A Comparative Study of Wound Healing Treatment Using Two Different Lasers

Mithaq M. Mahdy AL-Sultani[1] , Baneen Hussein Mohammed[2], and Mohammad jawad[3]

[1,2]University of Kufa - College of education for girls-Physics Department of Physics -Najaf-Iraq

[3]University of Kufa -College of Medici-Department of Dermatology – Najaf-Iraq

Corresponding authors :mithaq.alsultani@uokufa.edu.iq

beninhussein29@gmail.com

dr79mohamad@yahoo.com

Abstract

Wounds are among the most common health problems worldwide. Traumatic and surgical scars constitute a wide range of acute and chronic wounds, which are associated with increased rates of morbidity. Wound healing is a complex series of different cellular and biochemical processes that lead to the rebuilding and regeneration of damaged tissues. Many types of treatment methods have been used to promote wound healing, and the laser is currently one of the most widely used methods. The results of treatment with the Fractional CO_2 laser (60watt) were more effective in treating deep and medium-depth scars, and it also requires several sessions to obtain an appropriate clinical effect. As for the Fractional CO_2 laser (30watt), its results were more effective in patients with moderate to very deep wound effects. In addition, it required fewer treatment sessions. The high power of the Fractional Er: YAG laser also contributed to reducing the width of the scar because the wavelength of the Erbium laser (2940nm) can be absorbed by the water molecules in the skin faster than the wavelength of the CO_2 laser.

Keywords: surgical scars, fractional CO_2, fractional Erbium YAG

1. Introduction

Lasers have become widely used in biology and medicine, and the majority of health centers and hospitals use modern laser systems for diagnostic and treatment applications. [1]. Researchers have determined that laser therapy is associated with a relatively low complication rate. Complications and side effects that are observed after laser treatment are temporary and are not significantly severe or do not lead to long-term effects [2]. Lasers can cause serious complications and medical costs if not performed carefully and appropriately [3]. The study aims to investigate the safety and efficacy of CO_2 and Er: YAG fractional lasers for the treatment of scars of various types.

Mona Saheli et.al. studied the effectiveness of the MSC-CM technique in speeding wound healing in diabetic patients in 2020. In addition, they demonstrated the effect of this treatment on the cellular behavior of human HDFS cells in high glucose (HG) medium, as a model for diabetic patients in vitro. As a result of this technique, the skin is stimulated to multiply stem cells, and blood vessels are formed [4].

In 2021 K. R. Harikrishna et.al., a study was conducted on the effect of photobiomodulation as an adjunctive therapy Eleven patients with chronic wounds such as diabetic foot ulcers and pressure ulcers were selected. They concluded that the use of the K laser, which operates at multiple wavelengths (970, 800, 660 nm) generated an estimated energy of 30 kJ and a period of up to 3 minutes. The results have shown the efficiency of this laser in reducing edema and inflammation. It also significantly increases the formation of blood capillaries and speeds up the healing process [5].

2. Theoretical part

2.1 Interaction of Laser Beams with Biological Tissues

Laser interaction with tissue is of great interest due to its important application in biomedical optics for both diagnostic and therapeutic purposes. The main aspects of laser interaction with tissue that must be considered in biomedical studies are the thermal properties of the tissue and the thermal changes caused by the interaction of light and tissue [6]. The most important optical characteristic that determines the suitability of the laser for a surgical procedure is the depth of penetration of its radiation into the tissues. Figure (1) shows the depth of optical penetration by laser radiation.

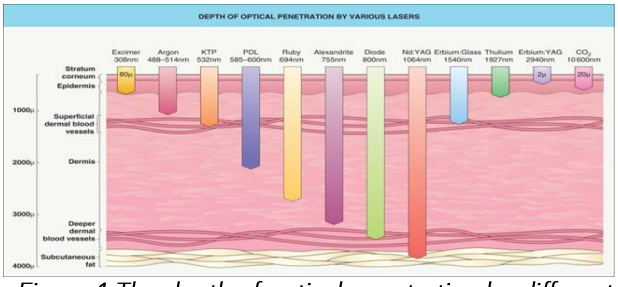

Figure 1 The depth of optical penetration by different lasers [7]

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2.2 Theoretical Analysis

It is the physical characteristics of laser-treated wounds

2.2.1 Thermal Breakdown Degree of Tissue K(T)

$$K(T) = Aexp\left(-\frac{E_\alpha}{RT}\right) \qquad (1)$$

Where:

A: Frequency factor (Hz), E_α: represents the laser energy (J), R: the general constant for gases and equal to 8.314 ($J.k^{-1}.mol$), : T human temperature (and is constant around 37℃) [8].

