

Course Objectives:

- Describe the microanatomy of skin tissue and cellulite development.
- Compare and contrast gender differences in skin tissue and subcutaneous fat.
- Discuss the efficacy of various cellulite treatment therapy options.

Cellulite: A Review of Its Anatomy, Physiology and Treatment

There is more to cellulite than meets the eye.

By Len Kravitz, PhD, and Nicole J. Achenbach

Cellulite is a skin alteration often described as an "orange peel," "mattress" or "dimpling" appearance on the thighs, buttocks and sometimes lower abdomen and upper arms of otherwise healthy women.

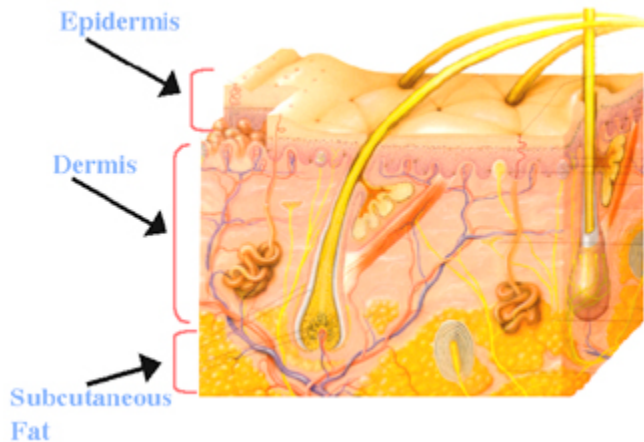
Approximately 85% of postpubertal women have a form of cellulite (Avram 2004; Rawlings 2006). The condition is rarely observed in males. Men presenting with cellulite are commonly deficient in male hormones (Avram 2004). The name first appeared in French medical literature in the early 19th century (Scherwitz & Braun-Falco 1978). The original name cellulite implied that it was a disease; however, years of study have now disproved this theory. As a matter of fact, some of the scientific literature refers to this changed skin condition as "so-called cellulite, an invented disease" (Nurnberger & Muller 1978; Scherwitz & Braun-Falco 1978). What follows is a comprehensive review of cellulite research, along with answers to several pressing questions and a discussion of purported treatments.

What Is Cellulite?

To better understand cellulite, a review of skin microanatomy is needed (see Figure 1). The outermost layer of skin is referred to as the **epidermis**. Immediately under this is the **dermis** (also called the corium), which is richly filled with hair follicles, sweat glands, blood vessels, nerve receptors and connective tissue. The next layer of tissue is the first of two layers of **subcutaneous** (beneath the skin) fat (Rawlings 2006). The prevailing evidence-based understanding is that cellulite originates in this first region of the subcutaneous fat (called the **areolar layer**, where fat cell chambers [or lobules] are arranged vertically in females) (Wanner & Avram 2008; Rawlings 2006; Avram 2004) (see Figure 2).

According to this scientific explanation, cellulite is caused by small protrusions of fat (called papillae adiposae) into the dermis. This structural alteration of subcutaneous fat protruding (or herniating) into the dermis gives skin the bumpy appearance referred to as cellulite (Sadick & Magro 2007). This theory has been confirmed using magnetic resonance imaging (Querleux et al. 2002), sonography (imaging with high-frequency sound waves) (Rosenbaum et al. 1998) and skin biopsy (Nurnberger & Muller 1978). A second, similar theory is that cellulite results from a laxity (or weakening) in the connective-tissue bands in the dermis, with the fat protrusions occurring as a consequence (Pierard, Nizet & Pierard-Franchimont 2000).

