Effects of Infrared Laser Versus Zinc Iontophoresis on Burn Wound Healing in Children

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Abstract

Background and Purpose: The purpose of this study was to compare between the effect of both Infrared (IR) laser bio-stimulation and the effect of zinc iontophoresis on the accelerating rate of healing of burn wound in children.

Subjects: Thirty children from both sexes (20 males and 10 females), participated in this study were selected randomly from King Abdul-Aziz University Hospital Burns Unit, Jeddah, Saudi Arabia, having burn in their lower extremities, anterior surface of the leg and/or dorsum of feet. Their ages were ranging between 5 and 9 years.

Methods: These children were randomly divided into two Study groups of equal number. Study group A (n=15), 10 males and 5 females) and group B (n=15) 10 males and 5 females). Patients belonging to the group (A) received physical therapy program, comprising positioning, stretching and remedial exercises in addition to IR laser for the burnt area. On the other hand, patients belonging to the group (B) were subjected the same physical therapy program in addition to zinc Iontophoresis for the burnt area. Treatment continued for both groups of patients for one hour/session, three times/week, for twelve successive weeks. The wound surface area was assessed before and after the suggested period of treatment, using the metric graph paper method. The wound area was calculated from the product of cross-diameters of the wound sites. The curative effect was expressed as the percentile of wound area compared with that on day 0 (100%). The passive range of foot dorsi-flexion was assessed by using a LCD goniometry. Furthermore, the present pain intensity scores were assessed.

Results: The collected data after termination of the suggested period of treatment of both groups revealed significant improvement in the study group (A), compared to those of the study group (B). Furthermore, a similar improvement was also noted in comparing the results of each Study group before and after treatment. Such an improvement included reduction of the wound area and pain intensity scores in addition to an increase in the foot dorsi-flexion ROM.

Conclusion: It should be stressed that utilization of IR laser irradiation in combination with the traditional physical therapy modalities have promotive effects on burn wound healing and more effective in treating burnt areas than using zinc iontophoresis.

Key Words: Zinc iontophoresis – Burn wound healing in children.

Introduction

BURNS often happen unexpectedly and have the potential to cause lifelong disfigurement, dysfunction or death [1]. The critical part of burn management is assessing the depth and extent of injury. A systemic approach to burn care focuses on the six “Cs”, Clothing, cooling, cleaning, chemoprophylaxis, covering and comforting (i.e., pain relief). Complication of burns include slow healing, scar formation and contracture [2].

The extent of burn is expressed as the total percentage of body surface area (TBSA) affected by the injury. Accurate estimation of the TBSA of a burn is essential to guide management [3].

The ultimate goals of wound management are to allow a wound to close as rapidly as possible, to resemble the original tissue as near as possible and to produce the least amount of scarring. Maintaining joint movement and maximizing functional ability in patient with a major burn presents a formidable challenge to physical therapists. A comprehensive team approach to burn and early therapeutic intervention can reduce the possibility of joint dysfunction [4].

Physical therapists identified a variety of wounds, which respond well to different types of commonly used electro-therapeutic modalities such as interferential, short wave and most notably ultrasound and Laser therapy [5]. Conventional methods for treating soft tissue wounds include applications of various ointments or medications to aid the natural body healing process. However, it has been found that some wounds, including chronic wounds, do not respond to conventional treatment method and resist healing [6].

Laser may be an effective adjunct modality to promote wound healing. Increased rates of epider-
mal regeneration, collagen synthesis, granulation tissue formation and wound closure have been reported with low intensity laser application on wounds and burns [7,8,9].

Several researchers investigated the bio–stimulation effect of laser and revealed many positive effects of the rays, including acceleration of wound healing.

Infrared laser therapy is the application of red and near infrared light over injuries or wounds to improve soft tissue healing and relieve both acute and chronic pain. Low-level Laser therapy, sub thermal laser light energy, with energy range of low level laser light lies between 1 and 500mw (mill watts has direct bio-simulative effect to the body’s cells without injuring or damaging them. The fibroblast cell, when stimulated four times at 24-hour interval, showed increased bending ability to the lectin, which emphasized laser bio–stimulation [10].

Iontophoresis is the transfer of ions across the skin (transdermal) by use of weak continues direct current; iontophoresis is based on the principle that an electrically charged electrode will repel a similarly charged ion (first reported by LeDue in 1903).

Zinc ion has been reported to be necessary for active growth and repair of tissue. Some investigators have thought that zinc promotes resynthesis of protein and nucleic acid at the wound site by incorporating itself into certain enzymes. The zinc ion, when introduced into body tissues by iontophoresis, has also been documented to have antibacterial effect [11].

