

The use of a thermographic camera in aiding the diagnosis of cellulite appearance

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279

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Abstract

Aesthetic cellulite is a disorder characterized by the skin with an “orange peel” appearance and has negatively affected the self-esteem and social life of more than 80% of post-pubertal women. The content in question covers the scarcity of evaluative studies in the area of aesthetics and favors the standardization of a technique for evaluating this dysfunction. The present study aimed to verify the use of thermography as an auxiliary method in the diagnosis of possible circulatory alterations in the gluteal region, as in cases of cellulite appearance, and to investigate the possibility of preventing its worsening. This is an observational study, carried out with eighteen female volunteers aged between 18 and 35 years old, with striae alba in the gluteal region, without drug treatment with photosensitive substances, or using isotretinoin, or still applying any specific topical treatment on the buttocks. The participants were divided into 2 groups, which were group 1 (non-uniform thermographic images) and group 2 (uniform thermographic images). Assessments of the cellulite’s appearance were performed through conventional photographs, thermography, and by 3 specialists in the field of dermatofunctional physiotherapy. The results showed that the severity of cellulite cannot be classified only through a visual assessment or questionnaires, since the participants who do not have the physical characteristic of cellulite, demonstrated through the thermography, a circulatory compromise, which suggests a possible risk in developing cellulite. Therefore, this study concluded that a previous diagnosis through a thermographic camera can help in the prevention of this dysfunction.

Keywords: Cellulite. Evaluation. Aesthetics.

INTRODUCTION

Dermopaniculosis, known as aesthetic cellulite, is a disorder characterized by an “orange-peel” appearance and has affected more than 80% of post-pubertal women¹. This change can be generated due to an increase in the lipid content in the adipose cells in a localized way together with the accumulation of local interstitial fluid^{2,3,4}.

Aesthetic cellulite predominantly affects females and is present in all races, with the white

race being the most affected¹. Its pathophysiology is not fully understood; however, it is known that the structural increase in fat cells can stretch the collagen septa that support the skin, pulling them downwards, giving the skin the visible feature of punctual depressions^{5,6,7}.

The accumulation of interstitial fluid at the site can also generate this stretching of the septa by increasing local pressure, and this agglomeration of fluid in the long term can solidify

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through the polymerization of the fluid, thus leading to fibrosis^{6,7,8}. Among the most affected areas, the trochanteric region, the buttocks, and the back of the thighs are highlighted⁹. The impairment of the local circulation due to the pressure exerted on the vessels by the increase in fat cells can affect the blood and lymphatic network in the long term, causing a decrease in the passage of liquids to other regions or even favoring stasis and generating liquid retention^{10,11}.

Local liquid stagnation can create protective channels and favor the process of polymerization of the interstitial fluid, which can induce fibrosis of the septa supporting the skin, with a reduction in circulation of up to 35% in places affected by cellulite¹². Estrogen may play a key role in the physiology of this dysfunction. Moreover, studies report that the increase in the activity of collagen-producing cells and fibroblasts favors the increase in the synthesis of glycosaminoglycans and collagen; therefore, there is an increase in capillary pressure and liquid stasis⁷. According to Bauer¹⁰, the excessive deposition of fat through the stimulation of estrogen in the main areas of cellulite involvement could justify the influence of this hormone on the development of cellulite.

Although it is not considered a pathological condition¹³, the quality of life, especially in women in whom there is a predominance of up to 90% of cases, can be directly affected in terms of low self-esteem and social interaction¹⁴. This is due to the arrangement of the connective septa which are arranged perpendicular to the skin, protruding towards its surface, in which any increase in the level of triglycerides in the fat cells will have a tendency to pull the skin downwards through the distension of the collagen septa, generating skin depressions⁸. On the other hand, in males, the connective septa are obliquely arranged at 45° angles to the skin, which ends up making it difficult protruding towards the epidermis, and for this reason, it is

less incident^{4,5,8,9}.

