The Device for External Ultrasonic Liposuction

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Abstract – The article is devoted to the development of ultrasonic device for destruction of subcutaneous fat as an aid during weight-reducing treatment. Developed equipment meets necessary technical requirements and now is at the stage of clinical trials.

Index Terms – Ultrasound, subcutaneous fat, liposuction.

I. INTRODUCTION

LIPOSUCTION BECAME WELL-KNOWN last ten years and is the most popular among cosmetic surgery performed nowadays. Its main point is in the surgical correction of body outline due to subcutaneous fat removal after its mechanical and ultrasonic destruction.

During the mechanical liposuction fat preliminary dissolved by physiological solution is removed by long curettes (tubes) with perforated nozzle due to negative pressure in the vacuum suction pump. This method is labor-consuming and may lead to unpleasant results. Because of high-degree injury postsurgical period can last up to 7-14 days.

During ultrasonic liposuction fat cells are destroyed by ultrasonic waves, the cavitation process occurs – the formation of bubbles in fat cells. Neighboring tissues and nerves do not expose to cavitation owing to their dense structure that is why they are not damaged. After ultrasonic processing subcutaneous fat forms emulsion, which is easily removed through thin titanium cannulas 2-3 mm in diameter with the help of vacuum suction pump.

It is known that any surgical operation may cause complications and is characterized by long period of postoperative rehabilitation. More over the use of general or local anesthesia, large hemorrhage (up to 30-40% from the volume of removed emulsion), influence only on the clusters of adipose tissues, the list of contraindications and high price of the operation make liposuction for many categories of people inaccessible and rather dangerous.

At present it is known the method of non-operative removal of subcutaneous fat with the help of mechanical influence on patient’s regions, where it is necessary to reduce adipose interlayer. Here mechanical influence means the processing of patient’s regions with ultrasonic irradiator with the intensity enough for occurring cavitation in adipose tissues.

II. PROBLEM STATEMENT

Now several medical devices of foreign manufacturers exist, they realize internal liposuction by ultrasonic low-frequency vibrations. The technology of non-operative liposuction is based on the processing of problem zones by ultrasound of certain amplitude, which selectively destroys the membranes fat cells not injuring surrounding tissues. Contents of fat cell get into blood flow; they are gradually split in lever and normally removed from the organism. The majority of such devices are generators with irradiator of ultrasonic vibrations.

The analysis of technical performance of the existing devices for realization of external liposuction showed that:

1) operating frequency of piezoelectric transducers varies from 40 to 44 kHz;
2) the irradiators are made in the form of body of rotation with inside diameter 44-54 mm;
3) maximum output radiated power does not exceed 30 W.

Taking into consideration this data it is possible to note that produced intensity of such devices does not transcend 1.5 W/cm². To provide cavitation process in subcutaneous adipose tissue such intensity is not sufficient.

Summarizing all mentioned above and taking into account the fact that such equipment was not developed in our country, it is necessary to design and create ultrasonic device for external liposuction with frequency within 40-44 kHz, working ending 50 mm or less in diameter, intensity of radiation enough for occurrence of cavitation (as is well known it is more than 2 W/cm²). It should also meet the requirements to medical apparatus.

III. DEVELOPMENT OF THE VIBRATING SYSTEM

Carried out research showed that the creation of such construction is possible only with use of half-
wave construction of ultrasonic vibrating system. It consists of irradiating and reflecting cover plates and piezoelectric rings of standard size 50x20x6.

Medical conditions of device operation determined the material choice for irradiating cover plate of ultrasonic vibrating system. It should be made of titanium alloy. In order to provide gain factor of electromechanical transduction steel 45 was chosen as a material for reflecting cover plate.

For verification of calculations accuracy [1, 2] and bringing in necessary corrections in geometry the model of ultrasonic vibrating system was designed with use of finite elements method.

The simulated results are shown in Fig. 1.

Measurement results of the designed construction confirmed the accordance of main performance characteristics obtained as a result of mathematical simulation to experimental data. It proves the correctness of offered designing idea of ultrasonic vibrating system.

The construction of the ultrasonic vibrating system is shown in Fig. 2.

Irradiating cover plate 1 is fastened to the case 6 through fluoroplastic ring with cone fit. The ring is fixed in the zero vibration of the irradiator and pressed to the case by flange 5. The use of cone fit provides with acoustic uncoupling, case watertightness during its immersion into disinfectant solution. To achieve required vibration intensity the device has to be operated in power modes close to maximum for such type of piezoelectric rings [3]. It leads to extreme heating of piezoelements and respectively irradiating cover plate that is inadmissible. For such situation the placement of fan and performance of apertures for air cooling are needed.

The appearance of ultrasonic vibrating system with the generator is demonstrated in Fig. 3.

Measurement of output performance of designed equipment by calorimetric method showed that the intensity was 2.7 W/cm² that exceeded required parameters. Frequency of the ultrasonic vibrating system equaled 42 kHz.

IV. EXPERIMENTAL RESULTS

In order to confirm the effectiveness of designed equipment the researches aimed at destroying of adipose tissue were carried out. The analogue of men’s adipose tissue was used. Fig.4 presents the experiment.
Experimental results demonstrated that destroying of structure of adipose tissue was observed at the distance of 5-7 mm from contact zone. The time of influence was 5 min at 100% power. The temperature on the irradiator surface was not more than 40 °C. If the power is 56% (irradiated one is 30W), the temperature reaches 40 °C in 25 min and then it stabilizes.

V. CONCLUSION

The device for external ultrasonic liposuction – non-operative removal of adipose tissue was developed and designed as a result of work. The intensity of ultrasonic influence corresponded to required conditions for operation performing. Now created masseur is being passed the tests after which the decision about its further clinical use and series manufacturing will be made.

REFERENCES


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