The Use of Low Intensity Direct Current for Enhancement of Tissue Healing

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ABSTRACT

A portable low intensity direct current (LIDC) stimulator was used to compare the effect of LIDC on wound healing rates among inpatients. Thirty hospital inpatients with chronic open wound participated in this study subject with indolent ulcers located either below the knee or in the sacral area were randomly assigned to receive the LICD protocol while the control used conventional wound therapy. The results suggested that 1.5 to 2.5 times faster healing in those received LICD which was statistically significant. The wounds treated with LICD required less debridement and the healed scars were more resilient. Moreover, patients reported less discomfort at the wound site with no wound infection occurred. Low intensity direct current appears to be a convenient reproducible and effective method for improved healing of chronic wounds.
Key Word: *electric stimulation, physical therapy, and skin ulcer.*

INTRODUCTION

Recently, an increasing interest in alternative methods for promoting wound healing has been indicated especially for indolent wounds. Chronic wounds such as pressure ulcers continue a problem in rehabilitation. To determine the amount of healing in response to treatment, sequential assessments of changes in ulcer size are essential[6].

The use of electrotherapy has provided beneficial and reproducible healing even when other methods have failed. Controlling and differentiation of tissues is one of biology's most intriguing challenges. Because the body can be viewed as a bioelectric system, electrocurrent has been applied for therapeutic purpose for many years[15].

Electrical current of low amplitude and frequency modulation has become on increasingly popular treatment modality. Some studies have suggested that these forms of stimulation are more effective for the treatment of a wide variety of conditions including wound healing more than conventional modes of electrical stimulation[1,16].

Low intensity direct current therapy warrants consideration in the management of indolent wounds an area of clinical use, which needs predictability beneficial results. The electrical field creates stable secondary magnetic fields around direct currents and alternating or reversing polarity around direct currents[4].

The electromagnetic field and the changed polarity of the treating electrode have been associated with tissue stress that increases collagen deposition[9,17].

Many other researchers have noted

similar acceleration of healing rates, stronger scar tissues and /or bactericidal effects without harmful effects to the patients with ulcers[14].

SUBJECTS MATERIAL AND METHODS

Subjects

Thirty hospital inpatients with chronic open wounds due to venous insufficiency participated in this study. Subjects with indolent ulcers located either below the knee or in the sacral area were randomly assigned to receive LIDC protocol (15patients) while the control used conventional wound therapy (15patients). All wounds were divided before admission to the study. Table (1) provides a general description of the study population for the two groups.

Table (1): General characteristics of LIDC and control groups

Group	Sex (M/F)	Age*	Wound duration*
LIDC protocol	10/5	58.60±8.387	6.16±2.892
Control	9/6	62.59±8.489	4.12±1.65

* Mean + S.D.

Equipment

A small portable direct current stimulator was used in this study. The unit stimulated accurately at 100 mA. Increment with a variance of ± 10% and used a 9V battery of as a power source. Audible and visible alarms were built for safety and continuity of the prescribed current level. It also contained an internal two-hour timer, which would terminate the output current and sound an audible alarm. The unit possessed a rugged extensor and a plastic clip for attaching to the patient clothes. The electrode material was modified using flexible carbon material, which is much more resistant to corrosion and breakage. Each electrode was destroyed after the individual patients completed the study.

PROCEDURES

A - LIDC treatment protocol

The scheduled treatment application of LIDC involved two hours of stimulation, twice daily with treatments given five days a week. The two periods of LIDC stimulation were separated by a two to four pauses during which the unit was in the "off" position. The unit was connected in the morning and would automatically turn off within two hours after initially turning the unit on. It was restarted in the afternoon a two to four hour pause during which the unit was in the off position. The wounds were irrigated with saline solution and packed with either saline damped gauze or various absorption gels daily. The electrodes were then placed over this conductive interface so that it was not in actual contact with the wound a waterproof tape was applied over the dressing to maintain moisture and keep the electrode in place. The electrode at the wound site was termed the active electrode and the electrode located 15cm to 25cm proximal to it was termed the indifferent electrode. The active electrode was of negative polarity for the first three days of LIDC application, while the indifferent electrode was of positive polarity. After these three days, the active electrode became positive while the indifferent electrode was negative. The current output levels were set between 300mA and 500mA.

B - LIDC Placebo Protocol

The same protocol of the treatment group was applied, but the electrodes were disconnected from the cables of the device.

Also, the patients in both groups were received conventional wound therapy.

