

**ORIGINAL ARTICLES****Low-Level Laser-Assisted Lipoplasty Appearance of Fat Demonstrated by MRI on Abdominal Tissue**

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**Introduction:** In an effort to study the changes of subcutaneous fat after exposure to a low-level diode laser and tumescent infiltration, the magnetic resonance imaging (MRI) findings are presented. The subcutaneous abdominal fat is exposed for 4 and 6 minutes irradiation time. This has previously been studied using a scanning electron microscope. The anatomical characteristics of the superficial and deep fat previously described by other authors are correlated with the scanning electron microscope and MRI. The changes in the characteristics of the fat before and after tumescence and before and after application of the low-level diode laser are shown.

**Materials and Methods:** By using MRI techniques, 3 patients were evaluated prior to infiltrating the subcutaneous tissue with tumescent fluid with T1 and T2 sequences. The same patients were evaluated again after applying or infiltrating the tumescence and again after exposure using the low-level laser beam for 4 and 6 minutes.

**Conclusion:** The MRI showed no laser exposure in the T1 sequence; the adipose tissue, both superficially and deep, appears to have a bright signal and is homogeneously distributed. After 4 minutes of laser exposure, the T1 sequence demonstrated that the adipose tissue is partially coalescent and has changed its signal. After 6 minutes of laser exposure, the MRI demonstrated that the adipose tissue is much more coalescent and is blurred. The fatty density and organization seems to have changed completely after exposure to the laser beam for this period of time. (The scanning electron microscope revealed that at this particular time 100% of the fat was in the interstitial space and the transitory pore was now open.) The MRI evaluation of the subcutaneous fat seems to correlate well with the findings of the scanning electron microscope, showing that there is a definite change in the consistency of the subcutaneous fat following exposure to the low-level electronic diode laser.

fatty and fibrous architecture. Authors Tobin and Benjamin,<sup>2</sup> Congdom et al,<sup>3</sup> and Gray, Gardner, and Orally<sup>4</sup> challenge the validity of Gray's classification.

The subcutaneous tissue in the abdomen exhibited a prominent fascial plane that coursed parallel to the dermis and separated the fat into 2 layers, superficial and deep. By using magnetic resonance imaging (MRI), the subcutaneous fascia appears to fuse medially with the linea alba, laterally with the external oblique muscle fascia and paralumbar musculature, superiorly with the costal margin, and inferiorly with the pubis and inguinal ligament.

The superficial adipose layer extends from the subcutaneous fascia to the dermis and consists of small fat lobules packed tightly between fibrous septa located perpendicular to the skin (Figure 1). The thickness of the superficial layer is constant throughout the region and varies considerably among individuals.<sup>5</sup> The deep adipose layer consists of large lobules loosely packed within widely spaced, fibrous septa. The boundary between the deep adipose layer and the muscle consisted of a membranous sheet<sup>6</sup> (innominate or Gallaudet fascia that is indistinguishable from the underlying Scarpa's fascia). The deep layer was always thicker in the periumbilical region over the rectus sheath and tapered laterally as it approached the external oblique muscle.<sup>5</sup>

The septal framework of the superficial and deep adipose layers is visibly different. The fat lobules of the superficial layer are small and tightly packed within close-spaced septa, whereas those of the deep layer are large, irregular, and much less organized (Figure 2). Markman and Barton described, in 1987, the anatomy of the subcutaneous tissue in the bodies trunk and extremities.<sup>5</sup>

The deep layer is contained by the subcutaneous fascia above and the muscle fascia below to form the deep adipose compartments. The deep adipose compartment contributes significantly to adipose thickness, is bilateral, and is found in the abdomen, paralumbar, and gluteal-thigh regions. The fat MRI signal is very well known, for it is bright on spin-lattice or longitudinal relaxation time (T1) sequences and dark on spin-spin or transverse relaxation time (T2) sequences.<sup>7</sup>

Neira et al<sup>8</sup> originally described the low-level laser-

According to Gray's Anatomy,<sup>1</sup> 2 fascial planes are described in the abdomen, each with a different

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Figure 1. Photo of actual MRI.

assisted lipoplasty as a new and revolutionary technique that uses an electric diode laser with a wavelength of 635 nm. Applying it in a specific area for a period of 6 minutes, which yields to liquefaction of almost 100% of the fat, makes it easier to be extracted and with better clinical results. With all of the fat completely in the interstitial space, it is also easier to extract with less surgical trauma.

