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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2019 16(3):2417-2422. **OPEN ACCESS**

Effect of orange polarized light on Metacarpo-phalyngeal range of motion in pediatric hand burn: A single blind randomized trial

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Burn injuries of any magnitude can be devastating to patients and their families, both functionally and emotionally, the focus of intervention has shifted from survival to optimizing functional and cosmetic outcome. To evaluate the effect of orange filtered polarized polychromatic light on metacarpophalangeal (MCP) joints range of motion in children with hand burn. Thirty children with post burn scar in wrist and hands participated in this study, their ages were from 3-7 years, having Hypertrophic burn scar ≥ 2 months post healing, free from concomitant skin disease and keloids. They were divided randomly into two groups; the control group (A) *(n=15)* received Scar Standard Management (SSM) protocol and the study group (B) *(n=15)* received SSM protocol along with 15 minutes/area polarized light with medical color followed by 15 min/area orange filtered polarized light. All children received the study protocol once a day, 3 times /week for one month. Hand held goniometer was used to evaluate the MCP range of motion before and after the study. There was significant improvement of MCP flexion and extension range of motion for both groups with significant difference when comparing post treatment results between groups in favor to study group ($p<0.05$). It was concluded from the results of this clinical study that orange filtered polarized light has a special and beneficial effect on improving the MCP range of motion in children with hand burn

Keywords: Hand burn, Metatarsophalangeal joints, orange Polarized light, Goniometer, Scar.

INTRODUCTION

Burn injury in children is considered to be a major epidemiologic problem worldwide. Nearly 25% of all burn injuries occur in children under the age of 16 years, of whom the majority are under the age of five.(kader et al.,2015) Most burn injuries are minor and do not necessitate hospital admission. (Anzarut et al., 2005)

Pediatric burns differ from adult burns in many aspects. Their skin is more sensitive and less resistant to heat, and because it is harder for them to escape from the burning object, this may lead to longer exposure, which may increase the burn severity. Pediatric patients have a smaller body than adults, with a greater body surface area in relation to their weight. Burns can leave a pediatric patient with severely debilitating and deforming contractures, which can lead to significant disability when left untreated. Therefore, burn rehabilitation is not to be undertaken by individuals, but should involve a multidisciplinary team so that every aspect of the child's physical, psychological, and social needs is met during hospitalization and following

discharge. (Bayat et al., 2010)

Hand burns are particularly common in the pediatric population, as children explore their surroundings frequently by touching and feeling (Bhertha Tamura , 2018) .Dorsal hand burns, for example, are frequently scald injuries from hot liquids, whereas burns to the palm usually result from direct contact with a hot surface such as a radiator or iron (Birchenough et al.,2008)

There are some special characteristics in the hand's anatomy. Its physical sturdiness, the sensory qualities and the high capillary density in the stratum papillae make this skin unique. Significant density of Merkel's tactile disks, Meissner's tactile corpuscles, Vater–Pacini's corpuscles and free nerve ends are located in the skin and therefore hand burns may cause severe sensory deficits. Blood vessels, tendons and joints are located very close to the skin surface in the hand and these structures are extremely vulnerable when exposed to high thermal energy (Carlsson et al , 2006).

Optimal hand function is a crucial component of a high quality survival after burn injury and can be achieved only with a coordinated approach (Casanova, 1992)

Scars and contractures, which are often disfiguring and seriously debilitating both socially and physically, and which may also be associated with difficulties in speech or feeding, are further aggravating factors. (Clarke et al., 1990) Burn scar contractures are a major source of late morbidity, particularly in children that continue to grow long after burn healing has occurred; they may restrict normal growth resulting in secondary deformities (Davoodi et al., 2008)(Depuyd et al.,2001) and (Disseldorp et al.,2012)

Light is a form of energy and has different colored wavelength; that is anciently used for healing. There is now better understanding of which component of natural light are useful in the stimulation of healing such as Biptron light therapy (BLT) which is a device emits a polarized light containing a range of wavelengths that correspond to visible light plus infrared radiation which have been reported to stimulate the biological reactions (Feldmann et al.,2008).

It was reported that orange polarized light enhances the cell membrane activities, accelerates production of adenosine tri-phosphate (ATP) in mitochondria, stimulates regeneration processes and acceleration of fibroblast proliferation and deposition of collagen 13(Heath et al.,2011) and (Huang et al., 2011) It was considered that polarized light rearrange the polar heads of a lipid bilayer in the cell membrane where enzyme reactions take place lead to structural changes occur in cell membranes in consequence the surface features and lipid protein connection can be modified (Heath et al.,2011,Schindl et al.,2000 and (Hysenaj et al,,2010) stated that Biptron light therapy may significantly stimulate the faster epithelialization of the damaged skin, reducing the risk for the formation of the functionally and unacceptable scars.

MATERIALS AND METHODS

The research design of this study was a prospective, randomized, controlled trial. After clear explanation of the study procedure and obtaining the written consent from all children families or care givers, The Ethics committee, Faculty of Physical Therapy, Cairo University approved this study with number P.T.REC/012/00440. The study followed the Guidelines of Declaration of Helsinki on conduction of human research.