C - Wound Healing Assessment Phase

The measurements of WSA were conducted by tracing of wound perimeters according based on the work of Kloth and Feedar (1988). The mean of three trails was calculated and considered as WSA.

RESULTS

The results of this study are presented under the following headings:

I. Results of the Low Intensity Direct Current Group (LIDC).

As show in table (2) and illustrated in figure (1) the mean value of WSA before application of treatment was 4.667 ± 1.318 cm^2. On the other hand the values of WSA after the application of treatment at the end of first, second, third, fourth and fifth weeks were 3.759 ± 1.223, 1.907 ± 0.687, 1.057 ± 0.327, 0.784 ± 0.33 and 0.497 ± 0.331 cm^2 respectively.

As observed in table (2) there were significant decreases in the WSA after first, second, third, fourth, and fifth weeks post initiation of LIDC treatment ($P<0.0001$). Figure (1) shows the mean values of WSA per cm^2.

Table (2): The statistical analysis of the differences of WSA in the treatment group pre and post treatment (first, second, third, fourth, fifth weeks).

Evaluation time	Mean	S.D.	Paired t-test between initial area and the week		Percentage of improvement
			t- value	P- value	
Initial area	4.667	1.318			
1st week	3.759	1.223	12.622	0.0001	19.46%
2nd week	1.907	0.687	9.344	0.0001	59.14%
3rd week	1.057	0.327	11.549	0.0001	77.35%
4th week	0.784	0.33	12.492	0.0001	83.20%
5th week	0.497	0.331	12.768	0.0001	89.35%

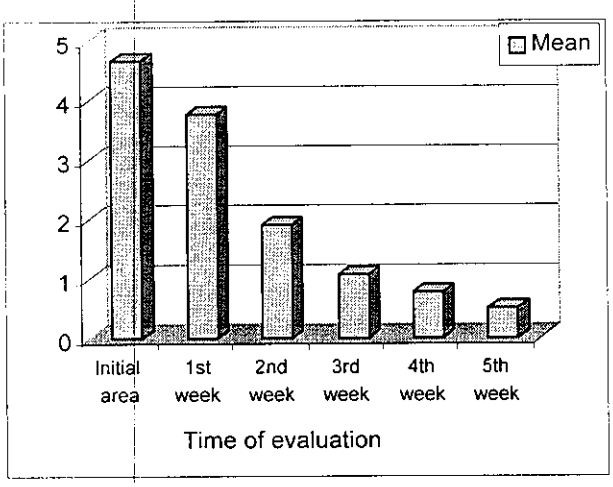

Fig. (1): The mean values of WSA of the treatment group pre and post treatment (first, second, third, fourth, fifth weeks).

II. Results of the Placebo Group.

As revealed from table (3) the mean value of WSA pre application was 4.009 1.073 cm^2 while the mean values after the application measured at the first, second, third, fourth, and fifth weeks were 3.623 ± 1.033, 3.033 ± 0.957, 2.526 ± 0.736, 2.42 ± 1.067, and 2.164 ± 0.743 cm^2 respectively. Figure (2) shows the mean values of WSA measured by cm^2.

Also there were significant reductions in WSA after the first, second, third, fourth, and fifth weeks ($P<0.0004$). Figure (2) shows the mean values of WSA per cm^2.

Table (3): The statistical analysis of the differences of WSA in the control group pre and post treatment (first, second, third, fourth, fifth weeks).

Evaluation time	Mean	S.D.	Paired t-test between initial area and the week		Percentage of Improvement
Initial area	4.009	1.073	t- value	P- value	
1st week	3.623	1.033	5.781	0.0001	9.631%
2nd week	2.899	0.957	4.606	0.0004	27.69%
3rd week	2.526	0.736	7.945	0.0001	36.99%
4th week	2.42	1.067	6.878	0.0001	39.73%
5th week	2.164	0.743	8.955	0.001	46.02%

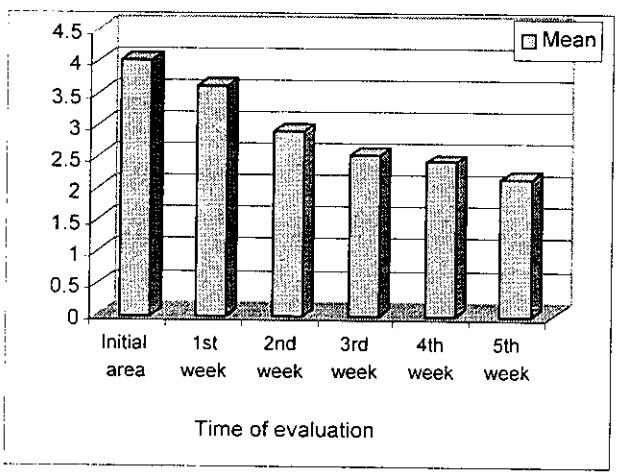

Fig. (2): The mean values of WSA of the control group pre and post treatment (first, second, third, fourth, fifth weeks).

