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INVITED REVIEW

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A novel 1470 nm radial fiber diode for fat harvesting and liposuction

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Abstract

Autologous fat grafting continues to be a challenge in maintaining viability and survival of grafted fat. Laser-assisted fat harvesting is a novel concept in liposuction. An all-in-one platform that optimizes wavelength, fiber design, cannula design, and current concepts in fat collection and preparation is available that may increase viability of harvested adipocytes and simplify the process. Here, the physics and principals of fat collection are reviewed and discussed in context of this device platform.

KEYWORDS

1470 nm, fat grafting, fat harvest, laser-assisted liposuction, viability

1 | BACKGROUND

Fat grafting (or transfer) was first applied by a German surgeon Gustav Neuber, who in 1893 used adipose tissue excised en bloc to correct a deformity. At the turn of the 20th Century Eugene Hollander, also a German surgeon, injected fat using a syringe and was the first to describe poor survival of grafted adipose tissue.[1] Fat grafting became more prevalent on both sides of the Atlantic throughout the first half of the 20th century. As the technique evolved it found use in multiple areas, including correction of saddle nose deformity, disfigurement in World War One veterans, breast asymmetry, and treating hand stiffness.[2]

The limitations of fat grafting are well recognized. As much as 50% of transplanted fat is resorbed and replaced with fibrosis. The procedure fell out of favor with most clinicians until a resurgence in the 1990s when Coleman[3] standardized post collection fat preparation. Chajchir then improved viability using gentle handling techniques and optimization of the Coleman protocol.[4] This involved centrifugation of collected fat at 3000 rpm which separated it into three layers: oil (lysed cells), fat (intact adipocytes), and serosanguinous fluid. The middle portion was isolated and used for transfer. Injection techniques involved building up layers of fat as small aliquots. A substantial improvement in fat survival was observed.[4]

Since that time several variables were described that improve adipocyte viability. These include cannula size, the addition of adjuncts (stem cells, platelet-rich plasma, etc.), lower centrifugation speeds, and rolling in gauze or sedimentation. Other factors also decrease adipocyte function such as lidocaine in tumescent solution, though washing collected cells reverses this effect.[5] Epinephrine appears to play no significant role.[6] Adipose-derived stromal cells (vascular and fibrous components) and adipose stem cells may enhance graft survival.[7]

Tumescent fluid and serosanguinous fluid both have detrimental effects on viability. Adipocyte survival decreases the longer fat is exposed to these fluids. Rinsing may be added to the centrifuge step. However, Gupta et al.[8] reviewed 13 studies and found no demonstrable difference in processing strategies. However, all techniques that involved manipulation of fat did decrease viability.[8]

Energy-based treatments such as laser liposuction or radiofrequency-based liposuction have long been thought to decrease fat cell viability through heat damage. More recently ultrasound-based liposuction has been thought to not damage cells. Water-assisted liposuction has also been thought to increase fat cell viability.[9,10]

Investigators continue to search for improved methods to harvest and graft fat. Fat grafting has many benefits over hyaluronic acid fillers. Autologous fat transfer offers a longer lasting result than traditional fillers, a significantly lower price point, and the ability to

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correct large areas of volume loss such as the breast or buttock where the cost of filler would be prohibitive. In addition, fat grafting may help psychosocial well-being as described in breast augmentation patients.[11] Generally, physicians and patients have been hesitant to embrace fat grafting because of these technical challenges and poor outcomes. To a provider considering adding fat grafting to their practice, these variables may be a daunting to synthesize and overcome. However, popular interest in fat grafting is on the resurgence and there is a need for a reliable and standardized approach.[12]

2 | DEVICE

Beautifill is a multicomponent liposuction and fat collection system by Alma Lasers. The platform offers all of the components needed for performing tumescence, liposuction, fat collection, and preparation for grafting.