Aim of the work:
To investigate quantitatively the effect of both infra red laser therapy and zinc iontophoresis on the enhancement of recovery of wounds and pain reduction in burnt children.

Subjects, Material and Methods

Thirty children from both sexes (20 males and 10 females), with age ranged from 5 to 9 years were included in this study. They were collected randomly from the burn unit in King Abdul-Aziz University Hospital, Jeddah, Saudi Arabia, as having burn in their lower extremities (in the anterior aspect of the leg). As a result of their burn, they were suffering from a decrease in foot dorsiflexion ROM and pain. All Subjects were examined clinically by medical specialist before the study. They were randomly classified into two Study groups, each comprised 15 patients: Study group A (10 males and 5 females) and Study group B (10 males and 5 females).

The subjects chosen to participate met the following criteria:

1- All of the patients were diagnosed as having direct flame or scald injuries mixed burn (superficial or deep dermal burns).
2- All of them were having free passive range of motion of the ankle joint of the affected lower limb.
3- All of them were having sufficient cognition to understand the requirements of the study.
4- None of them reported a history of other skin abnormalities in the area to be treated.
5- None of them were having associated injuries, anemia or pathological conditions have been identified.
6- None of them were having any surgical interference of the Ankle joint of the affected lower limb.

Materials:

1- For treatment:
   BTL-5840 SLCombi Unit: (Combined Electrotherapy, Ultrasound, Laser unit).
   (Manufactured by BLT Technology Ltd., Electronic Corp, USA)

   The main features of the treatment unit include:
   a- Black and white touch screen.
   b- Full range of low and medium waveforms and their modifications.
   c- Constant current and current voltage modes (CC/CV).
   d- Reversal of polarity of electrodes.
   e- Multi frequency ergonomic ultrasound heads of 1 and 4cm with a visual indicator of contact control on the head and 3MHz frequency that can be used with any ultrasound head, Continuous and pulse ultrasound operation in the range of 10-150Hz.
   f- Continuous and pulse laser therapy (frequency modulation) ~500Hz.
   g- Red probes of 685nm wavelength and 30-50mW powe output.
   h- Infrared probes of 830nm wavelength and 50-400mW power output.
i- Acupuncture set for laser acupuncture.
j- Sound volume adjustment. Display color and brightness setting.
k- Screen saver, auto switch-off.

2- For evaluation:
a- Sterilized transparency film.
b- Fine tipped transparency marker.
c- Carbon papers.
d- Metric graph papers (1mm²).
e- White papers.
f- LCD goniometer.
g- Present pain intensity scale (Form 1 & 2).

Form (1): Shows the present pain intensity scale.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No pain</td>
</tr>
<tr>
<td>1</td>
<td>Mild pain</td>
</tr>
<tr>
<td>2</td>
<td>Moderate pain</td>
</tr>
<tr>
<td>3</td>
<td>Severe pain</td>
</tr>
<tr>
<td>4</td>
<td>Unbearable pain</td>
</tr>
</tbody>
</table>

Adopted from Srijutanabul et al. (1982).

Methods:

For evaluation:

- The measurements of burn wound surface area were conducted before and after 12 weeks of treatment. A plastic sheet was placed over the burn (after being cleaned with anti-septic solution) and traced the burn’s parameters with a fine tipped transparency marker. The carbon paper was placed over the metric graph paper and then traced transparency film was placed over a carbon paper, with a white paper in between. The tracing was transcribed onto the metric graph paper and the number of square mm on the metric graph paper was calculated, within the wound tracing. The measurement for each wound was repeated for three times and the mean value was recorded as the actual reading.

- The measurement of foot dorsi-flexion ROM was achieved while the patient was in supine lying position with the heel outside the treatment table. The fixed arm of the goniometry was placed parallel to the tibial side. The ankle joint was moved passively, within the limit of pain, to the maximum available ankle dorsi-flexion range. Then, the degree of foot dorsi-flexion was recorded.

- The assessment of the present pain intensity (PPI) for each subject was done before and after treatment for both groups through the PPI scales (Form 1).

For treatment:

Study group A:

Patients belonging to study group (A) received a traditional physical therapy program, which comprised of positioning, splinting and remedial exercises, in addition to IR laser bio-stimulation for the burnt area. The patient was placed in the supine position with his heels out side the treatment table. The burnt area was divided into equal zones. The therapist stood beside the affected side of the patient, the unit head was placed perpendicular to the burn area on the dorsum aspect of affected foot and leg. The main power switch was turned on. The Hi/Lo power switch was turned to Hi position. The unit head held in place for one minute for each treatment zone while the current was applied and then moved down the sides of the burn wound at approximately one centimeter increments. This process was repeated as many times as necessary to cover the entire length of the burnt area. The head of laser unit was cleaned with sterilized solution before and after application for each patient. Time of treatment was 10 minutes for each zone.

