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Aesthetics

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Case Study: Treating Cellulite with Microwave Technology

Dr Paolo Bonan shares a case study of cellulite treatment and explains how microwave technology works to achieve successful results

When we think of microwaves, the first thought which will come to mind is of microwave ovens. These emit microwaves via a free emission antenna, and the generated electromagnetic field is of 'radiative type' (free air emission), where the light is free to bounce back and forth over the metallic walls. If the microwaves encounter any water molecules on their journey, such as those found in food, then the molecules will attempt to align with the electromagnetic field. It is this molecular motion which creates heat, and the resultant warming of our dinner.[1]

Less commonly known is that microwave technology is also employed in many branches of medicine, including oncology, urology and dermatology.[2] Within the field of aesthetics, perhaps the most well-known application for microwaves is in the treatment of axillary hyperhidrosis.[3] Microwaves have been shown to be effective for the selective heating of the interface between the skin and underlying fat in the underarm area, resulting in damage of the sweat glands, and a reduction in excess sweating.[4,5] The ability of microwaves to penetrate to deeper layers of the subcutaneous tissue[6] has naturally led to research being conducted to the application of the technology for body contouring and the targeting of unwanted fat, cellulite and skin laxity. Its use for these applications, more specifically cellulite, will be discussed in this paper.

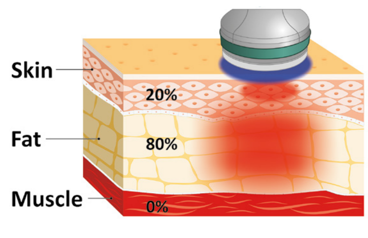

Figure 1: The distribution of microwave energy through the tissue[13]

How microwave technology targets cellulite

The hypodermis consists of small 'recesses' or 'lobules' which are separated by bands of fibrous tissue called septa. In men, these bands tend to run in-line with the skin, but in women, these bands are perpendicular to the skin. Cellulite results from both a build-up of fat in the adipose tissue (the hypodermic fat cells) and water retention around them in the dermis and hypodermis. If adipocytes increase their volume, as happens with weight gain, and if water accumulates in these recesses, then the walls are compressed, damaging the microcirculation and the natural form of the cell. Because these walls are attached to the dermis in the anchor points they pull at the skin's surface, whilst fat cells push towards the dermis. In other words, when the adipocytes get bigger or the oedema increases, the 'envelopes' containing them change shape and pull on their anchor points on the skin. The result is a skin surface that takes on a bumpy 'orange-peel' appearance. Over time, as the condition worsens, fat and water become wholly enclosed in a prison of always hardened septa, which is composed of fibrous connective tissue.[7,8]

Studies have shown that compared to radiofrequency, which ranges from a frequency of 30kHz to 1GHz, microwaves at a frequency of 2.45GHz result in more absorption in the fat than they do in the uppermost layers of skin.[9,10] The skin allows the passage of energy with high frequencies (from MHz to GHz), but it does not allow it when the frequency of the same energy gets lower (from KHz to MHz). This is due to the different dielectric properties of fat and skin; in the microwave range, skin shows low permittivity (meaning that it absorbs little energy) and high conductivity (so microwaves can easily pass through the skin), whereas fat has lower conductivity, meaning that the energy will stop in the fatty layers, and higher permittivity, so it can store a large amount of energy. The result of this is that energy can be effectively deposited within the fat cells, as opposed to the cutaneous tissue, without causing excessive heating in the dermis.[11]

This allows for the microwaves to provoke oscillation and vibration effects in the fat molecules, creating heating within the fatty tissue (**Figure 1**). This heat creates an imbalance inside the adipocyte, leading to the fat content changing its chemical structure, and causing the cell to increase its metabolism and to expel small droplets of fat. This process is known as 'blebbing', and can be seen in **Figure 2**.[11]

To deliver this microwave energy to tissue safely, the emission of the radiation must be highly controlled. Unlike the 'free-air' emission of a microwave oven, these microwaves are delivered via a handpiece with a central emitting electrode and are then 'recalled back' by the peripheral circular return electrode. In this way, the penetration depth of the microwaves can be closely defined to avoid heating in the muscle.[12]