#### Materials and Methods

The purpose of this study was to clarify the behavior of the abdominal fat prior to and after exposure to the laser beam for 4 and 6 minutes, correlating the findings with those found with the scanning electron microscope (SEM) samples in the abdominal area.

The patients underwent the following procedure:

- Step 1. The patient had MRI for T1 and T2 sequences.
- Step 2. Tumescence of the abdominal area was accomplished.
- Step 3. The patient had MRI for T1 and T2 sequences.

- Step 4. The abdominal adipose tissue received 4 minutes of laser exposure.
- Step 5. The patient had MRI for T1 and T2 sequences.
- Step 6. The abdominal adipose tissue received 6 minutes of laser exposure.
- Step 7. The patient had MRI for T1 and T2 sequences.
- Step 8. Liposuction with the Neira low-level laser-assisted lipoplasty technique was accomplished.

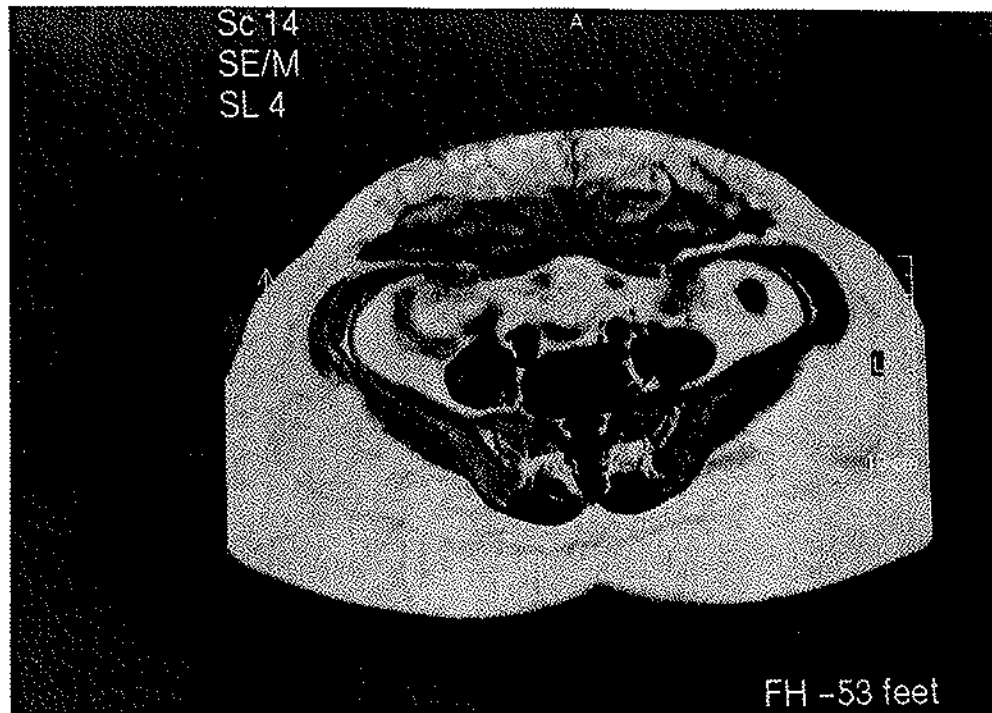
The laser used was an electric diode laser with a wavelength of 635 nm. The MRI equipment used was a 0.5 Tesla Philips Gyroscan (Philips Medical Systems Inc, Bothell, Wash), with the body coil antenna. The sequences performed in all patients were T1 and T2, with TR 443 and TE 10, and TR 1800 and TE 150 for the T2 sequences.

#### Results

The MRI with no minutes of laser exposure without tumescence shows distribution of the adipose tissue in 2 layers, superficial and deep. The superficial adipose



Figure 2. Schematic drawing of subcutaneous fat layers.