Some main aspects that can influence the aggravation or the appearance of these alterations in the cutaneous relief in female individuals are physical inactivity, age, poor diet, and the use of contraceptive agents¹⁵.

Exams such as magnetic resonance imaging and diagnostic ultrasound have been used as non-invasive techniques to assess and diagnose cellulite appearance, especially digital thermography¹⁶. Thermography has the advantages of having a lower cost and, above all, is more practical for professionals who works with cellulite treatment¹⁷.

Bauer *et al.* (2020)¹⁰ demonstrate that skin with no visible change in skin relief is more uniform in thermography images, with little variation in color and with approximate temperatures. However, in affected skins, there are hotter spots than the unaffected regions, with strong coloring and there is not a uniform tone or close to being uniform.

Professionals in the field of dermatofunctional physiotherapy and the like, who seek to obtain satisfactory results in the treatment of aesthetic cellulite, must carry out a detailed anamnesis and evaluation of the patient. Therefore, the application of a thermographic camera at the first evaluation must collaborate with the identification of contributing factors for the appearance of the dysfunction in question, which may not be seen without the aid of the equipment.

Given the above, the present study aimed to verify the use of thermography as an auxiliary method in the diagnosis of possible circulatory changes in the gluteal region, as in cases of cellulite appearance, and to investigate the possibility of preventing its worsening. Therefore, the present study sought to analyze and compare the visual aspect of conventional and thermographic photography, to identify the habitual and physical characteristics of the studied volunteers, and to identify, through

thermography, the circulatory behavior of the individuals who do not present the physical characteristics of the cellulite appearance but may progress to the dysfunction in question.

It is presumed that the inclusion of thermo-

graphy images should enrich the professional's knowledge about the patient, offering more information that allows for drawing up an adequate treatment plan for the cellulite appearance.

METHODOLOGY

Study location and ethical aspects

This is an observational study carried out at the Department of Physiotherapy at the Federal University of Pernambuco (UFPE), at the Electrothermophotherapy Laboratory (LETER). This study is part of the clinical trial called "The use of a thermographic camera in aiding the diagnosis of cellulite appearance", approved by the Ethics Committee, with the approval number: 4,173,122 developed in the period from December 2020 to September 2021.

The participants of this study have their ethical commitment assured and the confidentiality of the use of their data as recommended by resolution 466 of December 2012, of the National Health Council (NHC). The information collected will be preserved and archived in the main evaluator's personal computer at the address: Avenida José Ferreira Lins, 477, Bairro Imbiribeira, Recife - PE - under CEP: 51170-320, for a minimum period of five years.

Inclusion and exclusion criteria

In relation to the participants of this study, in total there were 36 women who agreed to participate in the study through the consent of the Informed Consent Form (ICF), which contained all the information about the study. In addition, the participants filled out an anamnesis form, prepared by the main author of this study, through the Google Forms® platform, so that it was possible to collect their main daily habits and then relate them or not to their current dysfunction. The inclusion cri-

teria were women aged between 18 and 35 years old, female, with striae alba in the gluteal region, without drug treatment with photosensitive substances, or using isotretinoin, or undergoing specific topical treatment on the buttocks. Moreover, the participants who accepted to be part of this study following the inclusion criteria, duly evaluated by anamnesis and after signing the informed consent form, were invited to go to the research site to take the photographs. Exclusion criteria were patients with a BMI above the limit (18.5 to 24.9 kg/m²), use of photosensitive drugs, a high phototype, and unavailability.

Data collection and analysis

From the total of 18 volunteers participating in this study, 36 images were analyzed, and for each volunteer, one conventional photograph and one thermographic photograph were taken, totaling 18 photographs using a conventional photographic camera and 18 using a thermographic camera. From the analysis with thermographic photographs, the volunteers were then divided into 2 groups: group 1, composed of 10 participants who presented non-uniform thermographic images, and group 2, composed of 8 participants who presented a more uniform coloration in the thermography image.

