2014 5th International Conference on Chemical Engineering and Applications
IPCBEE vol.74(2014) © (2014) IACSIT Press, Singapore
DOI: 10.7763/IPCBEE. 2014. V74. 18

Effect the Er:YAG Laser Treatment on Skin Tissue

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Abstract. The skin is the most important organ in our body which protects us from external environmental effects. The determination of the histological examination of irradiated tissue has a significant scientific and medical application value. In this work, the materials used in this investigation were skin samples taken from the rat's dorsal where they were excised to different Er:YAG laser pulses of 1, 3, 6, and 10 pulses of each. The histological investigation indicated that, there was a loss in epidermis layer thickness with a deep of collagen coagulation in dermis layer. Besides that, more collagen fibers were remolded in the treated samples by Er:YAG laser after six days of treatment. We conclude that the Er:YAG laser was perfect device for skin treatment which confirmed by our histological data, the collagen of irradiated skin increased with minimal thermal damage to surrounding the tissue.

Keywords: Rat Skin, histology, Er:YAG laser

1. Introduction

Due to high absorption of Er:YAG laser in tissue water, the skin surface is heated by the diffusion of heat from the laser tissue interaction layer with minimal thermal damage to surrounding tissue. The action of collagen regeneration induced by Er: YAG laser skin treatment can be referred to the unique physical properties of the Er:YAG laser. Because of its wavelength, the laser can properly target the specific chromospheres and the penetration depth can be set, which affects the range of the laser treatment process. Since the Er:YAG laser induces high absorption of water in tissue, the layer below the surface is heated by diffusion of heat from the superficial laser – tissue interaction. The deeper coagulation of collagen increased by the use of more Er:YAG laser pulses on the skin tissue was earlier investigated on human tissue [1]. In this present paper, we aim to demonstrate that collagen remodeling in tissue is increased by an increase in Er:YAG laser pulses on rat skin as an animal model.

Collagen plays a significant role in maintaining skin's structural integrity, elasticity and strength. Furthermore, it has a vital role in healing process, and is considered as a key protein to reconnect and repair wounds through the formation of scars, which improve the tensile strength of the wound. This is due to an increase in the number of fibroblasts [2]. Numerous studies have been carried out to understand the relationship between the laser influence and the type and quantity of collagen. When tissue is irradiated with laser, type III collagen is produce first and then replaced by type I collagen over time [3], [4]. Most collagen has a specific contraction temperature, which does not affect connective tissue but leads to a restructuring effect in collagen fiber. The average temperature that causes tissue shrinkage ranges from 60 ºto 80 º[5] .The aim of this present study was to evaluated the effect the Er:YAG laser device with different number of pulses on the rat skin tissue in terms of the damage depth and collagen remolding.