**Figure 3.** *Magnetic resonance imaging (MRI) T1 sequence. Fat appears bright and the tumescent solution dark.*

layer is contained within organized, compact fascial septa. The deep adipose layer is contained in a loose, less organized and more widely spaced fascial septa. The deep layer is contained by the subcutaneous fascia above and the muscle fascia below to form the deep adipose compartments. The deep adipose compartment contributes significantly to adipose thickness, is bilateral, and is found in the abdomen, paralumbar, and gluteal–thigh regions.

On the T1 sequence, the adipose tissue is bright, and on the T2 sequence, the fat is dark. MRI with no minutes of laser exposure and after tumescence reveals most of the saline solution (dark on T1) going into the deep layer because it is loose. The superficial layer is better organized, the perpendicular septae are better defined and better visualized when compared with the sequences after applying laser. The superficial fat is bright on this sequence (Figure 3).

MRI with no minutes of laser exposure after applying the tumescence in the T2 sequence shows that the saline solution is bright on the deep loose layer; the superficial layer has its perpendicular organized septae, and the saline solution is now in the superficial septa (bright on T2). The superficial layer adipose tissue is dark on T2 (Figure 4).

Figure 5 shows an MRI after 4 minutes of laser exposure and after tumescence. The T1 sequence shows the superficial adipose layer becoming more coalescent, the septa are less defined, and the superficial adipose tissue less bright on T1. The deep layer, with the tumescent solution, is dark on T1.

Figure 6 shows findings on the T2 sequence after applying the laser for 4 minutes. The tumescent solu-

tion shows a bright signal and the fat is dark; you can see that the superficial and deep fat appear more coalescent. Figure 7 shows the T1 sequence MRI at 6 minutes of laser exposure after tumescence. The superficial adipose layer is much more coalescent, and the septa are now disorganized and not defined, as was initially seen without laser exposure.

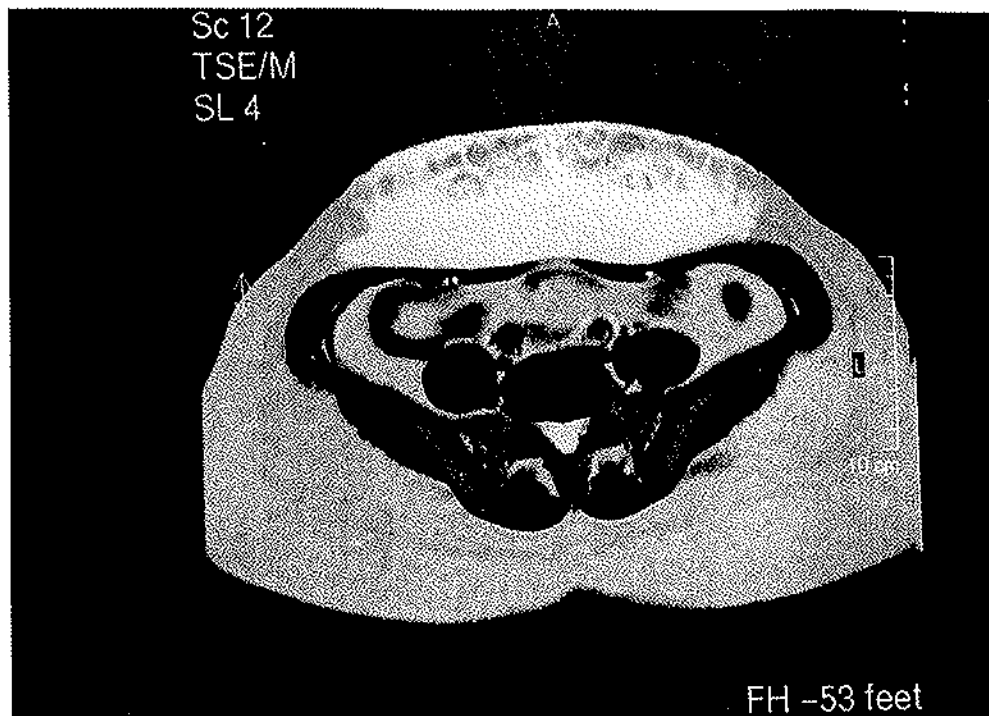
In the T2 sequence with 6 minutes of laser exposure, there is less definition of the superficial adipose layer, less definition of the septae, and the adipose tissue is much more coalescent (Figure 8). On SEM samples in this tridimensional picture you see the round grape-shaped adipose tissue when it has not been exposed to the laser beam (Figure 9).