The components of the platform are straightforward. A 15 W, 1470 nm diode laser sits atop a rolling platform. Within the platform there is a variable rate infusion pump and a vacuum port. As part of the vacuum system there are two in-line filtration cannisters that separate fat from tumescent and serosanguionous fluid. As of this writing the platform comes with infiltration cannulas, aspiration cannulas, a dual-port handle allowing connection with fiber and suction tubing, and a variety of injection cannulas. As such Beautifill represents a turnkey option for interested providers (Figure 1).

Using a laser to collect fat rather than for lipolysis is a novel concept. In choosing a wavelength the intention was to avoid destruction of fat cells as has been described with laser-assisted lipolysis (LAL) using 980 nm, 1064 nm, and 1319 nm lasers.[13] In addition, the 1440 nm wavelength has proven very efficient at lipolysis and skin tightening postliposuction. About 1440 nm ND:Yag is effectively a similar wavelength to 1470 nm but the device using this wavelength has demonstrated significant lipolysis rather than viable adipocytes. Because the 1440–1450 nm range is well absorbed by water and fat, lipolysis is variably effective depending on the constituent water versus fat content of selected body sites. Because of this, the 1470 nm wavelength is in and of itself insufficient to explain why Beautifill collects viable rather than destroyed adipocytes.

The 1470 nm wavelength is preferentially absorbed by water rather than fat (Figure 2). This discrepancy is taken advantage of with the Alma device by decreasing the effective wattage at the point of tissue interaction so that septa rupture rather than adipocytes. A conical tip diffuses laser energy, the device is used at 10–15 W, and the tip is adequately separated from adipocytes because it resides within the cannula. At the correct wattage and distance from the fiber tip, fibrous septa preferentially rupture before fat lipolyzes. The 1470 nm infrared light has a limited depth of 1 cm (vs. 5 cm for 980 nm) improving the control of energy around a cannula tip.[14]

The fiber tipped used in Beautifill is radial rather than a bare fiber (Figure 3). Power density (joules delivered to a surface area per second or W/cm^2) is decreased from a radial fiber versus that from a bare fiber. Bare fibers have a high power density concentrated at the tip, and are primarily use for vaporization in lipolysis and other surgical procedures (hysteroscopy, laparoscopy, and urology). In contrast, a 360° radial fiber has mainly found

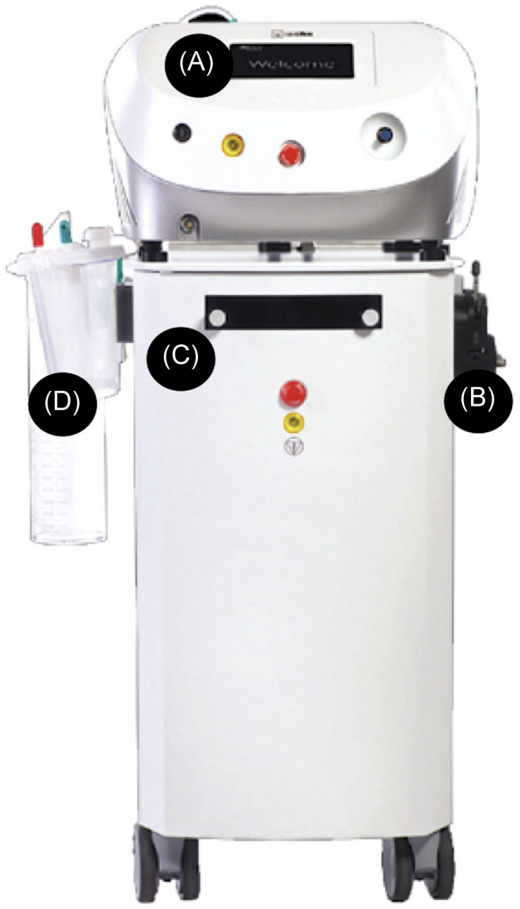

FIGURE 1 Beautifill platform consisting of a 1470 nm diode (A) on platform consisting of an infusion pump (B) and vacuum (C), and a two-step filtration system (D)