As a result, 80% of the emitted energy can be delivered to the fat, whilst 20% is retained within the skin. The integrated cooling tip of the handpiece counteracts some of this superficial heating, so that only approximately 6% of the energy is retained within the skin.[12]

At this point, the adipocyte cell membrane is still intact, but as the cellular stress increases, the blebbing increases to such a degree that the cell membrane will rupture. This is clearly demonstrated in **Figure 3**, which shows the broken cell membranes following treatment with a microwave device.[11]

The fat that has been excreted from the adipocytes, alongside the broken fat cells, are then eliminated through the lymphatic system in a process known as macrophage lipolysis. The trafficking of fatty acids into and out of adipocytes is a physiological mechanism regulated by a complex series of proteins and enzymes and is under control by a variety of hormonal and metabolic factors.[14]

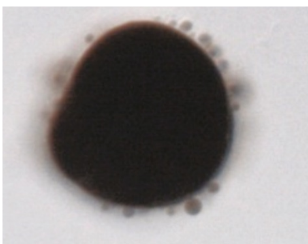
Figure 2: Optical microscopy showing a stressed fat cell, six hours after microwave exposure from the Onda microwave device, demonstrating evident blebbing all around the perimeter[11]

In a 2019 study with 19 healthy patients, Bonan *et al.* showed that microwaves could act directly on the adipocyte tissue, sparing the dermoepidermal layers,

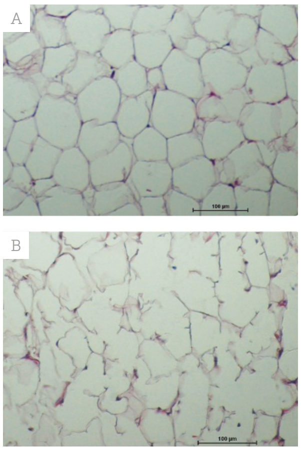

Figure 3: Histological images of tissue with human abdominal fat (magnification x 20). (A): Control. (B) Sample of patient immediately after treatment. Image (B) clearly shows adipocytes with broken membrane and initial hyperaemia with dilation of the blood vessels. Image courtesy of Prof. R. Perrotta, M.D. and M.s. Tarico, M.D., Catania – Italy.[11]

promoting heating of the adipocyte cell, and consequently leading to macrophage-mediated adipocytes lysis.[15]

Specifically related to cellulite, the energy of the technology is absorbed by the fibrous connective branches, which causes the solubilisation of the collagen with consequent debridement of the tight non-elastic weft that strangles the lobules. The solubilisation of collagen, in addition to producing the loss of the pitted appearance of the skin, also makes it possible to reactivate the fibroblasts which are stimulated to produce new, more elastic collagen. The heat produced by the microwave technology causes an immediate collagen fibre, shrinking in the dermis with a consequent tightening. The final effect is the improvement of skin laxity and the visible result in the disappearance of the orange-peel cellulite effect.[11,13]

In my clinic, I use the Onda device with Coolwaves microwave technology, which at the time of publication is the first and only device available that uses this technology. It is very versatile, with a deep handpiece that holds a circumference of $35cm^2$ and the shallow handpiece which is $25cm^2$. The shallow handpiece was utilised in the treatment of the following case study to induce the shrinkage of fibrous connective branches causing the solubilisation of the collagen.

Patient concerns

A 45-year-old woman presented to clinic with unwanted cellulite on the super-lateral area of the thigh. I conducted a thorough lifestyle and medical check to discover any illnesses, risk factors and possible causes of concern which could be responsible for the onset of cellulite problems such as obesity, alcohol, smoking, hormonal imbalances or metabolic condition.[7] The patient was in good health with no medical history to note. She consumed alcohol in moderation, kept well hydrated and enjoyed exercise, but had difficulty targeting this area to reduce unwanted cellulite. There were no open wounds/lesions within the intended treatment area and no history connected to contraindications such as medication, allergies or possible pregnancy. A physical assessment followed to identify the areas to be treated and to evaluate the scale of the cellulite. The Nurnberger-Muller scale helpfully charts four distinct levels of cellulite affliction (**Figure 4**). This patient's cellulite was at grade 3 on the scale, with visible depressions on standing and lying down, without having to pinch the skin.[16]