After 4 minutes of laser exposure, there is 80% disruption of the adipose membrane, and the fat is now going into the interstitial space (Figure 10). After 6 minutes of laser exposure, there is almost 100% of the fat in the interstitial space. The fat is now liquified and ready to be extracted (Figure 11).

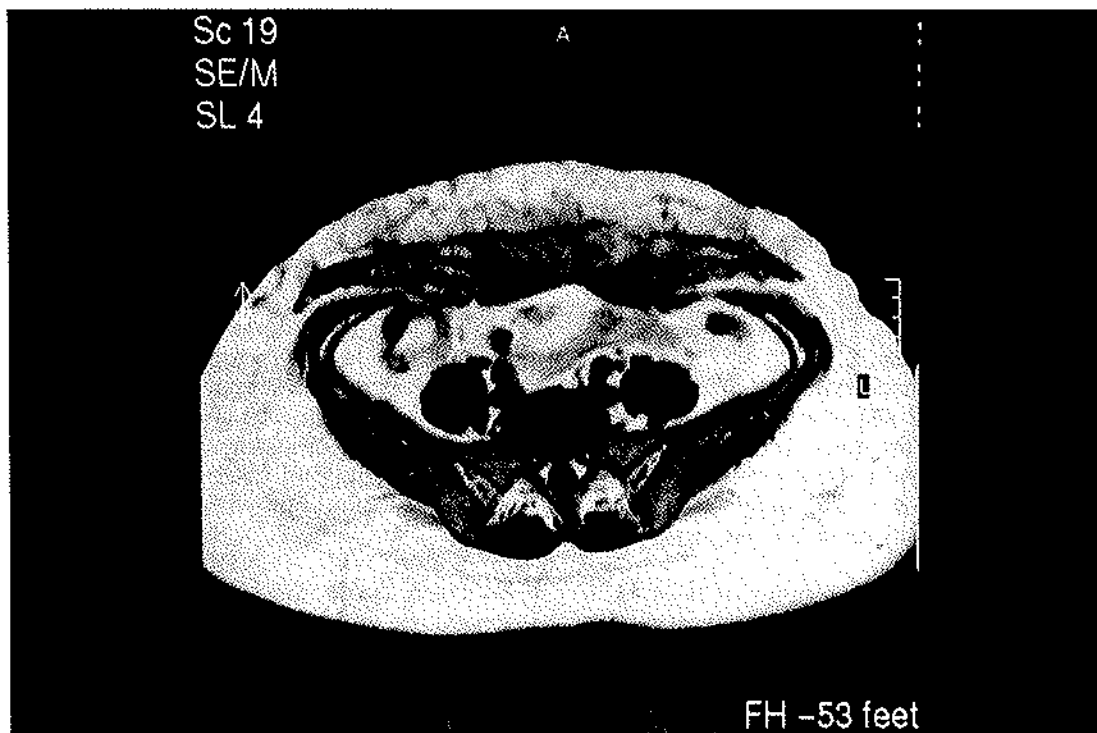
We have demonstrated the changes that are happening after applying laser for 4 and 6 minutes and correlated the findings with those seen in SEM samples.