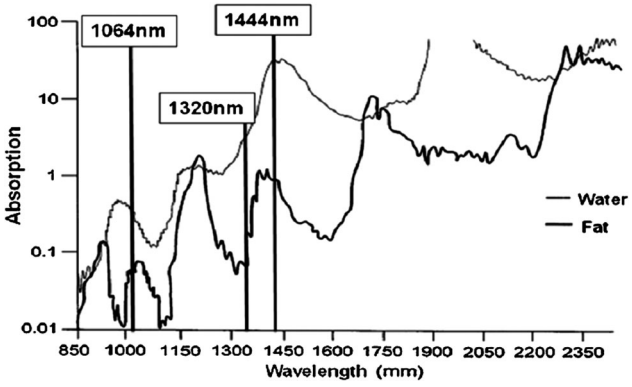

FIGURE 2 Absorption spectrum of water versus fat and several wavelengths. Table from Khoury et al.[15]

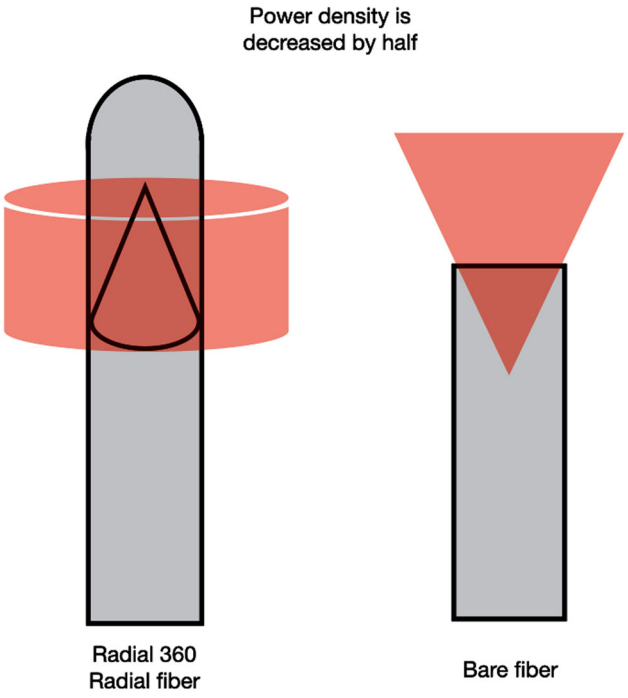

FIGURE 3 Power density (W/cm^2) from a radial fiber is that of a bare fiber. Lateral surface of a cylinder ($2\pi rh$) versus the circular end of a round fiber (πr^2)

application in endovenous laser ablation because the area energy distribution is greater. The difference in power density can be as much as 100–300 fold depending on the angle of the prism in the tip. Assuming an angle of 45°, a radial fiber has a power density half that of a bare fiber. Beautifill takes advantage of this same radial tip to decrease energy distribution, allowing fibrous components to be lyzed rather than adipocytes. Because the radial fiber and bare fiber remain in contact with tissue approximately the same amount of time (as the clinician moves the fiber through the tissue), the total energy density (J/cm^2) is similarly decreased.

The 1470 nm laser is introduced into a 3–4 mm Mercedes cannula. This is a logical design allowing uninterrupted radial distribution but also keeping the tip away from direct tissue contact. The diameter of the cannula is also important. The change of pressure through which an adipocyte must traverse is based on Poiseuille's law. The pressure change is inversely proportional to the radius of the cannula (r^4) and proportional to its length. The 2009 ASPS Fat Grafting Task Force recommended use of 3 or 4 mm blunt cannulas because they decrease shear forces.[16] Beautifill cannulas are designed accordingly, ranging from 3 to 4 mm and 15 cm or 23 cm in length.

