INVESTIGATION OF THE DESTRUCTION OF BIOLOGICAL TISSUES BY LASER RADIATION WITH A WAVELENGTH OF 405 NM FOR SURGICAL CORRECTION OF AN INGROWN NAIL

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Introduction

One of the most popular and gentle is considered to be the Schmieden operation. (Fig. 1)

1.The posterior nail roller and nail plate are dissected under local anesthesia, followed by its removal. That is, it is necessary to make an incision from 0.5 to 1.5 cm.

2.Laser alignment of granulations is performed, pathologically altered tissue and a section of the germinal zone adjacent to the removed nail plate are removed

3.The periarticular roller is resected and a bridge flap is created.

4.Suturing. In this way, the skin is pulled away from the nail bed and space is freed for the future nail.

The use of laser radiation in surgery helps to reduce pain and the number of relapses.In most of the work on the correction of an ingrown nail, a CO2 laser was used. However, this laser has a number of disadvantages, including large dimensions and high cost.

Therefore, we decided to consider a source with laser radiation with a wavelength of 405 nm, since it has small dimensions and relatively low cost.InGaN laser radiation with a wavelength of 405 nm can be used for effective laser destruction of the skin and nail plate, since its radiation is well absorbed by keratin and melanin.

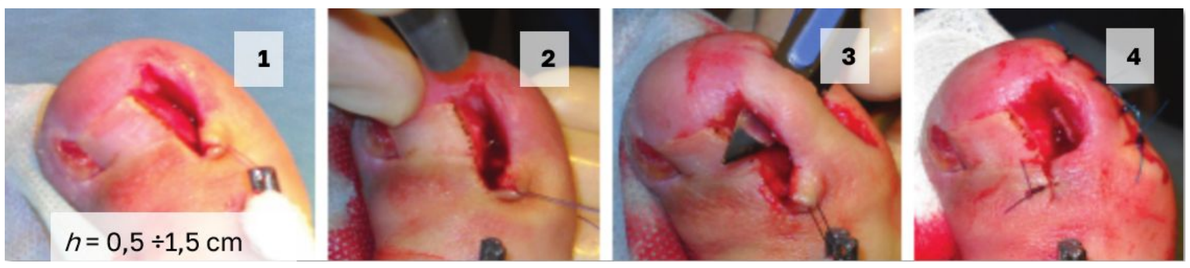
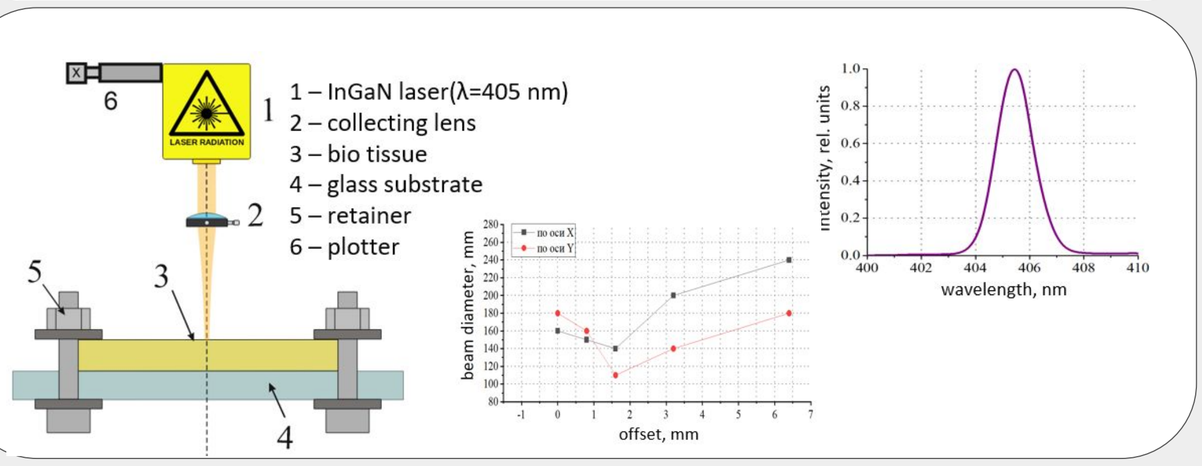


Fig. 1. Stages of the Schmieden operation



Methodology

The study used samples of biological tissue, which are fragments of chicken skin and muscle tissue (average thickness - 420 ± 20 microns), cleaned of fat deposits and fragments of nail plates (average thickness 640 ± 20 microns.), which were mechanically cleaned and washed with distilled water before the experiments.