We discussed the treatment options available to address her concerns, which included liposuction or various massage treatments. We outlined that the method we would utilise to treat her concerns would be microwave technology because excellent results can be seen within as little as one treatment, it is tolerated very well, it is very safe and I thought she would be an excellent candidate. It's important to understand a patient's goals and ensure that as a practitioner you set realistic expectations when discussing treatment approaches. The individual should understand how many treatments are needed, at what intervals, and what can be done to improve results. It's important to highlight that results can vary from patient to patient.

I explained to her that mild side effects could occur, including itching, numbness, warmth, tenderness, redness, swelling, burns, bruising and blisters on the treated area. These possible adverse reactions are usually transient and are resolved a few days after treatment. Possible adverse effects on the treated area include skin and fat tissue necrosis, skin contour irregularities and asymmetry. This may occur after improper use of the system, such as excessive energy levels or incorrect fat tissue evaluation.[17]

The heat produced by the microwave technology causes an immediate collagen fibre, shrinking in the dermis with a consequent tightening

Pre-treatment

Given the high degree of absorption of microwaves by water,[18] it is recommended to suspend the use of body creams in the area at least one week before the treatment. This is to avoid greater absorption of the microwaves in the superficial layers of the skin and, therefore increasing the penetration within the adipose tissue.[13] The patient should drink two litres of water a day to facilitate the drainage of interstitial fluids. It is recommended to start this the day before the treatment and continue after the treatment.[13] Standardised pre-and post-treatment photographic documentation of area treated should always be carried out at a variety of angles. This helps to monitor the effectiveness of the treatment.

Figure 4: The Nurnberger-Muller scale[16]

Dimpling while both standing and lying down

Dimpling is visible when standing, but not when lying down

Dimpling when pressure is applied

No dimpling when pressure is applied

Figure 5: Patient before and after three cellulite treatments using Onda Coolwave technology

parameters of 140W/90.000J per 15x15cm square (one placed on the trochanter and one on the inner thigh) per session. The whole treatment was over in around 25 minutes.

Once treatment was completed, the patient returned to their normal daily routine and activities without downtime. Good hydration and a healthy diet and exercise regimen where recommended to the patient. Typically, two to four treatments are advised at four-week intervals to maximise clinical outcome with full visible results expected by 12 weeks' post treatment.[17] Some patients achieve their desired outcome in a single treatment, however this patient required three (**Figure 5**).

Treatment process

Before starting the treatment, the area must be cleansed of any impurities that could interact with the microwaves or obstruct the handpieces. The patient was advised to have any dense hair in the area removed before treatment, to improve the coupling between the handpiece and the skin.[13]

Identification of the boundaries of the cellulite were made and the treatment area was divided into sub-areas of 15x15cm. With the patient lying on the bed face down, a thin film of paraffin oil (pharmaceutical grade) is spread over the entire treatment area for proper contact of the handpiece with the skin for better coupling and greater fluidity of the movements. During the treatment the patient could feel slight heating effects in the tissue, which they described as a hot deep tissue massage, without undue discomfort.

Treatment parameter data, such as the stage of cellulite, handpiece utilised, power, dose, cooling and number of sessions must always be recorded in the patient's notes. For this patient, we utilised treatment

A study showed that microwaves could act directly on the adipocyte tissue, sparing the dermoepidermal layers, promoting heating of the adipocyte cell, and consequently leading to macrophage-mediated adipocytes lysis

Following treatment

I advocate that patients undergo lymphatic drainage massages after each session, as well as at the end of the cycle of treatments, to further assist in the removal of waste and toxins from bodily tissues, which was carried out for this patient. The results show an excellent improvement in visible dimpling, and a reduction on the cellulite score from three to two. The patient was extremely satisfied with the outcomes.

Summary

Microwave technology makes it possible to treat all three common concerns of body shaping: cellulite, fat loss and skin laxity. This case study is an example of the possibilities for cellulite using this approach. It is a comfortable procedure, with few side effects, which is safe and comfortable for patients.

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Qual: MD

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