2. Material and Methods

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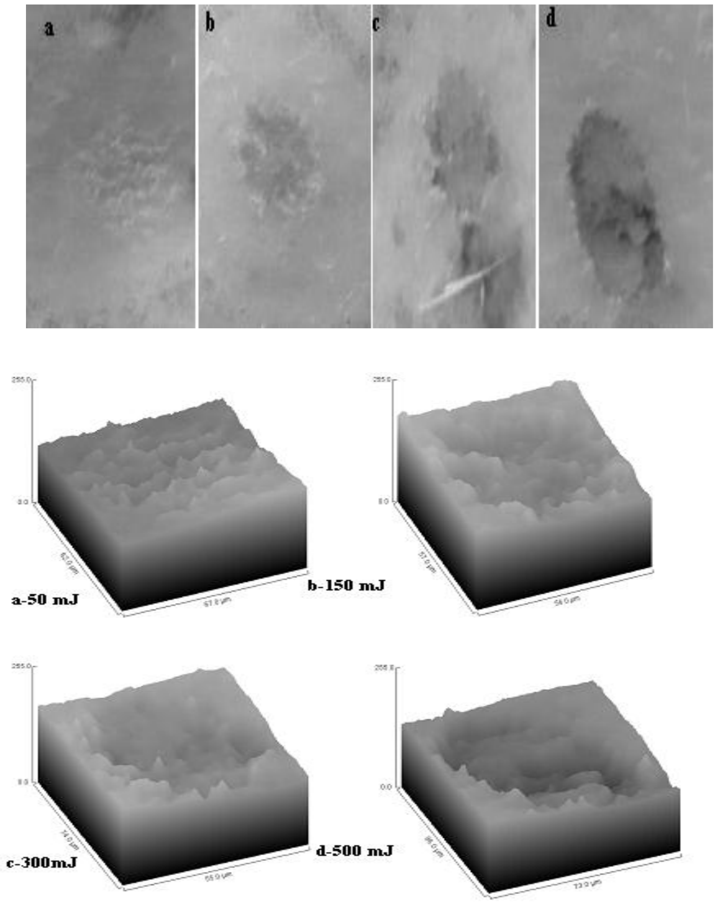
Twenty male rats with average weight of 120-200 g were obtained from the animal house of Universiti Teknologi Malaysia. These rats were 9-10 weeks old. They were fed standardized feed and kept in an environment with constant temperature and humidity with 12-hours light/dark. Next, the hair at the back skin surface was shaved gently using a razor blade and an electric shaver. Full-thickness skin from the dorsal back was excised and prepared for histological examination. Four different laser pulses were applied to all rats (1, 3, 6 and 10). Each exposure was done on the back of the rat in order to obtain duplicate samples for histology studies; control samples were obtained from the unexposed skin and processed under the same conditions as exposed samples immediately and one, three and six days after treatment. The laser was the Er:YAG laser manufactured in the USA. The laser operated in pulse mode and could be either internally or externally triggered. The internal trigger operated in repetitive mode with a frequency of 20 Hz. The external trigger was designed to operate with a single pulse. The maximum output was 500 mJ, however, with single pulse the output energy was 200 mJ. The pulse duration was for 130 μs. The beam spot was 3 mm in diameter.