The cameras were positioned at a distance of 100 cm from the volunteers and the height of the cameras was adjusted according to the height of the volunteers. A black cotton fabric background was used to standardize the loca-

tion of the photos, and the environment was maintained at a temperature between 18° and 23°C controlled by air conditioners, and relative humidity between 40 and 70%, monitored with the aid of thermo-hygrometer KT-908®.

The thermography equipment used was FLIR Systems - E40bx® (FLIR® Company, Wilsonville, Oregon, USA), with a sensitivity of 0.05°C, infrared resolution of 160 x 120 pixels, programmed with an emissivity of 0.987, reflected temperature of 20°C, picture-in-picture fusion, and a rainbow palette, in addition to a professional conventional Canon® brand camera, model Rebel T100 for conventional photographs.

The volunteers were instructed not to practice any physical exercise before the procedure, as well as to remain in an orthostatic position for 5 minutes before capturing the thermography, for acclimatization of the camera. Prior body rest is necessary so that blood circulation does not undergo stimuli that may influence its flow. Participants were also asked to wear black bikini bottoms or underwear, so that the area was as exposed as possible, and the fabric color did not influen-

ce the temperature of the photos.

Thermographic analyses were performed by 3 specialists in the field of dermatofunctional physiotherapy, from a file on the Google Forms platform containing the 36 photos of the experimental groups. Among the first 18 thermographic evaluations, the specialists should select 2 options from the 4 available, referring to approximate temperature uniformity; non-standardization of temperature; skin with fibroedema; and skin without fibroedema. The other 18 analyses were related to the classification according to Nurnberger and Muller regarding the degree of severity of fibroedema, such as: grade 0, without fibroedema; grade 1, mild fibroedema; grade 2, moderate fibroedema; and grade 3, severe fibroedema^{18,19}.

Statistical analysis

Data were expressed as mean and standard deviation and percentage of cases found in the studied sample. Statistical tests were not performed to compare the groups, the analysis presented is a qualitative analysis.

RESULTS

After searching the MEDLINE database with the terms "cellulite and thermography", in the last 5 years, using the PubMed interface, 3 articles were found, but one did not address this subject, one was unavailable, and only one of these was used herein. In the Scientific Electronic Library Online - SciELO, no studies were found using the terms mentioned above, and in the Science Direct database, 4 articles were displayed, however, none of them elaborated the topic.

Of the 36 volunteers who were interested in participating in the study, 8 were ex-

cluded because 5 of them were not available to commute during the research hours, 1 was using photosensitive medication, 1 had a BMI above the limit, and 1 had a phototype above III. In addition, 10 participants withdrew from going to the site to conduct the study. Therefore, 18 volunteers participated in the study until its completion, which were purposely divided according to their thermographic photographs into 2 groups. Figure 1 presents a flowchart that illustrates the division and loss process of the volunteers participating in this study.