III. Comparison and analysis of the mean values of WSA for the both groups.

1- There were no significant differences between LIDC group and control group before application of treatment and after the first week post application of treatment ($P > 0.05$).
2- On the other hand there were significant differences between LIDC group and control group at the end of the second, third, fourth, and fifth weeks post application of treatment ($P < 0.05$).

Figure (3) shows the mean values of WSA of both groups pre application and at the end of the first, second, third, fourth, and fifth weeks post application of treatment.

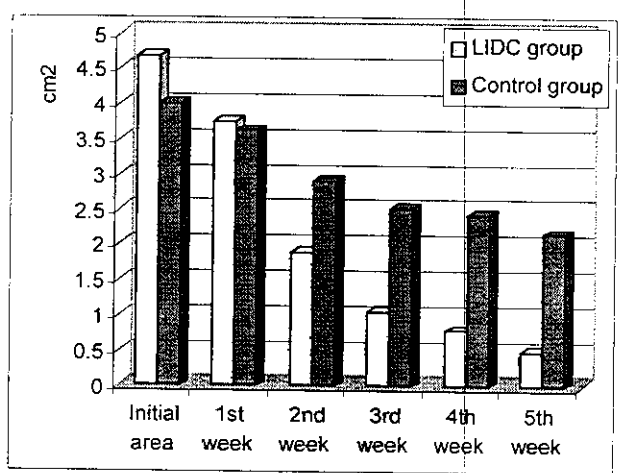

Fig. (3): the mean values of WSA of both groups pre application and post treatment (first, second, third, fourth, fifth weeks).

DISCUSSION

The findings of this controlled randomized study indicate that LIDC accelerates wound-healing process in patients who have indolent ulcers, which is similar to those reported in some scientific experimental studies. Some studies[2,3,4,17] conceptualized the existence of a direct current electrical system controlling tissue healing. When the electrical balance of the body is disturbed in an injury, the resulting shift in current flow triggers a

biologic repair system. As healing continues, the direct current potential difference will approach the normal electrical balance relative to surrounding tissue. Based on these concepts, externally applied LIDC could stimulate biologic homeostasis feedback mechanism and hence the events which result in tissue repair and replacement. Although a variety of types of electrical current are used in wound healing, the greatest attention has been given to direct current stimulation because predictable electric fields are known to form around the electrodes, attracting specific types of ions near the different poles.

The findings of this study indicate significant difference in WSA between the control group and the LIDC group after application of treatment, which can be explained, depends upon the following scientific explanations and concepts.

The anodal stimulation (positive polarity) enhances ion transport, fibroblast migration, and protein synthesis. Also the anodal stimulation decreases vascular congestion[5].

Whereas cathodal stimulation (negative polarity) increases migration of epidermal cells, macrophages and leukocytes in addition to decrease bacterial counts[7,8]. While both anodal and cathodal stimulation can increase transcutaneous oxygen, which is an important element for healing process[13].

The collagen deposition is well known to influence on the process of wound healing, this view is supported by the findings of Gentzkow et al., who concluded that the significant improvement after application of LIDC was attributed to the change of polarity and potential difference. This interaction lead to increase of collagen deposition that in turn enhance wound closure[10].

Application of direct current leads to increase blood flow, which increase oxygen delivery, which in turn should be correlated to enhancement of wound healing[11].

Depending on the previous scientific explanations, in addition to our parallel findings application of LIDC in addition to wound care program may accelerate wound healing and thus decrease the treatment time, cost, and length of institutional stay of patients.

REFERENCES

1- Alvarez, O.M.; Mertz, P.M. and Smerbeck, R.V.: The Healing of Superficial Skin Wound is Stimulated by External Electrical Current. J. Dermatol; 81:144-148, 1983.

2- Becker, R.M.: Electrical Control of Growth Processes. Med, Times, 95:657-669, 1967.

3- Byl, N.N.; McKenzie, A.M. and West, J.: Effects of Low Dose Ultrasound on Acceleration of Wound Healing in Mini Yucatan Pigs. Arch Phys Med Rehabil; 73:656-664, 1992.