2.2.2 Thermal Degradation of Laser-Treated Wound Tissue (T,t)Ω.

$$\Omega(T,t) = \int_0^t Aexp\,(-\frac{E_\alpha}{RT}).\,dt \qquad (2)$$

Where:

A: Frequency factor, E_α: represents the laser power, R: Gases constant, equal to 8.314 $J.k^{-1}.mol$), T is the human temperature (and is constant about 37℃), dt: the time of one session (sec) [8].

2.2.3 Spatial Distribution of Temperature in Laser-Treated Wound Skin (Z)Ψ

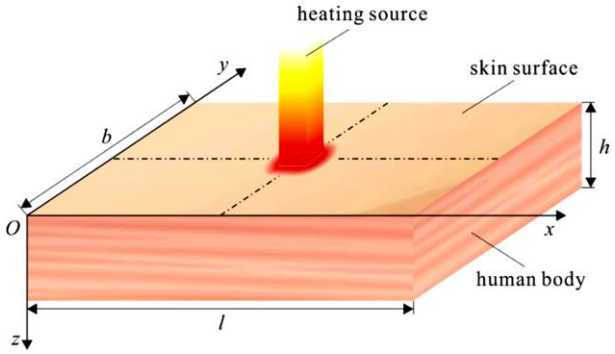

Figure 2 Thermal transfer process in a cubic dermal model exposed to laser pulses

Figure (2) shows a study of the thermal transfer process in a cubic skin model exposed to laser pulses. [8]. The governing equation based on the biothermal conduction model can be expressed

$$\Psi(z) = (1 - R_a)I_O\mu_a \exp(-\mu_a z) \qquad (3)$$

Where:

R_a: reflectance coefficient of the tissue, I_o power density of the input laser energy, and it represents the power per unit area,.μ_a is the skin absorption coefficient of the epidermis and dermis layers (mm), Z. thickness of the tissue (mm) [8]

3. The Experimental Part

3.1 The Devices Used

Three types of devices were used in fractional laser treatment, two CO_2 lasers and, Erbium YAG laser.

3.1.1Fractional CO2 laser device

- The fractional CO_2 laser used in the treatment purchased from Korea launched by Unixel RF .was used in the treatment. The fractional CO_2 laser emits light with a wavelength of 10600 nm. Its energy level reaches 60J. This device works by creating tiny columns of ablative laser energy that penetrate the skin, removing damaged tissue and stimulating the production of collagen and new skin cells.
- The second laser device used in the treatment, was from German-origin fractional CO_2 laser launched by SK EILY. The fractional CO_2 laser emits light with a wavelength of 10600 nm. Its energy level reaches 90mJ.

3.1.2 Fractional Er: YAG laser device

The Er: YAG fractional laser of German origin, launched by MCL 31 Dermablate, was used in the treatment. The fractional erbium laser emits light with a wavelength of 2940nm. Its energy level reaches 2.5J.

3.2.Materials Used

3.2.1Creams Used for Wound Conditions Before and After Laser Treatment

An anesthetic cream (Emla PLUS) is used to be applied to the area to be treated about thirty minutes before the treatment, and creams are also used after the session, including Fuocidad cream. The laser treatment and the second cream that is used after the session (MEBO SCAR) continue to be taken for a whole month and twice a day, as it is considered the stimulating substance for collagen production and fills the void caused by the wound, as shown in Figure (3).

Figure 3 MEBO SCAR and Fuocidad Cream

3.2.2 Sunscreen

The use of sunscreen is very necessary after the laser session to avoid burns caused by sunlight and also to reduce the risk of hyperpigmentation, as shown in Figure(4).