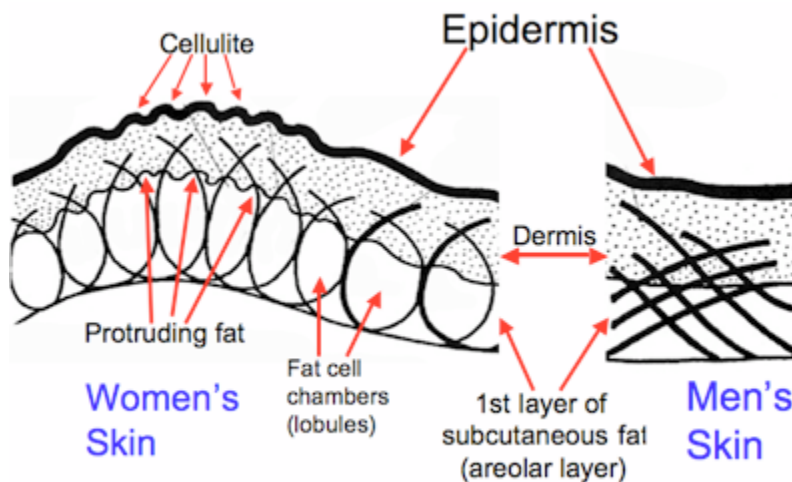
Figure 1. Skin Microanatomy



Cellulite and Males

Rosenbaum and colleagues (1998) and Nurnberger and Muller (1978) explain that men and women have a different connective-tissue organizational structure in the first layer of subcutaneous fat. With females, the adipose tissue is contained in chamberlike structures that favor the expansion of the adipose tissue into the dermis (see Figure 2). Conversely, men have a network of crisscrossing connective-tissue architecture, forming smaller polygonal units that allow for subcutaneous fat deposits to expand laterally and internally, but with little protrusion (if any) into the dermis. Men also have thicker layers of epidermis and dermis tissue in the thighs and buttocks than females (Wanner & Avram 2008; Nurnberger & Muller 1978).

Figure 2. Schematic Diagram of Structural Orientation of Female and Male Skin and Subcutaneous Fat



Source: Adapted from Nurnberger & Muller 1978 and Angehrn, Kuhn & Voss 2007.

Observe in the first layer of subcutaneous fat how the fat cell chamber structure in female skin allows fat to protrude more readily into the dermis compared with the crisscrossing connective-tissue

structure in men. Men also have a slightly thicker dermis and epidermis in the skin of the thighs and buttocks.

Gender Differences in Subcutaneous Fat Cell Organization

According to Nurnberger and Muller (1978), who examined male and female fetuses, there is no recognizable difference in subcutaneous tissue for up to 7 or 8 months of fetal development. During the end of the third trimester of fetal development, the gender structure differences become apparent and manifest themselves at birth. Variations in hormones between genders largely explain this skin structure deviation. It has been shown that men who are born deficient in male hormones will often have a subcutaneous fat cell appearance similar to females (Wanner & Avram 2008).

Connective Tissue in the Dermis

The connective tissue in the dermis provides the framework, insulation and stability for the dermis layer below the epidermis. The tissue offers necessary insulation and stability between the various organelles, permitting their proficient function without inhibiting adjacent structures. Connective tissue is composed primarily of collagen (an inelastic tissue with great tensile strength), ground substance (mainly water; its major role is to provide a route for diffusion transport between tissues) and elastic tissue (which gives the skin its ability to extend and return to normal resting length).

Proposed Treatments for Cellulite

Nature's Way. Improving diet and exercise is an excellent way to start improving cellulite appearance (Avram 2004). It has been shown that visible cellulite is reduced in females who lose weight (Sadick & Magro 2007). A calorie-restricted diet plan combined with a comprehensive exercise program (cardiovascular exercise and resistance training) should be implemented to reduce some of the underlying body fat. Histological research (examining the microscopic structure of tissue) shows that the fat cells do retract slightly from the dermis with weight loss (Rawlings 2006).

That said, what follows is a review of surgical options, injectable interventions, noninvasive devices, thermal treatments, topical ointments, herbals, lasers and shock wave treatments that have all been used in the treatment of cellulite. It is important to note that many of the cellulite treatment studies have used relatively small sample sizes and have generally not followed up with their participants for extended periods of time. Also, some of the methods used to analyze patient results have often been based more on human observation rather than scientific assessment. Last, it is difficult to rule out external factors, such as changes in diet and exercise, when interpreting the results of some studies.

Liposuction. Liposuction is a controversial intervention for the treatment of cellulite. Although there are some subjective reports that it has improved appearance, others have noted that it actually worsens the dimpled-skin look (Van Vliet et al. 2005; Avram 2004). Thus, Van Vliet and Avram do not recommend liposuction as a cellulite treatment.

Subcision. Subcision involves inserting a needle into the dermis of the cellulite site (after injection of a local anesthetic). The needle serves to alter the connective-tissue structure to purportedly improve the cellulite appearance. Adverse side effects include pain, bruising for 3-6 months and skin pigmentation alterations for 2-10 months (Van Vliet et al. 2005). No objective scientific assessment

data are available for this technique (Van Vliet et al. 2005).

