Lasers are being used for the emulsification of fat and coagulation of small blood vessels in conjunction with lipoaspiration. Ichikawa et al., Badin et al., and Goldman et al. all substantiated the lipolysis and coagulative effect of laser lipolysis through histologic analysis of irradiated fat and tissue sections. No studies to date have included objective data regarding the effects of subdermal application of laser energy on skin elasticity change and skin shrinkage.

It has been reported that external application of 1064- and 1320-nm wavelengths lead to the clinical and histologic effects of fibroblastic activation and stimulation of new collagen formation. Cytokines and growth factors released by inflammatory cells are thought to correlate with increased collagen production.

Laser effects on skin initiate a wound healing response that increases collagen types I and III. Laser treatments lead to marked improvements in dermal layer thickness and collagen fiber density, and to an increase in fibroblast number and hydroxyproline content. Liu et al. found that skin irradiated with a 1064-nm Q-switched (5 ns) laser resulted in the increased synthesis of collagen type III when compared with the long-pulse (0.3 ms) 1320-nm laser because of the photomechanical effects, while 1320-nm laser treatment resulted in a greater increase of collagen type I because of the photothermal effects on the irradiated tissue. Trelles et al. also investigated the histologic changes in human skin six weeks after eight treatments with the 1320-nm neodymium:yttrium-aluminium-garnet laser and observed an increase in the number and density of collagen fibers, indicating some compaction in the remodeling process, less interfibrillary space, and good linear orientation of the fibers parallel to the dermoepidermal junction.

The goal of our study was to gather and analyze data on the effects of dual wavelength subdermal laser lipolysis on skin shrinkage (reduction of area) and skin tightening (elasticity).

**METHODS**

Five female subjects with focal areas of adiposity were enrolled for the reduction of fat, skin tightening, and skin shrinkage of the abdomen through laser-assisted liposuction (LAL) using a SmartLipo MPX laser (Cynosure, Westford, MA). This device provides a sequential emission of 1064- and 1320-nm wavelengths through a 600-μm fiber that is extended 2 to 3 mm from the cannula. The handpiece was also fitted with an
Evaluation of Skin Tightening After Laser-Assisted Liposuction

accelerometer (SmartSense; Cynosure) to titrate the laser energy delivered based on manual movement. Institutional review board (IRB) approval was obtained.

Candidates were evaluated for mild to moderate skin laxity without structural ptosis. The median age of the subjects was 49 years. Informed consent was received from all subjects for the procedure and for tattoo markings. Subjects were followed for three months. Biopsy specimens from the treated areas were taken at baseline and at one and three months postoperatively. Subject questionnaires and physician evaluations were completed at one and three months postoperatively. The tattoos were removed at the three-month follow-up visit.

**Laser Treatment**

Treatment areas were demarcated into 5- × 5-cm squares with a surgical marker. Each corner was tattooed with India ink delivered by dermal puncture with a 20-gauge syringe to two sectors in the upper abdomen and two sectors in the lower abdomen. Subjects were given oral medications preoperatively (diazepam and oxycodone and acetaminophen) for pain management.

A series of consecutive lidocaine 1% injections was made into the premarked incision sites, followed by a 50-mL injection into each area with 0.5% lidocaine delivered via a 22-gauge spinal needle before tumescent fluid application. After the patient was prepped and draped, tumescent fluid (1000 mg lidocaine, 1mg epinephrine, and 10 mEq of sodium bicarbonate per 1 L of lactated Ringer’s solution) was then instilled, approximately 50 to 100 mL per sector. An average of 1550 mL of tumescent anesthesia was injected per patient.

Laser energy was delivered with a 600-μ disposable fiber placed through a 1-mm cannula. A fresh tip was obtained by stripping the fiber sheath and cleaving the fiber tip every 25000 J of energy. The skin of the abdomen was measured with calipers at a 5-cm width to determine deep fat energy application. Energy was applied at a rate of 1000 to 2000 J per 1 cm of caliper thickness. Then, 1- to 2-mm incisions were made around the perimeter of the marked area and in the umbilicus with a no. 11 scalpel.

Lasing of the deep subcutaneous fat (1–3 cm below the epidermis) was performed, first with multiplex mode three delivering 30 W (20 W of 1064-nm wavelength and 10 W of 1320-nm wavelength). Lasing was redirected superficially to the subdermal area (0.5 cm below the epidermis) with multiplex mode one delivering 16 W (8 W of 1064-nm wavelength and 8 W of 1320-nm wavelength). The lasing continued in a fan-like pattern within each 5- × 5-cm square. The endpoint was an epidermal temperature of 40°C to 42°C, which was measured with a thermal camera (FLIR Systems; ThermaCAM E45, Portland, OR). An even temperature was obtained throughout the sector. The third and final step was aspiration using a 2- or 3-mm cannula. At completion, wounds were left open and standard compression was applied, as with standard liposuction.