Study group B:

Patient belonging to study group (B) were exposed to the same line of traditional physical therapy program in addition to iontophoresis with a zinc oxide solution for the burnt area. The patient was placed in the supine position with his heels out side, the therapist stood beside the affected side of the patient. The current generator was set on, power switch was turned to 400 micro amp current with a pulse rate of 100 pulses per second. The current generator was applied to the patient's burn wound, by two probes, each of the probes consists of a handle portion made of an insulating material and head portion and a probe tip which screws into the head portion. Thus, the probe tip can be removed for cleaning and sterilization. The probes are connected to the current generator by wires. In use, cotton swabs are wetted with an Electrolyte solution (zinc oxide solution) and inserted into the probe tips. After each treatment, the swabs are disposed of and new swabs are inserted before treating the next patient. The burn area was divided into equal zones, the probes were placed closely adjacent the outer boundaries of burn zone on the laterally opposite sides along a line perpendicular to an imaginary line which...
generally bi-sects the wound on the dorsum aspect of affected foot and leg. The probes were held in place for one minute to apply an electrical current to this burn zone and then the probes were moved down the sides of the burn wound at approximately one centimeter increments. At each stop, the probes were held in place approximately one minute while the current are applied. This process was repeated as many times as necessary to cover the entire length of the burnt area.

The duration of each session for all patients lasted for one hour, all of them were treated for three days per week, for 12 successive weeks and received equivalent nursing care.

Results

The collected data were statistically treated to show the mean, standard deviation and standard error of the mean for both groups. The student test was then utilized to examine the significance of treatment in each group. It revealed no significant difference between both groups before the application of treatment (t <0.05), which insures homogenous sampling.

As shown from Table (1) and Fig. (1), the mean values of wound surface area in the Study group (A) before treatment with Infrared (IR) laser bio-stimulation was 138.46±24.6mm², which decreased after 12 weeks of the combined treatment to 106.2±20.73mm². The mean difference was 32.27mm², representing a percentage of change of 23.3%, suggesting a highly significant improvement (t=21.147 <0.001). Concerning the Study group (B), the mean value of wound surface area was 132.53±26.49mm² before treatment, which decreased to 123.53±26.69mm² after treatment with zinc iontophoresis, with a mean difference of 9mm². The percentage of change was 13.66%, which suggests a highly significant improvement (t=7.4 <0.001).

### Table (1): Shows the mean values of wound surface area in both groups (in mm²) before and after twelve weeks of treatment as well as the percentage of change.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Experimental Group (1) Before</th>
<th>After</th>
<th>Experimental Group (2) Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>148.8</td>
<td>104.2</td>
<td>137.7</td>
<td>128.5</td>
</tr>
<tr>
<td>SD</td>
<td>±31.08</td>
<td>±41.66</td>
<td>±30.38</td>
<td>±26.22</td>
</tr>
<tr>
<td>MD</td>
<td>44.6</td>
<td>9.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Change</td>
<td>29.97%</td>
<td>6.68%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t</td>
<td>6.5947</td>
<td>2.7446</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>&lt;0.001</td>
<td>&lt;0.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Fig. (1): The mean values of wound surface area in both groups before and after treatment.](image1)

The results obtained from Table (2) and Fig. (2), present the mean value of wrist dorsi-flexion ROM in the study group. It was 47.0±5.185º before treatment, which increased after the suggested period of treatment to 55.2±9.211º, with a mean difference of 8.2º. Such an increase had a percentage of change of 17.45%, which indicated a highly significant difference (t=5.7108 <0.001). The mean values of wrist dorsi-flexion ROM in the control group increased also from 45.1±4.886º before treatment with the traditional physical therapy methods to 46.3±5.021º after treatment, forming a mean difference of 1.8 and a percentage of change of 3.33%, suggesting a significant difference (t=3.1364 <0.02).