Suction is essential for rapid aspiration of large amounts of fat. Unfortunately, high negative pressures increase sheer forces as fat is collected and high pressures disrupt adipocyte cell membranes in an overwhelming majority of adipocytes sampled.[17] In one study of power-assisted liposuction (PAL) samples from three patients were collected at both 760 mmHg and 250 mmHg. Viability on Samples from 250 mmHg were 47% higher.[17] The device discussed here

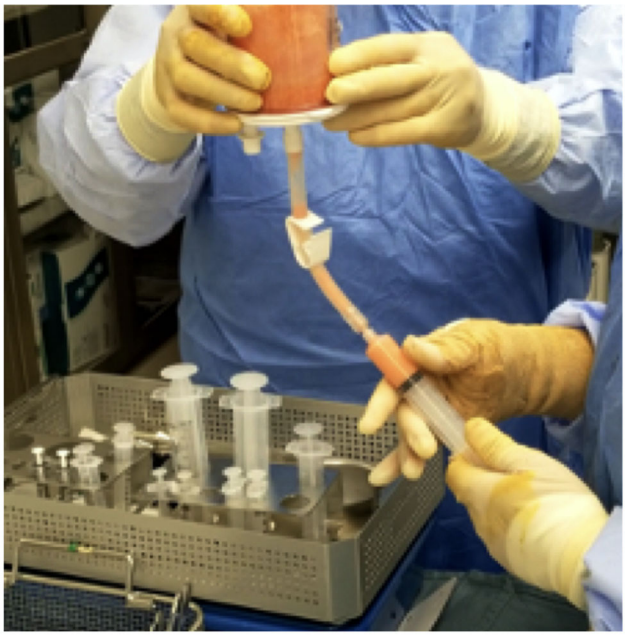

FIGURE 4 Harvested fat is filtered by the device and available for immediate injection

device uses pressures at 60–90 kPA (450–675 mmHg), allowing adjustment if the device is being used for collection of viable fat or just liposuction.

During aspiration, fat travels along a large bore tube and into a collection cannister. Collection cannisters range from 100 cc to 2000 cc. Within each collection cannister is a mesh trap. Fat is collected by the trap and tumescent fluids and blood filter through and are suctioned to another waste cannister in a two-stage system. This removes a predominance of the lidocaine and blood that may be toxic to adipocytes. After aspiration, the collection cannister is turned upside down and syringes can be filled directly, so that fat is not exposed to a nonsterile environment (Figure 4).

3 | HARVESTED FAT

In the past centrifugation was performed to separate oil and fluid from collected fat. In a study by Levenberg et al.[18] comparing 10 patients each underwent both laser-assisted harvesting (LAH) and suction-assisted liposuction (SAL) on opposite sides SAL demonstrated the typical three-phase sample consisting of an oil layer (22%), an adipose layer (60%), and a blood layer (18%).[8] LAH demonstrated a blood layer (1.1% and an adipose layer (98.9%). The diameter of lipid droplets between the two techniques was also quite different (20–100 μm SAL; 10–30μm LAH). There was no appreciable difference in the number of viable stem cells harvested.

Viability of adipocytes as determined using trypan blue hemocytometer counts ranged from an average in SAL of 79.7% (50%–96%) to 95.7% (90%–99%) for Beautifill.[18]