### Discussion

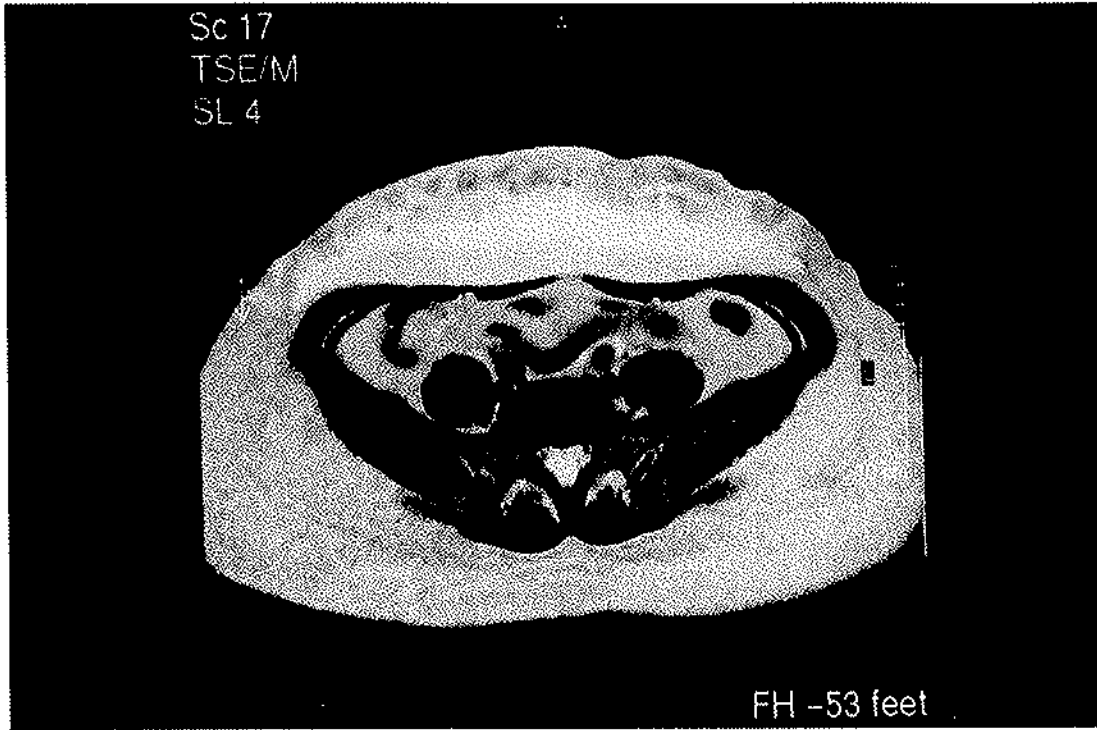
The electric diode laser utilized on these patients produces an impacted effect over the fat, including liquifying it after a period of 6 minutes. On MRI studies, the different sequences during the exposure time shows that the adipose tissue produces changes in the fat signal and in the fibrous septa. Such changes include the disorganization of the septa and the appearance of the septa. The fat and fibrous septa show more



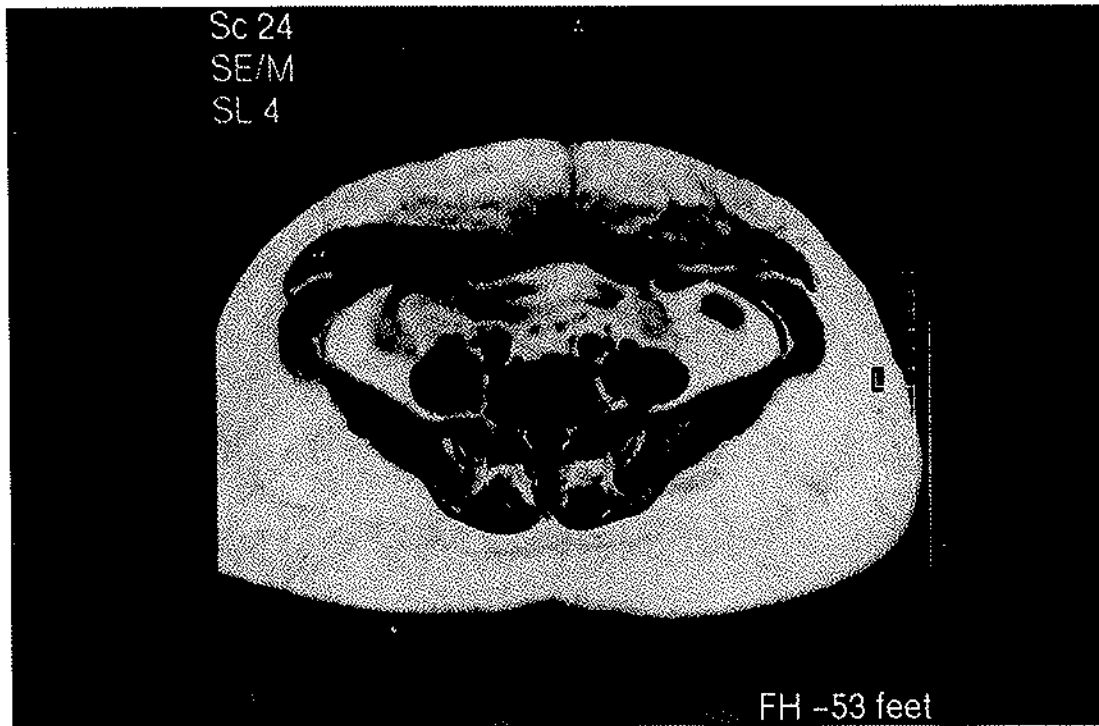
**Figure 4.** Magnetic resonance imaging (MRI) T2 sequence. Fat is dark and tumescent solution is bright.