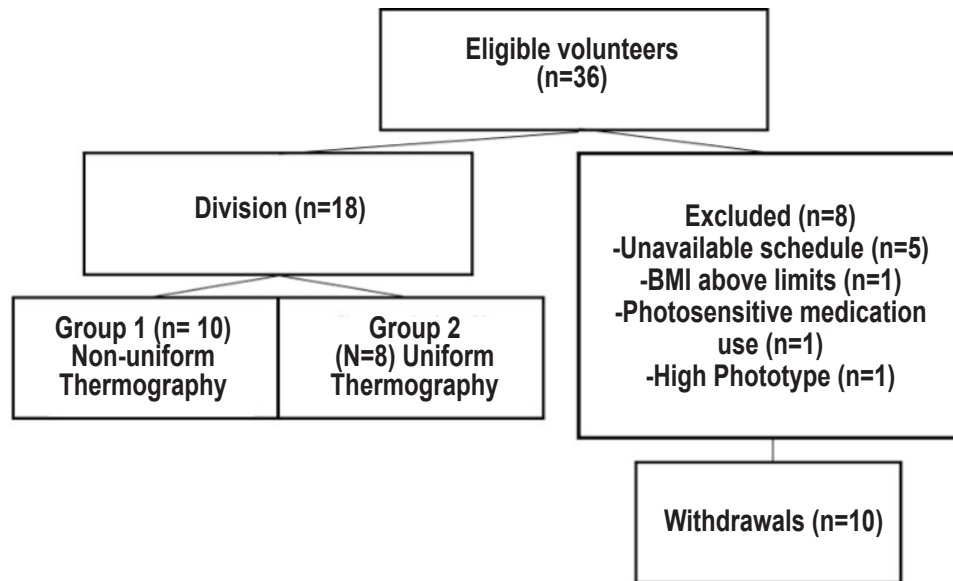


Figure 1 – Representative flowchart of the division process and loss of the number of volunteers.

Table 1 presents the common and physical characteristics of the volunteers, where it was possible to identify some factors that can cause or even worsen

the cellulite appearance, with an emphasis on the lack of physical exercise, low water intake, use of tight clothing, and the use of contraceptives.

Table 1 – Common and physical characteristics of the volunteers (n=18). Recife, PE, 2022.

CHARACTERISTICS	NON-UNIFORM THERMOGRAPHY	UNIFORM THERMOGRAPHY
Practices physical exercise	50% (5/10)	62.5% (5/8)
Uses contraceptive method	30% (3/10)	37.5% (3/8)
Wears tight clothing	60% (6/10)	100% (8/8)
Spends a lot of time sitting	90% (9/10)	87.5% (7/8)
Drinks +2L/day or ideal according to their weight	30% (3/10)	25% (2/8)
Shows signs of depression in the skin	90% (9/10)	25% (2/8)
BMI above normal	30% (3/10)	0% (0/8)
BMI below normal	10% (1/10)	12.5% (1/8)
Average age	26.5	25.37

The group “non-uniform thermography” refers to the volunteers in which most had visual characteristics of the cellulite appearance and the thermographic exam showed circulatory changes. In the “uniform thermography” group, the change in the circulation of the gluteal region was not demonstrated by the thermographic analysis.

Figure 2 (images A and C) shows two volunteers, both with visible cellulite-like alterations using conventional photography, al-

though with thermal photography, the second volunteer (image D) did not show signs of altered circulation.

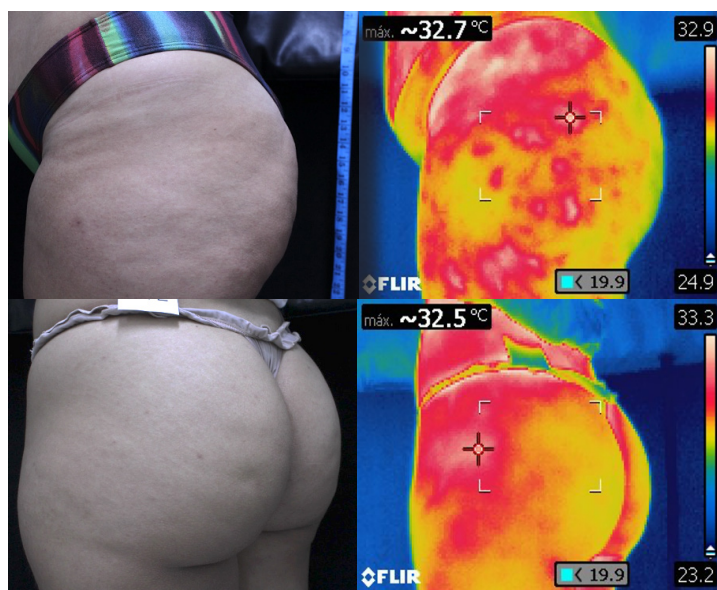


Figure 2 – Images A and B correspond to the same participant, in which it was possible to identify the cellulite appearance both in the conventional photographic image (A) and in the thermographic image (B). In image C, another participant presented depressions characteristic of the cellulite appearance, but in image D, there were no changes seen through thermography, as opposed to what was observed in image B.