Injectables. Phosphatidylcholine, which is a major component of biological membranes, is one injectable intervention that has been proposed for cellulite. Advocates of injecting a biological agent into the subcutaneous tissue argue that it promotes local lipolysis (i.e., fat cell shrinkage from the breakdown of fat) and reduces the appearance of cellulite. Currently, no scientific evidence is available to prove the effectiveness of these injections in treating cellulite (Van Vliet et al. 2005).

Mesotherapy was originally developed in Europe to offer pain relief for certain skin inflammatory conditions (Rotunda & Kolodney 2006). The technique involves a series of microinjections into the tissue layer just beneath the skin. Now, mesotherapy is also being employed as a cosmetic treatment for fat and cellulite reduction using medications and homeopathic substances (such as vitamins, minerals, amino acids and enzymes) injected into a cellulite site in the body. The ingredient most consistently used in mesotherapy is phosphatidylcholine (Alster & Tanzi 2005). Although there are findings to indicate that mesotherapy can induce lipolysis and slightly improve the appearance of cellulite (Caruso et al. 2008), Goldberg, Fazeli and Berlin (2008) note that owing to the lack of a precise treatment protocol and the risk of adverse effects (including swelling, infection and irregular contours), the use of this therapy is discouraged. Alster and Tanzi note that the Brazilian National Agency of Health banned mesotherapy in 2003 because of its undesirable effects.

Endermologie®. Endermologie is a suction massage technique developed in France in the 1980s. It is performed using an electrically powered device with two roller components. Recipients often wear nylon stockings to decrease the amount of friction as the skin is drawn into the machine (with a low-pressure vacuum) and kneaded by the two revolving rollers. Treatments last 10-45 minutes and consist of rolling the skin of the hips, thighs, legs, buttocks and stomach. Claims are that Endermologie improves fat tissue architecture, lymphatic drainage and capillary circulation. Research on the mechanobiology (the science that integrates mechanics, molecular biology and genetics) of the skin shows that deep mechanical massage will induce changes in the dermis connective tissue (Silver, Siperko & Seehra 2003). However, in a review of the published research on Endermologie--which is minimal--this device does not show meaningful efficacy in the treatment of cellulite (Avram 2004; Van Vliet et al. 2005).

Massage. Massage and tissue manipulation techniques are employed to enhance the removal of accumulated fluid in the dermis area. These techniques do not remove the cellulite but may have a temporary effect in reducing the dimpling appearance. Similar to Endermologie, deep massage may induce alterations in dermis connective tissue (Silver, Siperko & Seehra 2003). However, massage appears to offer only short-term minor skin changes, probably more related to the removal of excess fluid (Rawlings 2006).

Thermotherapy. Thermotherapy is a heat application technique that promotes blood flow and vasodilation. Van Vliet and colleagues (2005) note that no studies demonstrate any effectiveness with this treatment and that it may even aggravate the appearance of cellulite.

Topical Ointments. The role of topical treatments in cellulite removal is divisive. An initial challenge for any topical cream is that it must be able to penetrate the skin and dermis to reach the targeted fat tissue before being absorbed by the tissue. Although numerous topically applied ointments are

advertised as cellulite-diminishing creams, there are minimal data substantiating any of these claims. The majority of the creams function to promote fat lipolysis. Methylxanthines (e.g., caffeine, aminophylline and theophylline) are agents that stimulate lipolysis. In the review by Wanner and Avram (2008), the authors note that the research on methylxanthines shows a modest decrease in thigh circumference and/or subcutaneous fat thickness, but no reduction in cellulite.

Some topical cellulite creams use retinoids. Retinoids are similar in chemical structure to vitamin A, a well-known anti-aging ingredient in many facial creams. Retinoids, like vitamin A, have been found to increase the denseness of the epidermis of facial skin when applied for years. The hypothesis is that treating cellulite sites with retinoids will promote dermis thickness. Some research suggests modest improvements in cellulite appearance with retinoid creams over a treatment period of 6 months (Kligman, Pagnoni & Stoudemayer 1999). However, other randomized, placebo-controlled research on retinol treatment for cellulite shows little or no change in the cellulite appearance (Pierard-Franchimont et al. 2000). Alster and Tanzi (2005) observe that the downside of topical treatments is their inability to appreciably penetrate skin in order to render more than a superficial effect on tissue. On the other hand, new studies show that iontophoresis may enhance the transport of some of these creams across the skin (Akomeah, Martin & Brown 2009), thereby increasing their efficacy. Iontophoresis is a skin permeation enhancement strategy that delivers a charged substance across the epidermis using an electrical current (which helps drive other molecules across the membrane). Akomeah and colleagues suggest that this "electroperturbation" of the epidermis may potentially improve delivery of topical cellulite creams.