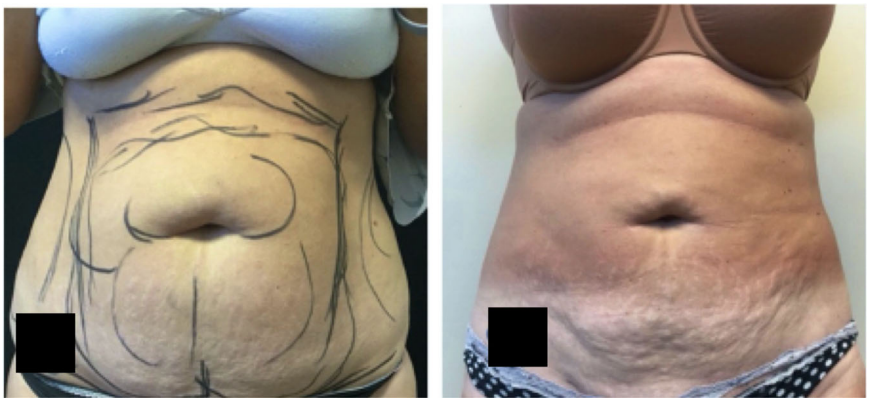

FIGURE 5 Abdominal liposuction using 1470 nm diode before (left) and 2 weeks after treatment (right). Total tumescence 3000 cc (500 mg lidocaine and 0.5 mg epinephrine per liter). 1470 nm laser 12 W continuous pulse using 4 mm bore cannula and 12 mmHg suction

4 | APPLICATIONS

Liposuction and fat grafting of various areas has been well described using many methods. In our office, the 1470 nm platform is the preferred method for both low to medium volume liposuction cases and fat grafting areas up to a total volume of 600 cc (Figures 5 and 6). We do not change any other variables in our tumescent procedure from those traditionally used for tumescent LAL or SAL. Anecdotally the collection of fat requires less manual effort and occurs faster. In our hands this means the time fat sits until it is reinjected is minimized. Preparation for reinjection is also rapid and prepared fat can be injected through a 19–20 gauge cannula with only occasional clearing of the cannula. With the application of a topical lidocaine compound, patients tolerate reinjection with minimal discomfort. Care must be given to be sure the patient does not have too much lidocaine. If they are near their maximum tumescent dose this step should be skipped.

FIGURE 6 Fat transfer using high viability fat. Only the patient's right temple, cheek and nasolabial fold have been treated. Left side and lips not treated. 20 cc injected in half the face. Photograph taken immediately before treatment of left face

The 1470 diode can also be used to apply additional heat to the reticular dermis without the risk of burn or penetration seen with bare fibers. We heat the subcutaneous tissue postliposuction until the surface temperature is 42° using an external infrared measuring device. There is some evidence this is effective. Trelles et al treated 45 patients for arm contouring using the 1470 nm diode with settings at 15 W, 600 μm radial fiber and the Mercedes cannula. Arm circumference reduced 4.9 ± 0.4 cm in the right arm and 4.7 = − 0.5 cm in the left arm. In addition, skin tightening was measured using a caliper and decreased 0.7 cm in both arms in the group with the least laxity and 2.9 ± 0.2 cm in the group with Teimourian grade IIb.[19]

The same group investigated the treatment of Rohrich Type I–IV aging necks using the device. LAL was considered sufficient in Groups I–III in separate papers. It was effective but insufficient in Type IV patients. In this group, 10 patients were treated and showed an improvement in cervicomental angle from 191.5 to 164.9 at 6 months 2 of the 10 patients went on to undergo platysma advancement and plication.[20]

5 | CONCLUSION

The Beautifill platform is an interesting option for providers who want a turn-key approach when adding liposuction to their practice and for experienced providers looking to improve adipocyte viability at harvest. We have found this improves patient satisfaction with results at 3-month follow-up. All features of the platform are optimized for maximum viability, from the wavelength and wattage, cannula and fiber design, and the vacuum and collection system. Studies are needed to determine the survivability and resorption of fat collected with this system.

The typical complications of Beautifill could be expected to be the same as any other fat grafting procedure. This includes granuloma formation, necrosis, infection, and failure of the graft to thrive. However, the excellent viability of the harvested fat should increase the percent of graft surviving. Studies are needed to determine the actual benefit.

CONFLICT OF INTERESTS

Dr. Robb is on the speaking panel for Alma.

PHOTO CONSENT

All subjects have agreed to full publication of their photographs.

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