Figure 3 represents thermographic images of four different volunteers, where it was possible to perceive the non-numerical temperature difference among them, classifying them as grade 0 (no cellulite), grade 1 (mild cellulite), grade 2 (moderate cellulite), and grade 3 (severe cellulitis), respectively.

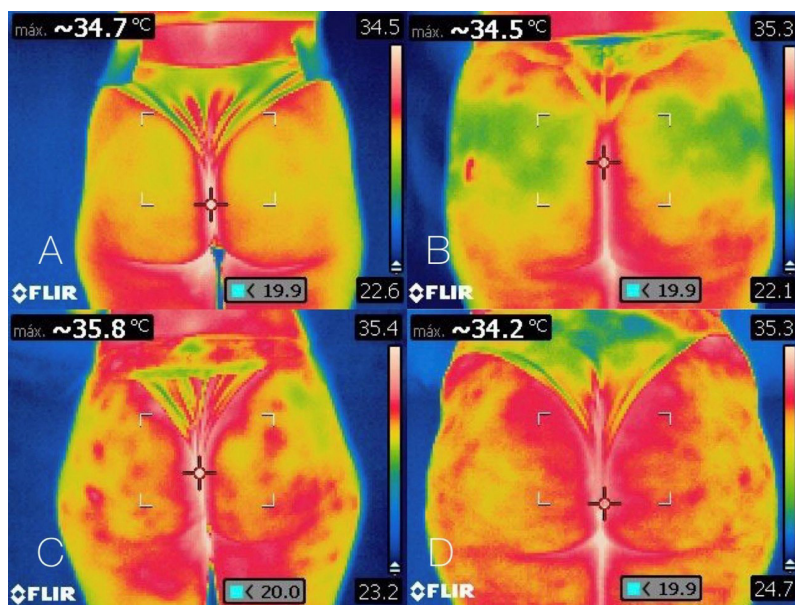


Figure 3 – (A) No cellulite, (B) Mild cellulite, (C) Moderate cellulite, and (D) Severe cellulite.

The analysis of conventional and thermographic photographs of the three specialists in the field of dermatofunctional physiotherapy showed, in some analyses, discrepancies between the answers. Among the 18 analyses of thermographic evaluations regarding the uniformity or not of the temperature, as well as

the presence of aesthetic cellulite or not, the three evaluators agreed with most questions (61.1%) and did not agree with the other questions (38%). On the other hand, in the analysis of the 18 conventional photographs, only 22.22% of the answers were similar among professionals.

DISCUSSION

Although the sample number was small (n=18), there were 6 volunteers who used contraceptive methods, 3 of them using the contraceptive pill, 2 using the IUD (copper and Mirena), and 1 who used a vaginal ring, which corresponds to approximately 30% of participants in both groups. Friedmann *et al.*¹⁵ evaluated cellulite aggravation in users of this type of medication. In this study, it was observed that a study participant who used the contraceptive method had the clinical signs of this dysfunction, on the other hand, it was also observed that 2 other volunteers, although they used the contraceptive method, did not show signs of this dysfunction. Thus, it is worth noting that hormonal changes present at the beginning of puberty, such as the increase in estrogen, also facilitate the development of the orange peel appearance in women through lipogenesis, which is stimulated in certain parts of the body^{18,20}.

Stefania *et al.*²¹ related high BMI with the appearance of cellulite. In this study, it was found that even with the BMI within the normal range of 18.5 to 24.9 kg/m², 7 volunteers had a cellulite appearance or “orange peel” condition. Corroborating this result, Bass and Kaminer⁹ highlighted that the protrusion of the fat cell to the surface of the skin is a secondary event, that is, the increase in the thickness of the septa is what causes the depressive changes in the cutaneous relief.