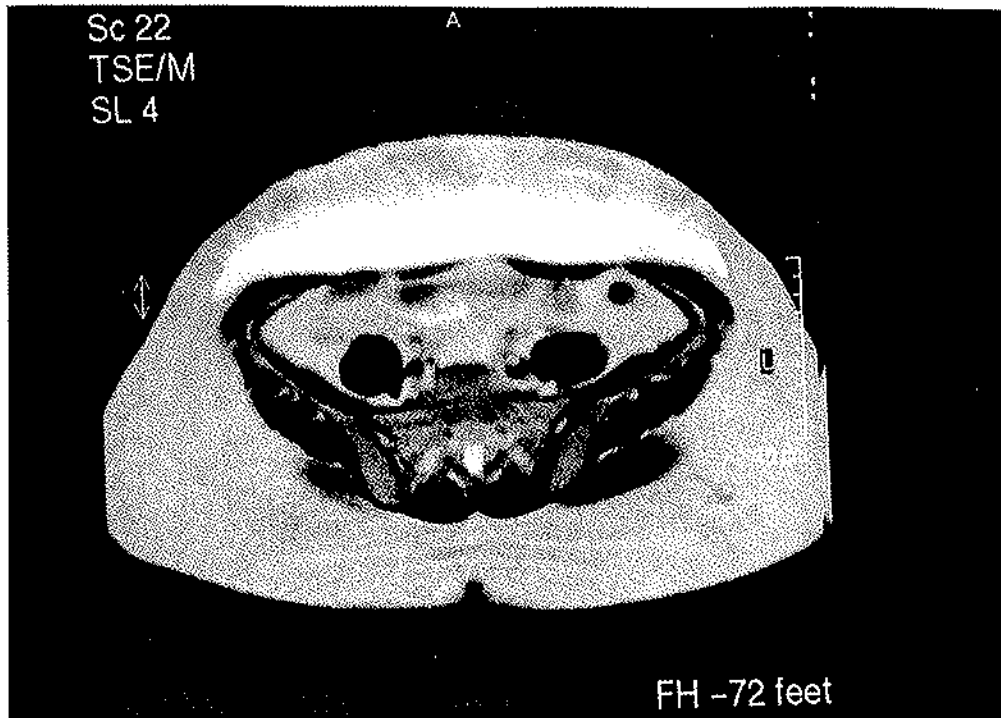
**Figure 5.** Magnetic resonance imaging (MRI) T1 sequence. After 4 minutes laser exposure, there is partial coalescence of adipose tissue.