Figure 4 Sunscreen cream

3.3 Methods of Treatment

The medical records and photographs of patients who underwent laser treatment for atrophic and hypertrophic facial scar scars between 2021 and 2023 were reviewed retrospectively. Some of the patients finished medical treatment. Patients were excluded if there was no documented follow-up or photographs after laser treatment. Patients who underwent concomitant biopsy or combined laser therapy were also excluded.

4. Result and discussion

To find out the effectiveness of Er: YAG and CO_2 lasers in treating scarring scars, some physical properties of each type of laser were calculated, and we also made a comparison between the three types by measuring scar depth reduction.

In this study, twenty-one patients suffering from the effects of surgical scars were enrolled and were looking for a treatment for them, 8 males and 13 females (8 of the patients were light-skinned, 3 were white-skinned, and 9 were dark-skinned, One case of Asian skin), with an average age of 12-50 years. Cases were treated in Iraq at a private clinic in Al-Najaf Governorate using the CO_2 fractional laser, and some data were also collected from the existing doctor's clinic in Erbil governorate using the Er: YAG fractional laser. Some data about patients treated with both 30-watt Fractional CO_2 and 60-watt Fractional CO_2 lasers can be clarified. Fractional Er: YAG 2500 watt. As indicated in Tables (1),(2), and (3), and figures (5), (6), (7).

shows the experimental results that we have reached using the 30watt Fractional CO_2 laser1 Table

The period between sessions	period sessions (min)	Number of sessions	laser (watt)powr	pulse (ms)duration	laser (J)power	Wavelength(nm)	Laser *type*	age (years)	skin color	gender	No.
1months	15	3	17	400	6.8	10600	Fractional CO_2 laser	45	IV	Female	P_1
1months	15	5	17	400	6.8	10600	Fractional CO_2 laser	36	IV	Female	P_2
1months	15	8	17	400	6.8	10600	Fractional CO_2 laser	36	III	Male	P_3
1months	10	2	16	450	7.2	10600	Fractional CO_2 laser	35	III	Female	P_4
1months	10	3	16	450	7.2	10600	Fractional CO_2 laser	35	III	Female	P_5
1months	10	2	16	450	7.2	10600	Fractional CO_2 laser	33	III	Male	P_6
1months	10	2	15	500	7.5	10600	Fractional CO_2 laser	32	IV	Male	P_7
1months	10	3	15	500	7.5	10600	Fractional CO_2 laser	26	III	Female	P_8
1months	10	2	15	500	7.5	10600	Fractional CO_2 laser	25	IV	Female	P_9
1months	10	7	15	500	7.5	10600	Fractional CO_2 laser	12	III	Female	P_{10}

Table 2 shows the practical results that were achieved using the 60watt Fractional CO_2 laser device

The period between sessions	period sessions (min)	Number of sessions	laser ower (watt)	pulse uration (ms)	laser (J)power	avelength (nm)	Laser type	age (years)	skin color	gender	No.
1months	10	3	30	2.5	0.075	10600	Fractional CO_2 laser	50	IV	Male	P_1
1months	8	1	30	2.5	0.075	10600	Fractional CO_2 laser	40	IV	Male	P_2
1months	8	1	30	2.5	0.075	10600	Fractional CO_2 laser	40	III	Female	P_3
1months	8	8	30	2.5	0.075	10600	Fractional CO_2 laser	40	IV	Female	P_4
1months	8	3	25	2.5	0.063	10600	Fractional CO_2 laser	35	III	Female	P_5
1months	8	8	25	2.5	0.063	10600	Fractional CO_2 laser	23	III	Male	P_6
1months	8	3	18	2.5	0.045	10600	Fractional CO_2 laser	13	IV	Male	p7

Table3 shows the experimental results obtained using the Fractional Er: YAG 2500watt laser device											
The period between sessions	period sessions (min)	Number of sessions	laser (watt)power	pulse (ms)duratin	laser (J)por	Wavelength(nm)	Laser type	age (years)	skin color	gender	No.
1months	10	1	666	0.2	40	300	2940	Fractional Er: YAG	30	Female	P_1
1months	15	2	2000	0.6	50	300	2940	Fractional Er: YAG	30	Male	P_2
1months	15	2	2333	0.7	50	300	2940	Fractional Er: YAG	35	Female	P_3
1months	15	2	2333	0.7	50	300	2940	Fractional Er: YAG	50	Female	P_4