A



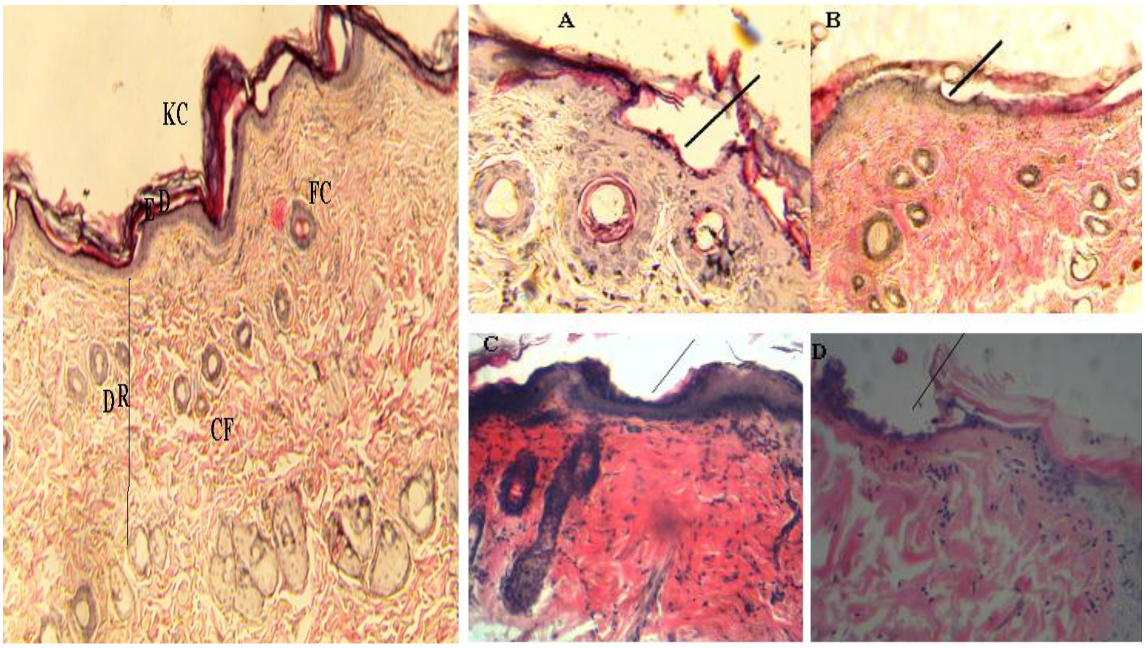
B

Fig. 1: (A) The rat's skin irradiated with different number of Er: YAG laser pulses (a)- with one pulse, (b) three pulses, (c) with 6 pulses and (d) with ten pulses,(B)- the 3D surface structure of exposed modeling skin at different energy according(a) with one pulse,(b) three pulses,(c) six pulses and (d) then pulses

3. Results

Since we are using the change in the pulses number of Er:YAG laser as a parameter in our study, this parameter will effect on the rat skin by different result due to, the change of number pulses lead to change in exposed energy to the target where the energy increase as the pulses of the laser increase as shown in Fig. 1, the frames was arranged according to increase order in laser pulses. In frame 1a, we can see the skin was heated without damage to surrounding area after exposure by a single Er:YAG pulse with 50 mJ. When the pulses increase, the damaged area increase as well as the color of photodamge became more burned and depth at 10 pulses with 500 mJ which means that the skin was carbonize due to the water absorption. Our results indicated that, there was clearly increase in photodamaged area as the exposure energy increased which was maximum at 10 pulses with energy 500 mJ due to the heat diffusion through the epidermis layer. As the pulses increased the depth increase as well due to ablation of epidermis layer and go depth to dermis layer which observed at 10 pulses with 500 mJ. As shown in Fig. 1, the frames were arranged according to increase order in laser pulses.

We are using the change in the pulse number of the Er:YAG laser as a parameter in our study. The difference in energy exposure received as the time of laser pulse was varied lead to a range of results. This is shown in Fig. 1-A, where the frames are arranged according to increasing number of laser pulses. In frame 1.A-a, we can see that the skin was heated without damage to surrounding area, after exposure by a single Er:YAG pulse of 50 mJ. When the pulses increased, the damaged area increased. Additionally, the color of the photodamage became darker, representing more severe and deeper damage at 10 pulses with 500 mJ which means that the skin layer vaporized due to water absorption. The Er:YAG laser's tissue interaction was viewed in 3D images as shown in Fig. 1-B, which shows the skin structure after irradiation. With a single pulse of the Er:YAG laser, the skin was heated and raised up forming wave form as shown Fig. 1.B(a). As the pulses increased, the depth increased as well due to ablation of the epidermis layer. The depth of dermis layers was observed to increase at 10 pulses with 500 mJ. The histological evaluation of no irradiated skin tissue sample as shown in Fig. 2 which occur like a normal human structure where consists of main three layer, epidermis , dermis and hypodermis layers. After laser irradiation, we observed the slight swelling and changes in epidermis in the farm of the cells destruction. Furthermore, the fat cells increased in the size and have more elongated shape than in control skin tissue and the most of the cells in irradiated skin are intensively stained with hemotexlyin. At the site irradiated with one Er:YAG laser pulse with 50 mJ shows a little ablated epidermis and a very thin superficial layer of thermally damage through dermis which identified by collagen coagulation (market by arrow). The histology examination in Fig. 3 indicated the marked increase in depth of collagen coagulation with more ablation in epidermis layer resulting from three pulses at 150 mJ flounce. Not that, the hyperchoromasia in hair follicle epithelium, indicating superficial thermal damage and most of them was ablated in the epidermis compared with all exposure skin samples from 1, 3, 6, and 10 pulses.



a b

Fig. 2: a- unexposed skin, b- the irradiated skin with different number of pulses (A) one pulse, (B) three pulses, (C) six pulses and (D) ten pulses

At sequence of 10 laser pulses at 500 mJ, the epidermis layer was totally ablated and we can observe more coagulated collagen in dermis layer. Fig. 3 presented the collagen in treated tissue with one, six and ten pulses. In one pulse, we observed little new collagen which presented by green color in six day after laser irradiation in epidermis-dermis junction and by increase the number of pulses to six we showed improvement in dermal collagen fiber which higher than one pulse of Er:YAG and the epidermis layer became thinner at six day which lead to the fast healing process using Er:YAG laser. At 10 pulses of Er:YAG laser, there was more collagen fiber through the dermis layer which became more at third day after laser irradiation and more at six days after treatment.