For the destruction of biological tissues, radiation of a continuous (CW) semiconductor InGaN laser of Xinrui technology (China) with a wavelength of 405 nm was used. The energy density took values up to 200 J/cm2, the diameter of the laser beam was 140 × 110 microns, the power took values in the range of 0.5–1 W and was limited the parameters of the laser diode used, and the scanning speed is 0.5–1.5 mm/s. The scheme of the experimental stand is shown in Figure 2. To study the incisions, optical-microscopic registration of the appearance of laser-treated biological tissues and the appearance of their longitudinal sections was carried out using the Axio Scope A1 microscope Scope A1 microscope (Carl Zeiss, Germany), as well as the analysis of the obtained images of sections in the CorelDRAW Graphics Suite 2021 program.

Results

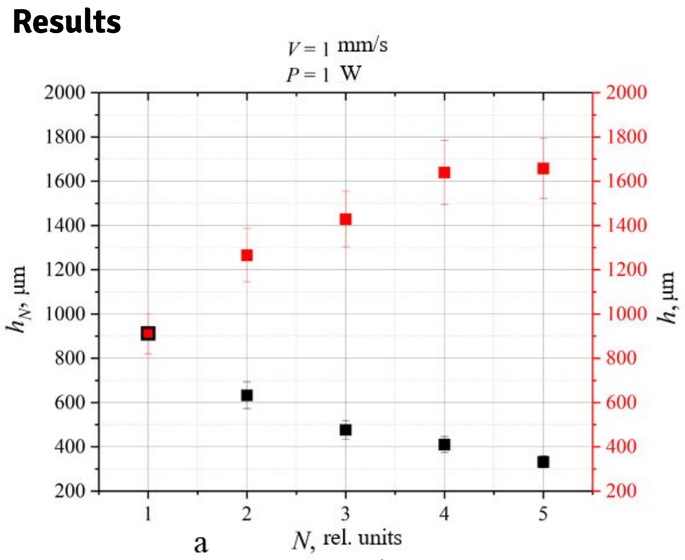
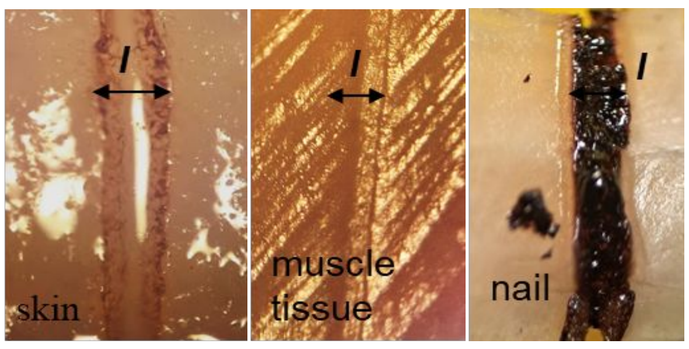


Fig.3. The dependence of depth and normalized depth on the number of passes on the number of passes at P = 1 W and V = 1 mm/s for the skin(a) and muscle tissue(b)