Herbals. The basis of most of the herbal treatments is to enhance microcirculation in the dermis area and to promote lipolysis of subcutaneous fat (Rawlings 2006). It is interesting to note that research has shown a slight decrease in thigh girth with herbal treatments but a return to normal when the application ceases (Rawlings 2006).

Lasers. Within the past few years, researchers have begun testing lasers, also referred to as radiofrequency energy, as a treatment for cellulite. Radiofrequency current is defined as a high-frequency electric current in the 0.3-100 MHz range (del Pino et al. 2006). It produces a thermal effect (light heat) on living tissue and is currently used in surgery for various dermatological applications. As a cellulite intervention, the application of a radiofrequency current is being tested to observe whether it can cause weakening dermis connective tissue in the hips, thighs and buttocks to "tighten up." The heating process from the current leads the collagen proteins in connective tissue to denaturalize (undergo changes in their protein structure) and then "tighten" as they regain their structural integrity, similar to the way a wound heals. It is also theorized that laser treatment increases local blood flow and fat metabolism at the cellulite site (Sadick & Mulholland 2004).

In the del Pino et al. study, 26 healthy female patients (aged 18-50) with cellulite received two treatment sessions (15 days apart) of unipolar radiofrequency. An appropriate energy level was set, and the treatment was delivered in three passes of 30 seconds each. Researchers evaluated the thickness of the subcutaneous tissue in subjects' buttocks and thighs before the first and second treatment, then 15 days after the second treatment, using a real-time scanning image ultrasound. The treatment resulted in visually (and with ultrasound imagery) observable decreases in cellulite appearance, with improvements still visible 6 months following the treatment. Goldberg, Fazeli and Berlin (2008) also employed radiofrequency treatments (six treatments every other week) and noted

that immediately following treatment and 6 months afterward, there were noticeable decreases in cellulite appearance. Side effects of this radiofrequency treatment are minimal (little blisters), but the long-term effects are unknown at this time. Other researchers have reported similar improvements in cellulite appearance and minimal side effects with radiofrequency treatments (Fink et al. 2006; Nootheti et al. 2006; Sadick & Magro 2007). This pioneering technology looks promising for the treatment of cellulite.

Shock Wave Therapy. Shock wave therapy is an energy pressure pulse of large amplitude followed by some small wave components (Angehrn, Kuhn & Voss 2007). High-energy shock waves are used therapeutically for the treatment of kidney and urethral stones. The application of low-energy shock wave therapy on biological tissue is very recent. It is noninvasive, free of side effects and delivered in brief treatments. There is a loud sound with this treatment that may be irritating to some. Angehrn, Kuhn and Voss treated the thighs of 21 females (aged 20-60) with shock wave therapy twice a week for 6 weeks. Results (via visual analysis and ultrasound measurement) showed less appearance of cellulite in most subjects. The authors hypothesize that shock wave therapy promotes a "remodeling" of the collagen proteins in the connective tissue in the dermis. However, the authors add that more research is needed in this area to determine what regimes and equipment parameters work most effectively for cellulite reduction.

The Ingredients in Cellulite Creams

Sainio, Rantanen and Kanerva (2000) examined the ingredients in 32 cellulite cream products. In total, 263 different substances were found, with most cellulite creams having an average of 22 ingredients. Botanicals (substances from a fruit) and emollients (moisturizing creams) are the chief ingredients in all products. The most common active agent is caffeine, as it is a stimulatory agent for lipolysis. All cellulite creams also contain some type of fragrance. The authors note that one-fourth of the substances in cellulite creams have been shown to trigger allergies. Therefore, the risk of unpleasant effects should always be known.

Presently, there are numerous medications, devices and diverse therapies that allegedly treat cellulite. As noted here, much of the evidence supporting these interventions is sketchy or nonexistent. Being well-informed on this topic will help exercise professionals thoughtfully educate clients on the truth about cellulite.*

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10 Primary Questions and Answers About Cellulite

1. Why is it rare to see cellulite in prepuberty stages of growth?

Rossi and Vergnanini (2000) propose that hormones play a predisposing role in the pathophysiology of cellulite after puberty. They note that estrogen (female steroid sex hormones that are secreted by the ovary) may aggravate the physiological changes causing cellulite. Estrogen also stimulates lipoprotein lipase, the main enzyme responsible for splitting lipoproteins found in chylomicrons (particles that transport dietary lipids from the intestines to other locations in the body) and in very low density lipoproteins into fatty acids for storage in fat deposits in the body.