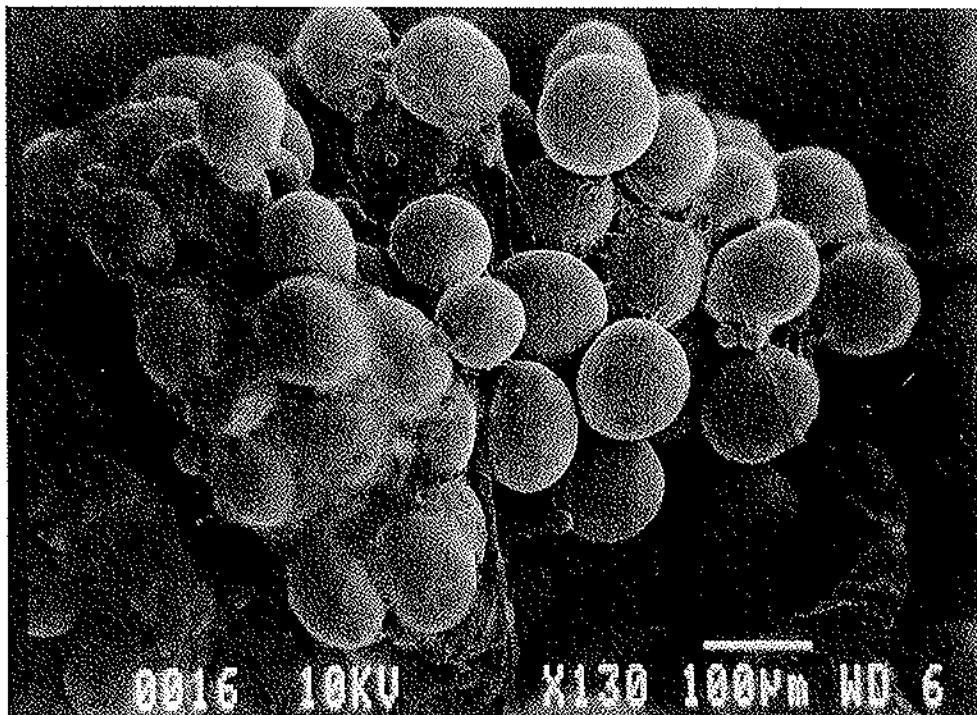
**Figure 6.** Magnetic resonance imaging (MRI) T2 sequence. After 4 minutes laser exposure, there is partial coalescence of adipose tissue.



**Figure 7.** Magnetic resonance imaging (MRI) T1 sequence. After 6 minutes laser exposure, there is homogeneity of fat tissue.



**Figure 8.** *Magnetic resonance imaging (MRI) T2 sequence. After 6 minutes laser exposure, there is homogeneity of fat tissue.*



