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LETTER TO THE EDITOR

Can a robot outperform a human operator in skin photorejuvenation?

To the Editor,

The use of 1064nm Nd:YAG laser for facial skin rejuvenation is a common practice in cosmetic dermatology. 1064nm laser technology tends less penetration inside the skin tissue and causes less coagulation than the classical 10,600nm CO_2 fractional lasers. Still extra deposition of laser light energy due to overdosage can cause the side effects that is pigment alteration blistering and erythema.[1-4]

In dermatology clinics the dermatologists or professional practitioners perform skin photorejuvenation treatments. For the optimal outcome the laser light energy should uniformly deliver on the skin tissues. The laser flashes last only for a few milliseconds and leave no traces of irradiation on the skin surface. Thus it is challenging for an operator to keep track of the irradiated region. The non-steady motion of the operator's hand can also cause a non-uniform distribution of laser light. To improve the quality of the aesthetic laser treatments we have developed a novel robotic system for the skin photorejuvenation capable of uniformly delivering the laser energy over the skin surface.

Figure 1 illustrates the developed robotic prototype to perform the skin photorejuvenation. This robotic prototype mainly consists of three major components robot mobile platform robot manipulator and customized end effector. The sensorized robotic prototype and the developed graphical user interface allow the operator to select any facial region for the desired treatment. The control system of the robotic prototype accurately delivers the laser light energy over the selected skin surface.

The developed technology has been deployed successfully to conduct the human trials on 18 healthy individuals after obtaining the ethics approval from the Human Subjects Ethics Sub-committee Departmental Research Committee. We applied the patches of the charcoal mask of 76 × 76mm on both sides of the participant's face as shown in Table 1 (two on the forehead and four on the cheek). The robotic prototype treated the left side of the participant's face and the professional practitioner treated the right side. Upon laser irradiation over the charcoal mask the charcoal burns and leaves a trace on the applied surface. The application of the charcoal mask is solely for visualization purposes. The comparison criteria between the robot and human operators were the time to fill each patch with laser irradiations the number of laser irradiations the distance between each shot and covered area (nonoverlapped irradiated area) inside each patch. The robot and human operator were not allowed to overlap the laser irradiation.

The average time taken by each operator is slightly varied. But the number of laser irradiations and area covered by the robot operator is 20% more than a human operator as shown in Table 1. Also the nonoverlapped distribution of the laser irradiation by the robot is more uniform than the human practitioner. The presented facts show that the complete control over the laser irradiation in terms of position and irradiation frequency can enable the dermatologist to perform the skin photorejuvenation treatment with a high degree of safety (without any side effects) and certainty (about the desired outcomes). This developed technology has also the potential to precisely regulate the optimal temperature required to enhance collagen synthesis. As the temperature rises to 45°C in the dermis due to laser induction increases the synthesis of collagen type I.[5]

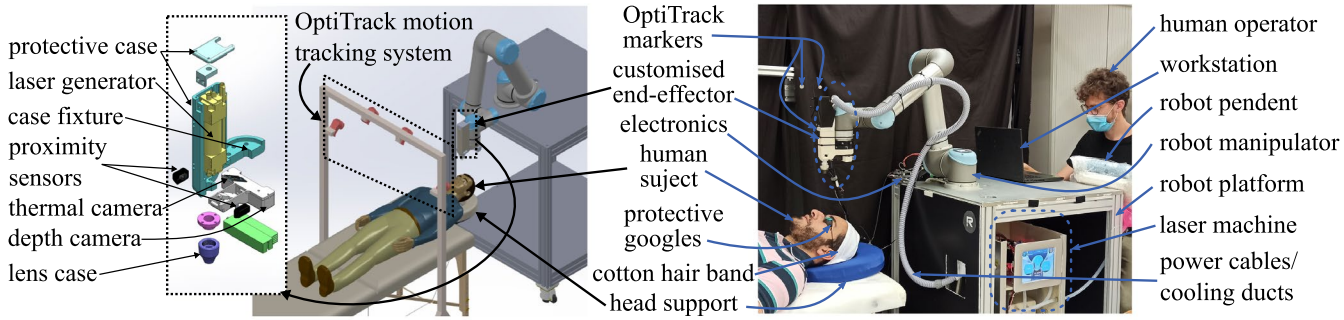

FIGURE 1 (Left) The proposed robotic prototype. (Right) Developed robotic system for skin photorejuvenation

TABLE 1 The comparison between human and robot operator in terms of area coverage. Φ is the percentage of the area covered with irradiations without overlapping

	Robot Treated			Practitioner Treated	
	Φ (%)	Irradiated Surface	Treated Subject	Irradiated Surface	Φ (%)
Forehead	69.29				47.19
Cheeks	70.27				55.86

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

KEYWORDS

Skin photorejuvenation, skin resurfacing, robots in dermatology, 1064nm Nd:YAG laser

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