and Lipid Disorder.* 2009;**8**(2):195–202.
16. Mokmeli S, AyatollahzadehShirazi Z, Daemi M, Ayatollahzadehshirazi F, Soosanabadi A, Hajizadeh M. Evaluating the Effect of the Different Diabetic Control's Methods Including Tight Control on the Healing Response of Diabetic Foot Ulcer Treated with Low Level Laser Therapy (LLLT). *J Laser Med Sci.* 2011;**2**(1):18.
17. Suzanne CS. Brunner and Suddarth's Textbook, Diabetes of Medical Surgical Nursing Twenty teachers Translation. 12 ed. publishing Salemi; 2009.
18. Tavakoli R, Najafipour H, Hadian MR, Talebian S, Aliaei GR, Nabipour F. Comparison of the effect of infrared (IR) and Phenytoin cream on skin wound healing in rat. *JBUMS.* 2004;**6**(2):7–11.
19. Fatemi E. Compare the effect of three methods of nursing care alone or combined with ultrasound and laser in the treatment of pressure sores. *Kowsar Med J.* 2000:54–9.
20. Houreld NN, Abrahamse H. Cellular damage in diabetic wounded fibroblast cells following phototherapy at 632.8, 830 and 1064nm. *Laser Chem.* 2007;**2007**:1–9.
21. Landau Z, Sommer A, Miller EB. Topical hyperbaric oxygen and low-energy laser for the treatment of chronic ulcers. *Eur J Intern Med.* 2006;**17**(4):272–5. doi: 10.1016/j.ejim.2005.11.028. [PubMed: 16762777].
22. Mahmodi A, Mohammadi E, Ahmadi F. Effect of using self-care plan on diabetic foot ulcer healing. *J Uremia Nursing and Midwifery.* 2005;**2**(2):85–7.
23. Franzen-Korzendorfer H, Blackinton M, Rone-Adams S, McCulloch J. The effect of monochromatic infrared energy on transcutaneous oxygen measurements and protective sensation: results of a controlled, double-blind, randomized clinical study. *Ostomy Wound Manage.* 2008;**54**(6):16–31. [PubMed: 18579924].
24. Khksari M, Rezvani ME, Sajadi MA, Soleimani A. The effect of topically applied water extract of Rhazya stricta on cutaneous wound healing in rats. *Koomesh.* 2000;**1**(3):1–10.
25. Hyland DB, Kirkland VJ. Infrared therapy for skin ulcers. *Am J Nurs.* 1980;**80**(10):1800–1.
26. Griffin JW, Tooms RE, Mendius RA, Clifft JK, Vander Zwaag R, el-Zeky F. Efficacy of high voltage pulsed current for healing of pressure ulcers in patients with spinal cord injury. *Phys Ther.* 1991;**71**(6):433–42. [PubMed: 2034707].
27. Zand N. Using low-level laser on wound healing. *Laser Med.* 2008,;**5**(1):39–44.
28. Malm M, Lundeberg T. Effect of low power gallium arsenide laser on healing of venous ulcers. *Scand J Plast Reconstr Surg Hand Surg.* 1991;**25**(3):249–51. [PubMed: 1780722].
29. Kajagar BM, Godhi AS, Pandit A, Khatri S. Efficacy of low level laser therapy on wound healing in patients with chronic diabetic foot ulcers-a randomised control trial. *Indian J Surg.* 2012;**74**(5):359–63. doi: 10.1007/s12262-011-0393-4. [PubMed: 24082586].
30. Mao Z, Wu JH, Dong T, Wu MX. Additive enhancement of wound healing in diabetic mice by low level light and topical CoQ10. *Sci Rep.* 2016;**6**:20084. doi: 10.1038/srep20084. [PubMed: 26830658].