**Figure 9.** *No minutes of laser exposure.*

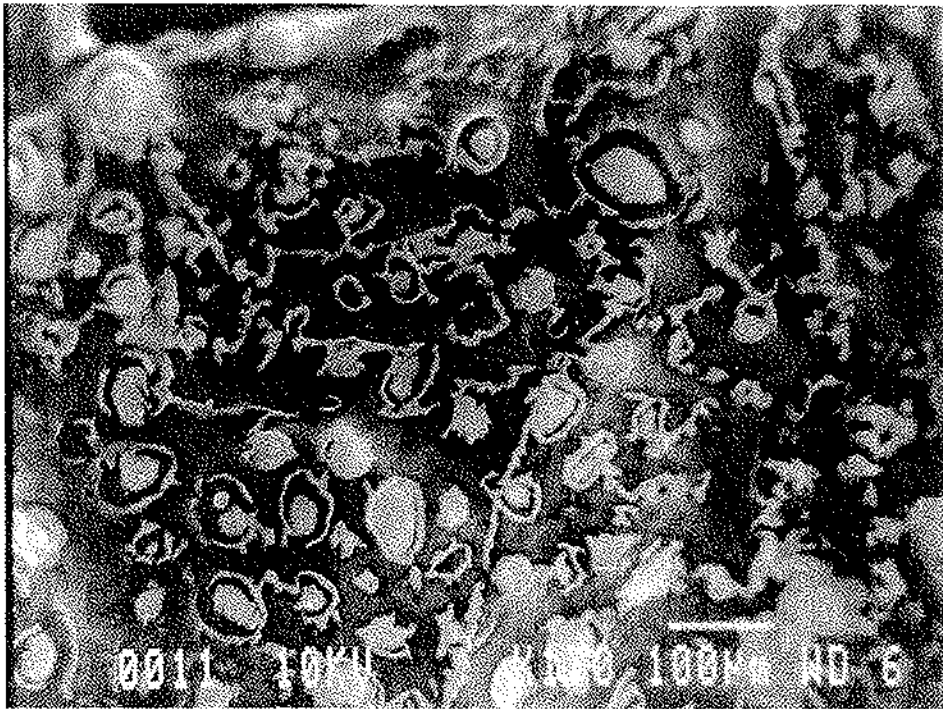


Figure 10. *Four minutes of laser exposure.*

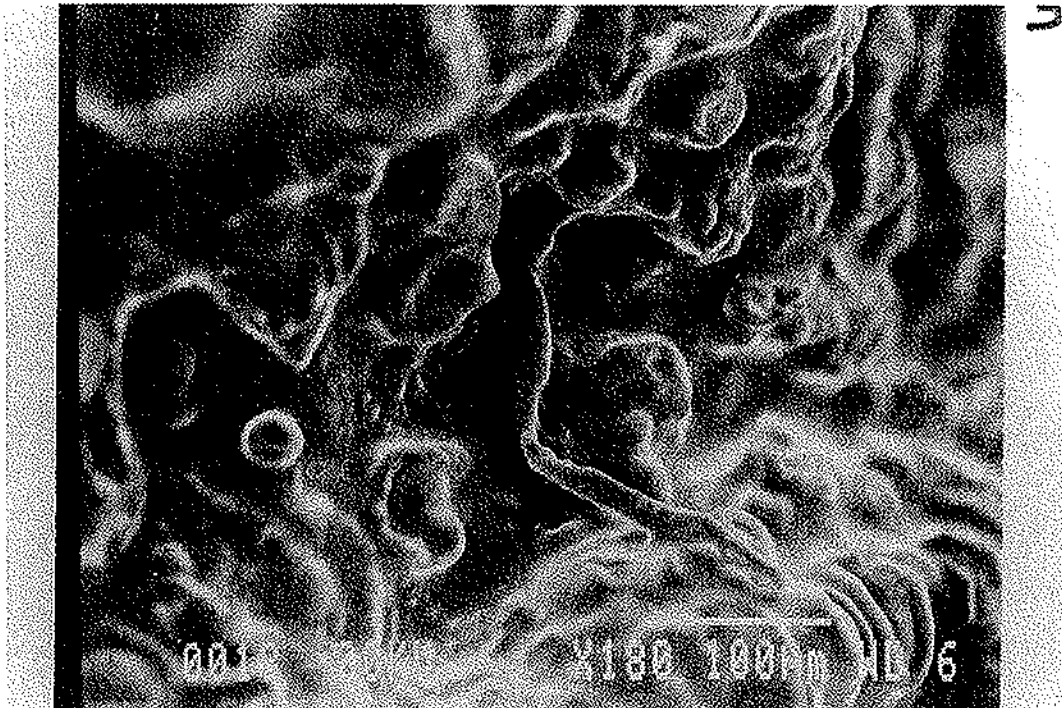


Figure 11. *Six minutes of laser exposure.*

blurring and more coalescence of the fat tissue throughout exposure of the applied laser beam.

The SEM samples also show a correlation with the findings on MRI, consisting of observing the fat in the interstitial space during exposure time with the laser beam for 4 and 6 minutes.

The low-level laser is an effective technique that liquifies fat by causing it to escape from inside the cell to the outside (interstitial space).

### Conclusion

In this study, we observed the behavior of the adipose tissue on MRI images after applying tumescent solution and exposure to the laser beam for 4 and 6 minutes. The findings are correlated with those seen in SEM studies.

The SEM samples demonstrate that 80% of the fat is in the interstitial space after 4 minutes of laser exposure. Likewise, the SEM samples demonstrate that almost 100% of the fat is in the interstitial space after 6 minutes of laser exposure. These MRI studies show that the septal framework on the superficial and deep adipose tissue is visibly different.

The fat lobules of the superficial fat are small and tightly packed within closely spaced septa. The fat lobules on the deep fascia are large, irregular, and less organized before you apply laser to the fat tissue.

The septae of the superficial layer appear less organized and not perpendicular after you apply the laser for 4 and 6 minutes, respectively. At 6 minutes, there is more coalescence of the adipose tissue, and the signal has completely changed, when you compare it with the initial images.

These findings correlate adequately with those seen in the SEM studies and are explained by the fact that the fat, after applying the laser for 6 minutes, is now outside the adipose cell in the interstitial space. Because the fat is now not contained inside the adipose

cell, it changes the signal and appreciation on the MRI studies. The septal framework is also affected by the laser application, because it loses the perpendicular organization seen anatomically before laser application. The laser produces destruction of the fibroblasts, and therefore the organization changes. There is a significantly disorganized framework after 6 minutes that seems to go in different directions. This topic will be an issue in articles that will be published in the future, and our thesis will be proven with the adipocyte cultures being investigated at the present moment.

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