Rudolph *et al.*²² reported that the increase in body mass index that alters the subcuta-

neous structure (thickening) was related to the worsening of body dysmorphia through increased tension in the collagen network. That is, the adipocyte protrusion is directed towards the skin surface while the fibers undergo opposite tension, which consequently causes the skin to be pulled down into the fiber which is more tense. However, this increase in fat cells usually covers an entire area, such as in the gluteal region. It is therefore believed that all adipocyte rows receive an equal stimulus for growth, otherwise there would be clear dysregulations in the skin. For this reason, it cannot be confirmed that the increase in lipid content is a determining factor for the development of cellulite, because if this hypothesis were true, we would have verified depressions in all areas of the gluteus and not only in isolated points, as observed in the volunteers studied herein.

Studies such as the one by Mirrached *et al.*²³ verified, through an analysis of magnetic resonance imaging, that there was no correlation between the thickening of the fat layer and the worsening of the cellulite appearance, which corroborates the results of the present study that overweight is not necessarily one of the causes of the appearance of cellulite.

Furthermore, the results of the study by Amore *et al.*²⁴ agree with the findings of this study, when they demonstrated that physical activity, age, and changes in body weight are not significant factors for the appearance of the disorder that affects the appearance of the skin. In this study, volunteers with a BMI

below, normal, or above the ideal levels presented the dysfunction, as well as those who practiced physical exercises of different ages (20 to 32 years old). Furthermore, Amore *et al.*²⁴ concluded that the depth and extension of the depressions were related to the severity of the cellulite condition; however, it is currently known that the fibrosis found in the septa of the superficial subcutaneous layer is the cause of this padded appearance, regardless of severity²⁵. Furthermore, Tokarska *et al.*²⁶ highlighted that physical inactivity could worsen this orange-peel appearance due to muscle hypotonicity of local blood vessels, which consequently can lead to local hemostasis.

Studies^{14,22,26} have reported age as a factor that facilitates the onset of the dysfunction in question. However, the present study selected women aged between 20 and 32 years old, with a similar mean age between the groups; therefore, the age of the sample of this study was not a causal factor for the development of the cellulite appearance. On the other hand, Hexsel *et al.*²⁷ demonstrated that advancing age could lead to the aggravation of cellulite.

The pathophysiology of cellulite is not yet fully elucidated, although some studies have stated that circulatory impairment can influence both its manifestation and its exacerbation^{15,28}. Local hypoxia, inflammation, and polymerization are directly linked to this impaired circulation, and are not only reflected in physical signs, but also in symptoms such as heaviness in the legs, pain, and decreased sensitivity, including greater local sensitivity to cold^{17,24}.

The fact that thermography indicated a change in circulation in 2 volunteers who did not have the visual characteristic of an orange-peel appearance, may possibly indicate that these volunteers are evolving to acquire the dysfunction¹¹. Inflammation and vasocon-

striction are two of the main characteristics of cellulite, and the first sign of progress towards acquiring the condition is precisely the change in circulation that leads to a depressive characteristic, which can be noticed in the long term (months or even years) or even when pressing the skin^{17,29}. Bauer *et al.*¹⁰ carried out a study similar to the present one, where they used thermography as an evaluative factor for cellulite and according to the analysis of the thermographic image they were classified as: no cellulite, mild cellulite, moderate cellulite, and severe cellulite. Herein, we performed the same classification with the images of the volunteers of the current study (Figure 3) manually since other studies performed it with the help of artificial intelligence¹⁰.

In one volunteer of Figure 2 (C and D), thermography (D) was uniform, that is, without significant visible circulatory changes; however, in conventional photographs (C), the skin showed some depression points that suggest a cellulite appearance. These results suggest that the alteration in the circulation may not be found in some cases, confirmed by the study by Wilczynski *et al.*¹²; therefore, alterations in the connective tissue cannot be captured in thermographic exams.