**Objective Measurement**

Digital photographs were taken at baseline and one and three months postoperatively (Figure 1). Skin shrinkage was evaluated using photographic documentation and tattoo measurements. Tattoos were applied and objectively measured using the Vectra System (Canfield Scientific, Fairfield, NJ). Linear distance, horizontal, vertical, diagonal, and perimeter measurements were documented from the tattoo markings and area calculations. Morphometric computer analysis was performed to analyze the baseline data as compared to data from one and three months postoperatively.

Skin tightening was evaluated using an elasticity device (DermaLab elasticity module; cyberDERM, Media, PA) that incorporates a suction cup probe placed at the center of each tattoo square. When suction was applied, the skin was drawn into the chamber and broke the lower light beam. The vacuum pump continued to increase the amount of suction. Eventually, the skin was lifted to the point where it broke the upper light beam, at which point the pressure difference at the lower and upper
points was recorded ($\Delta p$). Skin elasticity (Young’s module), indicated as a tightening index, was calculated based on a stress–strain relationship. Because the position of the lower and upper light beams was determined by the geometry of the probe, the strain at each level was known. The pressure required to lift the skin to each point provided a measure of the stress at that level. The stiffness of the skin ($E$) indicating the skin elasticity was calculated from the stress–strain relationship as follows:

$$E = a \cdot \frac{\Delta p}{\Delta x},$$

where $a$ was a system constant and $\Delta x$ was the distance between the lower and upper beams. Skin tightening indices were measured at baseline and at one and three months postoperatively.

**RESULTS**

Subjects tolerated the procedure well. Recovery symptoms were mild to none. Mild swelling was the primary complaint and it resolved in all subjects by three months postoperatively.

The surface areas of tattoos were compared to evaluate skin shrinkage. As much as 32% skin shrinkage was reported at one month postoperatively and 29% was reported at three months postoperatively, with ranges of 15% to 32% and 6% to 29%, respectively. When compared to baseline, an average of 22% of skin shrinkage or reduction in surface area was achieved at one month postoperatively; a 17% reduction was achieved at three months postoperatively (Figure 2). The $P$ value of the paired $t$ test was <.001, which indicated that application of laser energy achieved significant improvement in skin shrinkage.

Subjects experienced some weight fluctuation during the study. Specifically, one subject gained nine pounds between the one- and three-month follow-up visits, while three subjects had an average weight loss of four pounds. One subject’s weight was not taken during follow-up visits.

The skin tightening index was measured in order to evaluate elasticity changes. The $P$ value of the paired $t$ test was .0081, which indicated that the skin treated with the laser had a significantly higher skin tightening index than baseline. The average increase in skin tightening (elasticity) after three months was 26% (Figure 3).

It was understood that the sample size was small and that the paired $t$ tests did not have enough statistical power to test the hypothesis. Nevertheless, as shown in Figures 4 and 5, clear trends of skin shrinkage and skin tightening changes were shown at three months postoperatively. The trend lines comparing the area of skin shrinkage at baseline and at the three-month follow-up were consistently descending. This was also true of skin tightening. Except for one area on patient four at the upper abdomen, all other trend lines were consistently ascending. Based on the paired $t$ test and the comparison of trends, there was most likely a significant increase in skin tightening and decrease in skin area at three-month follow-up.
Physician evaluations (Figure 6) showed the overall reduction of adiposity as being subjectively “good.” These evaluations were based on the following scale: 1, mild; 2, moderate; 3, good; and 4, excellent. Skin firmness was rated as excellent in 75% of the patients at six months.

Subjects graded their skin tightening as fair at one month postoperative and good at three months postoperatively (Figure 7). Subjects reported their satisfaction rate with the overall results as good to excellent at three months. All subjects reported on the questionnaires that they would recommend this treatment.

Biopsy specimens collected in selected patients showed fibroplasias, which focally replaced the deep fat as grade II or partial replacement (Figure 8, A and B). Grade III is an almost complete replacement of fat. Parallel fascicles of spindle cells were embedded in dense connective tissue; the nuclei of some were plump, indicating myofibroblast differentiation.

**DISCUSSION**

In the testing of any new technology, it is necessary to prove a preliminary hypothesis in a small number of patients before embarking on a more definitive study. Also, the testing equipment or technology often has to be evaluated in the application. In the past, laser studies were rife with only qualitative data, without much accompanying numerical evidence. It has been our goal to obtain as much quantitative evidence as possible. Again, if the data collection instruments perform satisfactorily in a small group of patients, this methodology can be extended to a larger study population for a longer follow-up period.

In this preliminary study, patients were marked with visible tattoos on their abdomens (20 spots). The IRB required tattoo removal within three months. For this reason, additional data points could not be obtained going forward, but will be included in longer-term studies.

When used for superficial cutaneous treatment, applications of both 1064- and 1320-nm wavelengths have been associated with fibroblast activity and stimulation of collagen production. The device used in our study combined both wavelengths in multiplex mode, which were highly absorbed by both adipose tissue and water.