### Table (2): The mean values of ankle dorsi-flexion ROM in both groups (in degrees) before and after twelve weeks of treatment as well as percentage of change.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Experimental Group (1) Before</th>
<th>After</th>
<th>Experimental Group (2) Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>132.53</td>
<td>123.53</td>
<td>137.7</td>
<td>128.5</td>
</tr>
<tr>
<td>SD</td>
<td>±26.49</td>
<td>±26.69</td>
<td>±30.38</td>
<td>±26.22</td>
</tr>
<tr>
<td>MD</td>
<td>8.2</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Change</td>
<td>17.45%</td>
<td>3.33%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t</td>
<td>5.7108</td>
<td>3.1364</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>&lt;0.001</td>
<td>&lt;0.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Fig. (2): Shows the mean values of wrist dorsi-flexion ROM in both groups (in degrees) before and after treatment.](image2)
As shown from Table (3) and Fig. (3), the mean value of PPI score before treatment in the study group was 3.3 ± 0.675, which decreased eight weeks after treatment to be 2.4 ± 0.632. Similarly, in the control group, the mean value of PPI scores before treatment decreased from 3.2 ± 0.516 before treatment to 2.6 ± 0.699 after treatment, representing a percentage of reduction in both groups was 27.27% and 18.75%, respectively. Significant differences were found in both groups, but in favor of the study group ($t=5.0111 <0.001$ and 2.7113, respectively).

### Table (3): The mean values of present pain intensity (PPI) in both groups (In grades) before and after eight weeks of treatment as well as the percentage of change.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Experimental Group (1)</th>
<th>Experimental Group (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Mean</td>
<td>3.3</td>
<td>2.4</td>
</tr>
<tr>
<td>SD</td>
<td>±0.675</td>
<td>±0.516</td>
</tr>
<tr>
<td>MD</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>% of Change</td>
<td>27.27%</td>
<td>18.75%</td>
</tr>
<tr>
<td>$t$</td>
<td>5.0111</td>
<td>2.7113</td>
</tr>
<tr>
<td>$p$</td>
<td>&lt;0.001</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

The results of the present study came in agreement with the results of Salcido Tand Richard J. [4]. Who stated that epithelialization of the second-degree burn wound was accelerated by topical treatment with hydrogel dressing and further enhanced by electrical stimulation compared with no treatment (air exposure).

Balogun and co-workers [12] in their case study reported that by the application of Zinc iontophoresis in the management of bacterial colonized wounds the rate of epidermal regeneration and granulation tissue formation were accelerated. They stated that electrical stimulation for wound healing and pressure sore prevention could increase the rate of healing by more 50% than that treated by traditional topical treatment.

The present results also came in agreement with those stated by Banga et al. [10], in their study they investigated the effect of iontophoresis in conjunction with other traditional modalities and they came in conclusion that iontophoresis in conjunction with traditional modalities provides more immediate pain relieve than the traditional modalities alone.

The results of the present piece of work coincide with those reported by McWhorter, et al. [13] who evaluated the effect of iontophoresis with dexamethasone to the effect of iontophoresis with saline solution; they concluded that iontophoresis with dexamethasone were found to have a positive effect in the treatment of patient with acute Achilles tendon pain.

The results of the present piece of work coincide with those of Danno K, et al. [8]. Who reported in their study, that increased tensile strength was recorded in skin wounds of rabbits, bio-stimulated daily with pulsed IR laser for a period of 21 days. However, the non-stimulated wounds on the contra-lateral side in the same animal also showed an increase in tensile strength.

The present results also came in agreement with the results of Baxter GD, et al. [7], who stated that enhanced rates of wound and burn healing were reported in rats and guinea pigs with low-intensity laser therapy, attributed the effect of laser therapy in promoting wound healing to be due to an increase in fibroblast proliferation (fibroplasia) and faster collagen synthesis. The promoted wound healing in the present study may be due to the ability of immune cells to combat invading pathogens. They also stated that the immune system is an important and integral part of the healing process. The lymphocytes, in particular, are responsible

### Discussion

The findings of this study indicated considerable differences in measuring mean values of burn size in the control group patients after treatment, as compared with the pre-treatment values. A significant difference was also recorded between the mean values of both the study and control groups at the end of treatment.
for the release of soluble mediators of immunity and of tissue repair.

The results of the present piece of work coincide with those reported by Gardner S.E., et al. [3], who added that such an improvement might be attributed to increasing ATP synthesis by enhancing electron transfer in the inner membrane of the mitochondria. The mechanism for the acceleration of wound healing with low-energy laser bio-stimulation involved acceleration of the messenger ribonucleic acid (mRNA) transcription rate of the collagen gene or other enzymatic changes, following bio-stimulation.

The present results also supported by Danno K, et al. [8], who revealed that bio-stimulated full thickness skin wounds daily in rats with ruby and He Ne laser caused faster healing of wounds. They also found an increased collagen in wounds, treated with He Ne laser compared to wounds treated with ruby laser.

**Conclusion:**

From the results of this study, it can be concluded that the application of IR laser therapy is a more valuable method for treating and improving the healing process and the subsequent pain reduction among patients, suffering from superficial and deep thermal burns than the application of zinc Iontophoresis.

**References**