4- Carley, P.J. and Wainapel, S.F.: Electrotherapy for Acceleration of Wound Healing: Low Intensity Direct Current. Arch Phys Med Rehabil; 66: 443-446, 1985.

5- Cheng, N.; Van Hoof, H. and Bocker, E.: The Effects of Electric Current on ATP Generation, Protein Synthesis and Membrane Transport in Rat Skin. Clin Orthop; 171:261-271, 1982.

6- Covington, J.S.; Griffin, J.W. and Mendius, R.K.: Measurement of Pressure Ulcer Volume Using Dental Impression Materials. Suggestion From the Field. Phys Ther.; 69:690-694, 1989.

7- Dodgen, P.W.; Johnson, B.W.; Baker, L.L and Chambers, R.B.: The Effects of Electrical Stimulation on Cutaneous Oxygen Supply in Diabetic Older Adults. Phys Ther.; 67:793, 1987.

8- Dunn, M.G.; Doillon, G.H. and Berg, R.A.: Wound Healing Using a Collagen Matrix: Effect of DC Electric Stimulation. J Biomed Mater Res., 22(A2): 191-206, 1988.

9- Gault, W.R. and Gatens, P.F.: Use of Low Intensity Direct Current in Management of

Ischemic Skin Ulcers. Phys Ther.; 56:265-269, 1976.
10- Gentzkow, G.D.; Pollack, S.V.; Kloth, L.C. and Stubbs, M.A.: Improved Healing of Pressure Ulcer Using Dermapulse: A New Electrical Stimulation Device. Wounds; 3:158-170, 1991.
11- Hopf, H.A.; Jensen, J.A. and Hunt, T.K.: Calculation of Subcutaneous Tissue Blood Flow. Surg Forum; 39:33-36, 1988.
12- Kloth, L.C. and Feedar, J.A.: Acceleration of Wound Healing with High Voltage Monophasic, Pulsed Current. Phys Ther.; 68:503-508, 1988.
13- Knighton, D.R.; Halliday, B. and Hunt, T.K.: oxygen as an Antibiotic: The Effect of Inspired Oxygen on Infection. Arch Surg.; 23: 221-226, 1987.
14- Page, C.F. and Gault, W.R.: Managing Ischemic Skin Ulcers. Fam Physician; 11: 108-114, 1975.
15- Picker, R.I.: Current Trends: Low Volt Pulsed Microamp Stimulation. Part II Clinical Management of Physical Therapy; 9 (3): 28-33, 1989.
16- Picker, R.I.: Current Trends: Low Volt Pulsed Microamp Stimulation. Part II Clinical Management of Physical Therapy; 9 (2): 10-14, 1988.
17- Wollcott, L.E.; Wheeler, P.C. and Hardwicke, H.M.: Accelerated Healing of Skin Ulcers by Electrotherapy: Preliminary Clinical Results. South Med J.; 62 : 79+5-801, 1969.

الملخص العربي

استخدام التيار منخفض الشدة في زيادة معدل التئام الجروح

تهدف هذه الدراسة إلي مقارنة أثر استخدام التيار المباشر منخفض الشدة علي معدل التئام الجروح و القرح الغير مؤلمة في مرضي الأقسام الداخلية. لقد أشترك في هذه الدراسة ثلاثون مريضا من الذكور و الإناث المصابين بقرح غير مؤلمة تحت الركبة و في المنطقة العجزية و قد تم تقسيم المرضي عشوائيا إلي مجموعتين متساويتين عددا. المجموعة الأولي مجموعة(أ) و كانت هذه المجموعة مجموعة الاختيار وتم علاجهم بالتيار المباشر منخفض الشدة لمدة ساعتين خمس مرات أسبوعيا . والمجموعة (ب) و تم علاجهم بالعلاج التقليدي لعلاج القرح والجروح. ثم تم إجراء قياس مساحة سطح القرح لكل المرضي في المجموعتين بتطبيق طريقة (Kloth and Feedar) .

و قد أظهرت النتائج أن هناك نقص ذو دلالة إحصائية في متوسط مساحة سطح القرح في المجموعة الاختبار بالمقارنة بالمجموعة الحاكمة في الأسابيع الثانية و الثالثة و الرابعة و الخامسة بعد بدء العلاج .

و بعد مناقشة هذه النتائج و مطابقتها بالبحوث و التقارير العلمية في نفس المجال وجد أن التيارات المباشرة منخفضة الشدة لها تأثير فعال في معالجة القرح و الجروح و العمل علي سرعة التئامها في المرضي.