Thirty children (20 girls and 10 boys) participated in this study. They were recruited from the outpatient clinic of surgery, Faculty of Physical Therapy, Cairo University. They were enrolled and assessed for their eligibility to participate in the study according to the following inclusion criteria: Their ages from 3 to 7 years, having a hypertrophic burn scar (≥2 months post healing) that has been clinically diagnosed by a burn care specialist. Children with concomitant skin disease (i.e. chronic skin conditions, herpes infection) and those with a history of keloid scarring were excluded from the study.

Children enrolled in this study were divided randomly through using odd & even numbers for random allocation into two groups of 15 children each: The control group (group A) or the study group (group B) by a blinded and an independent research.

The control group (A) (n=15): each child was placed in sitting position while receiving the Scar Standard Management (SSM) protocol that includes: pulsed ultrasound waves (1.5 Watt/cm2), deep friction massage and range of motion (ROM) exercises. This protocol was conducted three sessions/week for 4 successive weeks.

The study group (B) (n=15): Each child was placed in sitting position. Firstly, child received the SSM protocol as conducted for the control group, then received the polarized light therapy with medical color at a distance of 10 cm for 15

min/area. After that, the orange filter was applied to emit the orange colored polarized non-coherent light on the post burn scar of wrist and hand for 15 min. Three times week for successive 4 weeks were applied using Bioptron Pro I Light Therapy System (PAG-990) by (Bioptron AG, Switzerland) with the following technical characteristics: Wavelength 480–3,400 nm, degree of polarization>95% (590–1,550 nm), specific power density 40 mW/cm2, light energy per minute 2.4 J/cm2. Also, the orange filter was used to emit the orange colored polarized light.

All children received the study protocol once a day, 3 times/week for one month. They were all analyzed as no participants dropped out of the study after randomization.

Hand held goniometer was used to measure the MCP flexion and extension range of motion. The fulcrum was placed dorsally over the MCP joint, the movable arm over the dorsal mid line of proximal phalanx while the stationary arm over dorsal mid line of metacarpal bones. Dorsal placement of the goniometer was used as recommended by the American society for hand therapists. (Ibolya , 2013) and (Jia , 2013)

Statistical analysis was conducted using SPSS for windows, version 22 (SPSS, Inc., Chicago, IL, USA). The sample size (30 patients) was calculated to yield a 90% power and α=0.05. Prior to final analysis. The current study involved two independent variables. The first one was the tested group that had two levels (the control group A received SSM protocol and the study group B received SSM protocol along with colored polarized light with medical range filter for 15 min followed by orange filtered polarized light for 15 min). The second one was the treatment periods, which had two levels (pre and post). In addition, this study involved one tested dependent variable metacarpo-phalyngeal (MCP) joint range of motion. Normality test of data using Shapiro-Wilk's test was used, that reflect the data was normally distributed for MCP range of motion scores, so parametric statistical tests in the form of (paired t-test) was used to compare between "pre" and "post" treatment for each group and "unpaired t-test" was conducted to compare MCP range of motion scores between both groups in the "pre" and "post" treatment. The alpha level was set at (0.05).

RESULTS

In this study; thirty children with hand burn enrolled in this study divided into two groups; the control group A consisted of 15 children (8 boys and 7 girls), their mean ± SD of ages were 7.27±-1.71years. The study group B consisted of 15 children (5 boys and 10 girls), their mean ± SD of ages were 8.07±1.28 years. There were no statistically significant differences (P>0.05) between subjects in both groups concerning age. Also, Chi square revealed no significant differences between both groups in sex distribution (p>0.05) (Table 1).

The "pre" and "post" treatment mean ± SD values of MCP flexion range of motion (Degrees) for both groups are presented in table (2).

"Paired t test" comparing pre and post treatment mean values of MCP flexion range of motion (Degrees) revealed that there was a significant improvement of children MCP flexion range of motion (p<0.05) in both groups. Considering the effect of the tested group (first independent variable) on MCP flexion range of motion, "unpaired t test" revealed that; "pre" treatment mean values of MCP flexion range of motion between both groups showed no significant differences (p>0.05). But, "post" treatment mean values of MCP flexion range of motion between both groups showed a significant differences (p<0.05) in favor of group B.

The "pre" and "post" treatment mean ± SD values of MCP extension range of motion (Degrees) for both groups are presented in table (3)."Paired t test" comparing pre and post treatment mean values of MCP extension range of motion (Degrees) revealed that there was a significant improvement of children MCP extension range of motion (p<0.05) in both groups. Considering the effect of the tested group (first independent variable) on MCP flexion range of motion, "unpaired t test" revealed that; "pre" treatment mean values of MCP extension range of motion between both groups showed no significant differences (p>0.05). But, "post" treatment mean values of MCP extension range of motion between both groups showed a significant differences (p<0.05) in favor of group B.

Table (1): Demographic characteristics of both groups:

	Group A	Group B	Comparison		
	Mean ± SD	Mean ± SD	t-value	P-value	
Age (years)	7.27±1.71	8.07±1.28	1.45	0.157	
Gender			X^2		P-value
Girls	7		10		
Boys	8		5	1.22	0.27

SD: Standard Deviation, P: probability, X^2: Chi -Square.