Previous laser lipolysis studies have shown histologic changes, such as collagen reorganization and neocollagenesis, which have been attributed to skin tightening. In this study, subjects achieved marked improvement in skin tightening and skin texture, attributed to improvement in skin elasticity.

In all subjects, skin shrinkage measurements showed overall average reductions of 22% and 17% at one and three months postoperatively, respectively. The decrease in skin shrinkage between one and three months can be attributed to weight gain or loss by subjects; weight control was required of patients in the study. Increasing weight will stretch abdominal skin.

In addition, these subjects achieved a significantly higher skin tightening index ($P$ value of paired $t$ test was .008). An average of 26% skin tightening was observed at three months as compared to pretreatment. Skin tightening or improvement in elasticity has also been correlated with neocollagenesis. Given the complexity of skin tissue production, this amount of change within the short period of time of the study is impressive.

Although much attention has been paid to fat disruption in the literature, the unique quality of adding a laser to the lipolysis procedure is its effect on the subdermal connective tissue structure. The histologic findings were significant with respect to fat replacement with fibroplasia, with evidence suggesting differentiation into myofibroblasts. This could explain the substructural tightening or contraction seen after laser application in these patients over several months.

The foundation for laser settings, temperature tolerances, and wavelength choice and quality in LAL have
**Figure 4.** Trend lines of changes in skin surface area three months after laser treatment.

**Figure 5.** Trend lines of changes in skin tightening indices three months after laser treatment.
been indicated in a previous study. The previously reported benefits of laser-assisted lipolysis are substantiated in this study. However, introducing the laser to the tissue also involves risks that are associated with tissue heating. These risks have to be addressed in the context of effective laser application. It is important to measure skin surface temperature when treating superficially to ensure the even distribution of heat. It is recommended that lasing should be discontinued when the surface temperature of the skin reaches 40°C to 42°C. It is also important to note that the temperature at 5 mm subdermally is about 5°C higher and that the surface temperature will continue to increase as the heat rises. However, caution must be used when treating superficially so as not to exceed 47°C, the temperature at which (in our experience) epidermolysis may occur.

Now that laser-assisted lipolysis is becoming more popular, it is important that the overall health of the

![Table 1](https://example.com/table1.png)

<table>
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<th>Swelling</th>
<th>Reduction in Fat</th>
<th>Firmness</th>
<th>Skin Tightening</th>
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</thead>
<tbody>
<tr>
<td>One Month</td>
<td>Mild</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>Three Months</td>
<td>None</td>
<td>Good</td>
<td>Excellent (3/4)</td>
<td>Good</td>
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Figure 6. Ratings as reported on the physician questionnaire.

![Table 2](https://example.com/table2.png)

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<th>Reduction in Fat</th>
<th>Skin Tightening</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Month</td>
<td>Mild</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>Three Months</td>
<td>None</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

Figure 7. Ratings as reported on the patient questionnaires.
treated tissue be well-studied and understood. Patient interest in skin tightening and improved elasticity—not merely the removal of fat—can be expected to increase as this technology develops and becomes better known. Based on this study, it is clear that the 1064-/1320-nm multiplexing combination is able to achieve effective skin tightening and skin shrinkage. The sequential firing of these two wavelengths maximizes the attributes of the individual wavelength properties. The combination of these wavelengths offers a more evenly distributed laser energy profile that benefits both superficial and deep treatment.

Because this study represents the first attempt at quantification of tightening and shrinkage, there were some limitations. First, although 20 sectors were sampled, they represented only five patients. This study evaluated only laser treatment to the skin, without comparison with standard suction-assisted lipectomy (SAL) or another energy source, such as ultrasound-assisted lipectomy (UAL). It was through this preliminary evaluation that the methods, instrumentation, and early results were to be tested. Obviously, given the promising findings, it will be expanded to include a larger number of patients in the next study. Comparison to other forms of lipectomy (such as SAL or UAL) were thought to be premature, because the evaluative methods themselves were still being tested. The next study will also include these variables.

Our concept involves the use of heat for fibroblast stimulation in the subdermal plane and production of skin tightening components (collagen, elastin, and myofibroblasts). This heat, however, if not carefully controlled, can lead to skin blistering and possible necrosis. Before this study, skin temperature dynamics and physics were studied to create a guide for safety parameters in LAL.9 The results of this study indicate a safe dermal temperature ceiling of 42°C.9 A thorough understanding of these parameters is necessary before attempting these procedures.

We plan to follow our positive preliminary findings with a study involving a larger number of patients and an internally controlled evaluation of lipectomy to the abdomen with blinded laser on one side and sham on the contralateral side, employing similar evaluative technology. Additional clinical studies should be conducted to evaluate the effect of LAL compared to lipectomy alone in the same patient, and to evaluate the use of this technique on other treatment areas.

CONCLUSIONS

Further study is necessary but these data represent the first quantifiable evidence that the addition of laser treatment to lipectomy procedures can result in positive changes to a patient’s skin quality and elasticity.

ACKNOWLEDGMENT

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DISCLOSURES

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