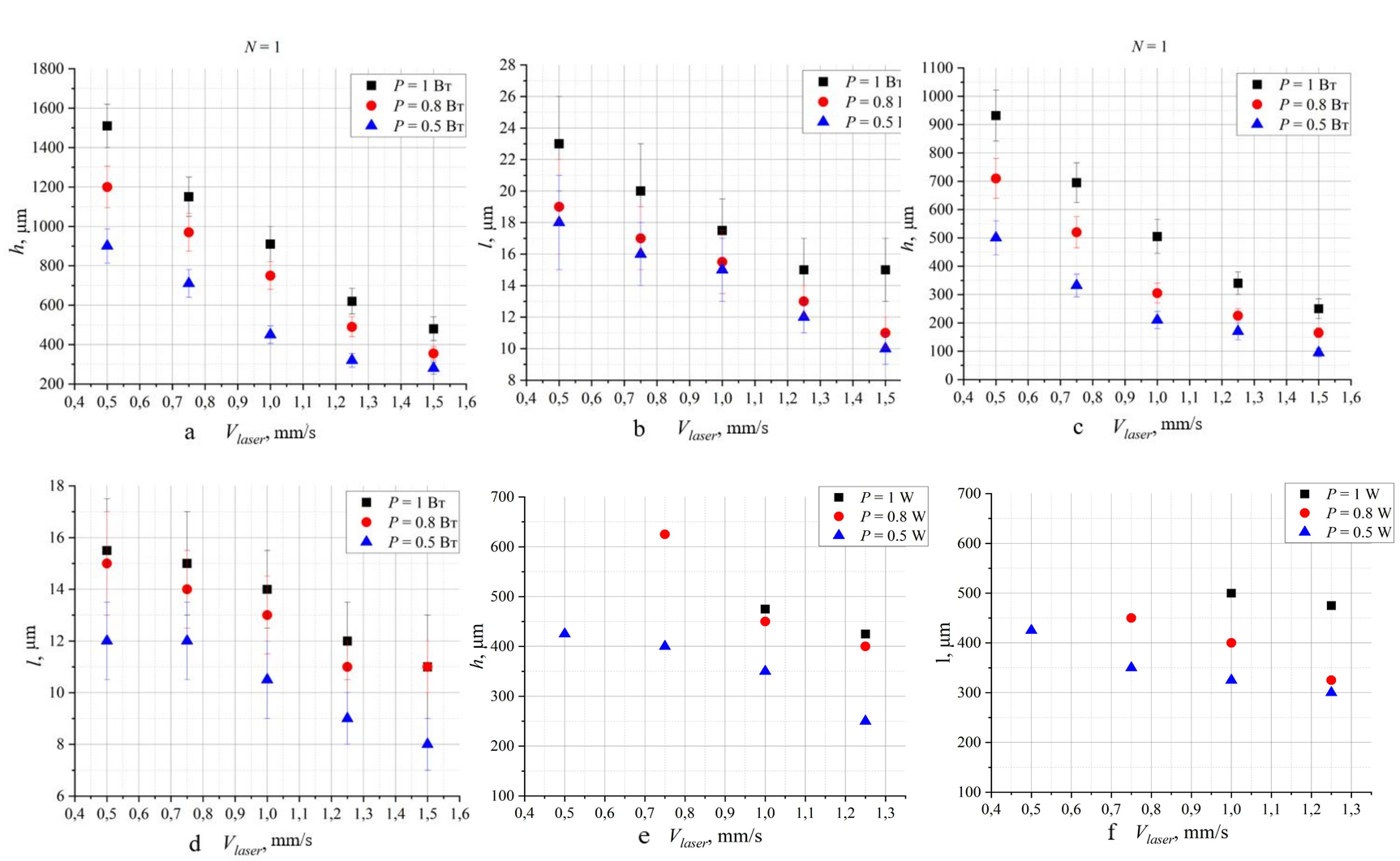


Fig. 2. a, c, e - dependences of incision depth on scanning speed and power for skin, muscle tissue and nail, respectively. b, d, f - the dependences of the width of the incisions from the speed to the scanning and the power for the skin, muscle tissue and nail, respectively

It was found that the width and depth of the sections of biological tissues increase with an increase in the power of laser radiation with a wavelength of 405 nm and a decrease in the scanning speed of the laser beam. (Fig. 2)It was found that the maximum width and depth of skin incisions by laser radiation with a wavelength of 405 nm were 1510 microns and 23 microns, and for muscle tissue - 932 microns and 15.5 microns. Through-cutting of the nail was recorded at P=0.8 W at V=0.5 mm/s and at P=1 W at V=0.75 mm/s and V=0.5 mm/s.It was found that with an increase in the number of passes for skin and muscle tissue, the efficiency of destruction of muscle tissue decreases. (Fig. 3). This may be due to the displacement of the surface of the processed sample from the focal plane during repeated passes. Therefore, it is more expedient to reduce the speed than to increase the number of laser passes.

Conclusion

The possibility of destruction of biological tissues (chicken skin, muscle tissue and nail) by laser radiation with a wavelength of 405 nm to correct an ingrown nail was investigated and demonstrated in vitro. Optimal parameters were selected for working with biological tissues, allowing to obtain the necessary incision depth: for skin and muscle tissue P= 1 W, V= 1 mm /s and for the nail P=1 W V= 0.75 mm/s.