4. Conclusion

Experiments that use an in vivo rat model explained that the depth of damage in the skin tissue become more when Er:YAG laser pulses are irradiated increase at 3,6and 10 pulsed on the skin tissue location. Histological investigation showed collagen coagulation below the epidermal-dermal junction, compared with observed on the average with a single-pulse exposure. In summary, coagulation of collagen became deeper below the epidermal dermal junction in skin tissue seems workup by using the convenient settings of a repetitive Er:YAG laser.

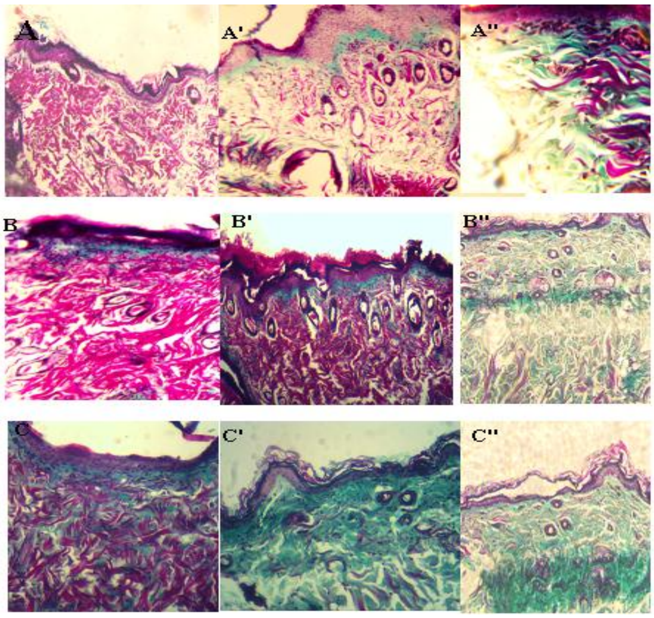


Fig. 3: The collagen fiber density at different days with different pulses (A)Skin irradiated with one pulse after one day of treatment and(A') after 3 days and (A'') after six days-B with six pulses after one day (B') after 3 days (B'') after 6 days-C skin with ten pulses(C') after 3 days,(C'') after 6 days

5. Acknowledgement

We would like to express our thanks to Malaysian Government and Universiti Teknologi Malaysia through Flagship grant vote 00G79 for financially support this research work.

6. References

[1] Majaron B, Plestenjak P, Lukacˇ M. Quantitative investigation of thermal damage in Er:YAG laser skin resurfacing.Proc SPIE 1998;3245:366–373.

[2] Kurkinen M, Vaheri A, Roberts PJ, Stenman S. Sequential appearance of fibronectin and collagen in experimental granulation tissue. Lab Invest 1980;43(1):47–51

[3] Oono T, Specks U, Eckes B, Majewski S, Hunzelmann N, Timpl R, Krieg T. Expression of type VI collagen mRNA during wound healing. J Invest Dermatol 1993;100(3):329–334.

[4] Asbell P. A., Maloney R. K., Davidorf J, Hersh P, McDonald M, Manche E (2001) Conductive keratoplasty for the correction of hyperopia. Trans Am Ophthalmol Soc 99:79–87.

[5] Newman J. B., Lord J. L., Ash K., and McDaniel D. H. Variable pulse Erbium:YAG laser skin resurfacing of perioral rhytids and side-by-side comparison with carbon dioxide laser. Lasers Surg Med 2000;26:208-214.