Figure 5 image of the wound for the case (from right to left) before and after laser treatment with a wavelength of 10600nm)

Figure (5-1) image of the wound for the case (from right to left) before and after laser treatment with a wavelength of 10600nm))

Figure(5) shows the effect of an old wound of medium depth as a result of an accident suffered by a twenty-six-year-old girl. A fractional CO_2 laser was used in the treatment. This result was obtained during three sessions of laser treatment

A B C

Figure 6 image of the wound for the case. The image represents (A) before the treatment sessions, (B) immediately after the first session, (C) a month after the eighth session of laser treatment with a wavelength of 10600nm)

Figure 7 Image of The Wound (From Right to Left) Before and After Laser Treatment, With A Wavelength of 2940 Nm.

The figure shows the effect of a wound as a result of surgery to remove the thyroid gland of a thirty-year-old man who used the Er: YAG Fractional laser in the treatment. This result was obtained during two sessions of laser treatment, where we see the clear effect of the laser in reducing the enlarged scar

4.1Comparison of Some Results Between the Three Types of Lasers

Four samples of each type were taken to clarify the comparison of the three types of lasers to show the effect of laser energy in reducing the depth of the wound, as shown in Table (4) and Figure (8)

Table 4 A comparison between Fractional CO_2 laser(30watt), Fractional CO_2 laser(60watt), and Fractional Er: YAG laser in effecting a change in wound depth depending on the energy of each type of laser.

Fractional CO_2 laser(30watt)			Fractional CO_2 laser(60watt)			Fractional Er: YAG laser		
Z_f(mm)	Z_0(mm)	(J)aser power	Z_f(mm)	Z_0(mm)	(J)Laser power	Z_f(mm)	Z_0(mm)	(J)Laser power
20	30	6.8	7	10	0.075	4.5	7	0.2
10	20	6.8	6	8	0.075	4.5	10	0.6
7	15	6.8	6	8	0.075	4.5	7	0.7
7	13	7.2	3.6	8	0.075	5	8	0.7

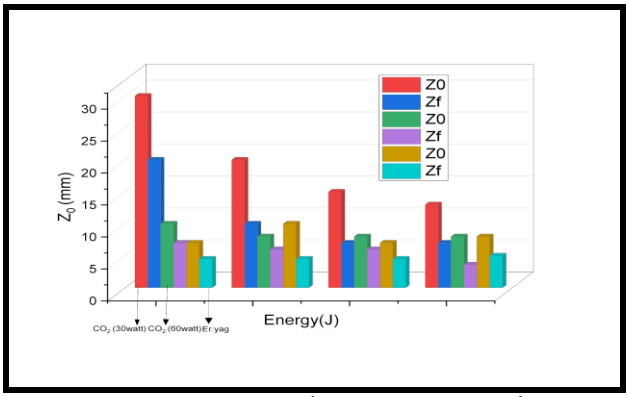

Figure 8 A comparison between Fractional CO2 laser(30watt), Fractional CO2 laser(60watt), and Fractional Er: YAG laser in making a change in wound depth depending on the laser energy

We note from Figure (8) the results obtained from Table (4) that the three types had a role in reducing the depth of the scar, but the significant effect was of the Fractional CO_2 laser (30watt). Its results were good in reducing the effects of very deep wounds. The reason is due to The energy of this laser is higher than the energy of the other two lasers, as its high energy works to break down the fibrosis in the wound and rearrange the tissues, which works to increase the secretion of collagen, which reduces the depth of the wound.

5. Conclusions

1- It can be concluded that laser treatment is a safe and effective way to reduce scars. Most studies indicate that early intervention in starting treatment shows the best results.

2- The results showed that the Fractional CO_2 laser treatment (60watt) was more effective in treating deep and medium-depth scars, and it also requires several sessions to obtain an appropriate clinical effect. As for the Fractional CO_2 laser (30watt), its results were more effective in patients with moderate to very deep scars. In addition, it requires fewer treatment sessions.

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