2. Do slender woman also have cellulite?

Yes. Rosenbaum and colleagues (1998) explain that cellulite is often present in slender women; however, the researchers add that weight gain exacerbates the condition.

3. Why does cellulite seem to get worse with age?

First, the dermis reaches its maximal thickness at the age of 30 (Nurnberger & Muller 1978). It steadily diminishes in thickness and structural integrity thereafter (Nurnberger & Muller 1978). Second, the connective tissue in the dermis starts to get looser as the collagen and elastic fibers age. This allows for more adipose cells to protrude into the dermis area, accentuating the cellulite appearance (Nurnberger & Muller 1978). In addition, an increased deposition of subcutaneous body fat, due to overeating and inactivity, may contribute.

4. Is cellulite present in women of all races?

Yes. Avram (2004) notes that cellulite is present in females of all races. However, he highlights that it is more prevalent in Caucasian females than in Asian females.

5. Why is cellulite more prevalent in the thighs and buttocks of females?

It is well established that women generally have a higher percentage of body fat than men. For instance, the average percent body fat values for adult men and women (aged 18-34) are 13% for men and 28% for women (Heyward 2006). The thighs and buttocks of women tend to store more of this body fat. This type of fat deposition is characteristically termed "gynoid" or "pear shaped."

Del Pino et al. (2006) also note that there are five times more adipocytes (fat cells) in the thighs, hips and buttocks of women than in other sites of the body.

6. Is there any truth to the proposition that damaged blood vessels cause cellulite?

There is no supporting evidence of this. In addition, no evidence exists that cellulite is a result of weakened capillaries or decreased circulation in the subcutaneous area.

7. Is cellulite related to any lymphatic disorder?

Some nonscientific sources have suggested that cellulite is a lymphatic disease, yet there is no scientific support for this contention. However, limitations to fluid movement and drainage (as seen with inflammatory skin conditions) may contribute to the appearance of cellulite.

8. When a person gains subcutaneous fat, is it in the areolar layer (see Figure 2)?

Beneath the areolar layer is a second layer of fat, called the lamella layer. The fat cells are arranged horizontally in this second region. When a person gains subcutaneous fat, this is typically the primary area that enlarges (Rawlings 2006).

9. Is cellulite hereditary?

Yes. Rossi and Vergnanini (2000) and del Pino et al. (2006) state that there is a clear genetic predisposition for cellulite to develop. This inherent tendency will affect the fat

distribution and deposition.

10. Will smoking worsen the appearance of cellulite?

Yes. Cigarette smoke has been shown to weaken the formation of collagen, the chief structural protein of connective tissue (Fink et al. 2006). Weakened connective tissue may allow for easier protrusion of fat into the dermis.

Five Realistic Cellulite Guidelines to Give Clients

1. Research distinctly shows that cellulite is a unique and distinctive layer of subcutaneous body fat that is common to females (Querleux et al. 2002).
2. Improving diet and exercise is an excellent way start improving cellulite appearance (Avram 2004). It has been shown that visible cellulite is reduced in females who lose weight (Sadick & Magro 2007). A calorie-restricted diet plan combined with a comprehensive exercise program (cardiovascular and resistance training) should be implemented to reduce some of the underlying body fat. Histological (microscopic structure of tissue) research shows that the fat cells do retract slightly from the dermis with weight loss (Rawlings 2006).
3. Subcutaneous fat is layered on top of muscle. Therefore, if the muscles in the hips, thighs and buttocks are weak and flaccid, this will contribute to the "uneven" view of the skin surface (Rossi & Vergnanini 2000). Therefore, minimizing the appearance of cellulite is definitely a meaningful benefit of resistance training.
4. Clients should not invest their hopes and money in liposuction, subcision, injectables, skin kneading and manipulation techniques, thermotherapy, topical ointments and herbals for cellulite management, as there is little evidence supporting their efficacy for minimizing cellulite.
5. The new frontier in the treatment of cellulite appears to be with laser therapy (Avram 2004) and potentially with low-energy shock wave therapy (Angehrn, Kuhn & Voss 2007). Laser therapy is noninvasive, has few side effects and shows great promise for appreciably reducing the appearance of cellulite.