Table (2): Pre and post treatment Mean ± SD, t and P values of MCP flexion (Degrees) for both groups A and B:

MCP flexion (Degrees)	Means ± SD	Means ± SD	% of improvement	t-value	P- value
	Pre test	Post test			
Group A	59.27±7.04	63.6±5.87	7.31 ↑	6.43	0.0001*
Group B	60.87±5.96	67.67±4.24	28.97 ↑	11.17	0.0001*
t-value	0.67	2.18			
P- value	0.507	0.0381*			

*****Significant level is set at alpha level <0.05.

Table (3): Pre and post treatment Mean ± SD, t and P values of MCP extension (Degrees) for both groups A and B:

MCP extension (Degrees)	Means ± SD	Means ± SD	% of improvement	t-value	P- value
	Pre test	Post test			
Group A	20.47±3.25	22.07±3.24	7.81 ↑	6.81	0.0001*
Group B	22.73±3.20	26.27±3.22	15.57 ↑	8.82	0.0001*
t-value	1.93	3.56			
P- value	0.064	0.0013*			

*****Significant level is set at alpha level <0.05.

DISCUSSION

Childhood is a very important period for development of social, motor and cognitive functioning. (Kamolz et al., 2009).Unfortunately, burns are relatively common especially within the pediatric age group worldwide. (Kassira and Namias, 2008) .Burn injuries may be severely stressful experiences with serious consequences that can persist from childhood through adolescence into adulthood. (Kamolz et al., 2009) and (Kealey and Jensen, 1988)

The burned hand represents serious injuries in children. Hand burn injuries are frequent component of burn injuries and provide opportunities for serious deformities in the future. Physical therapy, Splinting, Occupational therapy involvement from the early stage has been reported to be effective in preventing complications which are common after hand burn injuries as scars and contractures. (Medenica and Lens , 2004) and (Monstrey et al., 2002) ROM exercise also helps lessen the effect of edema fluid and immobilization, maintain joint mobility and muscle function, and decrease the physical deconditioning resulting from prolonged rest. The use of paraffin, ultrasound, ROM exercises, massage, and fluid therapy can both provide pain relief and increase the ROM. (Monstrey et al., 2004)

Rehabilitation focuses on scar prevention, hypertrophic scar suppression, management of heterotopic ossification, leukoderma, and pruritis, as well as restoration of the patient's functional capacity, such as full range of motion, muscle strength, and independent mobility and activities of daily living. It also includes complex reconstruction procedures and measures to reintegrate the patient into the home and community. (Norkin, and White, 2003)

The current study was conducted to investigate the effect of orange polarized light on MCP joint range of motion. The pretreatment mean values of the measured variables (MCP

flexion and extension) showed limited MCP flexion and extension range of motion in both groups with below normal goniometric measurements induced by abnormal development of scar and contractures secondary to hand burn. This come in agreement with (Anzarut et al.,2005) (Ohgi and Gu , 2013) who reported that hand injuries and burns along with induced scars and contractures limit the range of motion (ROM) of finger joints and hamper hand function, thereby degrading activities of daily living (ADLs) and quality of life.

The results of the current study revealed a significant improvement of post treatment MCP flexion and extension range of motion in favor of the study group compared with the control group. This may be due to the impact of the orange filtered polarized light on the pliability of the scar tissue besides the range of motion exercises.

These findings come in agreement with other studies (Schindl et al., 2000) and (Sheridan et al, 1999) reported that light is a form of energy used in healing long-time ago and that Biptron light therapy device stimulates the biological reactions in the body, as the polarized light has bio-activating effect on the cell membrane and other metabolic processes as ATP production and collagen synthesis.

Also, the light therapy can improve the pliability and extensibility of the scar tissue and improve the contracted skin allowing more available range of motion for the joints to move through. This come in agreement with Bhertha M. (Spires et al., 2007) who reported that recommended the light therapy in prevention or attenuation of hypertrophic scars or keloids development.

Although the exact mechanism of light therapy is not adequately determined; Light therapy is considered as a photochemical energy that have an effect similar to photosynthesis in plants. The efficient tissue penetration of light and the precise wave-length of light absorbed by photo-receptors are two of the main parameters to be considered in light therapy (Thaller , 2008)

Also the polarized light have many different colors with different wave lengths and different physiological effects on the different body tissues and structures. So this study was delimited to the orange filtered polarized light and its impact on the goniometric measurements of MCP flexion and extension range of motion.

Further studies are needed to investigate the effect of different filtered colors on different body tissues and systems in different pathologies and measuring other variables as the quality of life, functional activity and participation.

CONCLUSION

It was concluded from the results of this clinical study that orange filtered polarized light has a special and beneficial effect on improving the MCP range of motion in children with hand burn.

CONFLICT OF INTEREST

The authors declare no conflict of interest regarding this study.

ACKNOWLEGEMENT

For all children participated in this study and their families.

AUTHOR CONTRIBUTIONS

All authors contributed in collecting and analyzing data. All authors participated in writing every part of this study. All authors read and approved the final version.

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