The results of this study suggest that the severity of cellulite can be analyzed through thermography. In short, the thermographic camera used by professionals in the field of dermatofunctional physiotherapy, and the like, is a recent technique used to investigate the development of cellulite appearance, and, therefore, the number of scientific articles is also scarce. As the study began during the COVID-19 pandemic, the number of volunteers was limited and the distance from the research site also influenced the withdrawal of participation. Therefore, we suggest a greater number of participants in order to obtain more reliable data on the use of the thermographic camera to aid in the diagnosis of

aesthetic cellulite; although the results of this study suggest that a previous diagnosis throu-

gh the thermographic camera can help in the prevention of this dysfunction.

CONCLUSION

The severity of cellulite cannot be classified only through a visual assessment or questionnaires, since, as seen in this study, participants who do not have the physical characteristics of cellulite demonstrated a circulatory impairment evidenced by thermography, which may indicate a possible risk of acquiring cellulite.

We validated the hypothesis concerning the aid of thermography in the bodily assessment of cellulite, since it was possible to identify circulatory changes in patients who had not yet developed the characteristics of an "orange peel", which could be used to guide the patient on preventing the aggravation of this alte-

ration. Another finding was related to patients who had an orange-peel appearance, but not all of them had a deficiency in local circulation, so the goals and treatment of these patients should not be the same. Therefore, it is concluded that a previous diagnosis through a thermographic camera can help in preventing the implication of aesthetic cellulite.

Finally, although thermography has proved to be quite useful in finding circulatory changes, it is still necessary to carry out more research with specific photographs for the analysis of cellulite, as well as to increase the sample data.

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All authors have read and agreed to the published version of the manuscript.

REFERENCES

1. Young VL, DiBernardo BE. Comparison of Cellulite Severity Scales and Imaging Methods. *Aesthet Surg J.* 2020; 41(6):NP521-NP537, doi: 10.1093/asj/sjaa226.
2. Cohen JL, Sadick NS, Kirby MT, McLane MP, Lenderking WR, Bender RH et al. Development and Validation Clinician and Patient Photonumeric Scales to Assess Buttocks Cellulite Severity. *Dermatol Surg.* 2020; 46(12):1628-1635, doi: 10.1097/DSS.0000000000002756.
3. Sadick NS, Goldman MP, Liu G, Shusterman NH, McLane MP, Hurley D, Young VL. Collagenase Clostridium Histolyticum for the Treatment of Edematous Fibrosclerotic Panniculopathy (Cellulite): A Randomized Trial. *Dermatol Surg.* 2019;45(8):1047-1056, doi: 10.1097/DSS.0000000000001803.
4. Soares JLM, Miot HA, Sanudo A, Bagatin E. Cellulite: poor correlation between instrumental methods and photograph evaluation for severity classification. *Int J Cosmet Sci.* 2014;37(1):134-140, doi: 10.1111/ics.12177.
5. Callaghan III DJ, Robinson DM, Kaminer MS. Updates in cellulite reduction. *Adv in Cosmet Surg.* 2018;1(1):45-53, doi: 10.1016/j.yacs.2018.02.006.
6. Puviani M, Tovecci F, Milani M. A two-center, assessor-blinded, prospective trial evaluating the efficacy of a novel hypertonic draining

- cream for cellulite reduction: A Clinical and instrumental (Antera 3D CS) assessment. *J Cosmet Dermatol.* 2018;17(3): 448-453, doi: 10.1111/jocd.12467.
7. Pianez LR, Custódio FS, Guidi RM, Freitas JN, Sant'Ana E. Effectiveness of carboxytherapy in the treatment of cellulite in healthy women: a pilot study. *Clin Cosmet Investig Dermatol.* 2016; 9:183-190, doi: 10.2147/CCID.S102503.
 8. Yoshida Y, Kajiya K, Kishimoto J, Detmar M. Quantitative histological analyses, and transcriptional profiling reveal structural and molecular changes of the dermal extracellular matrix in cellulite. *J Dermat Sci.* 2018;92(1):6-9, doi: 10.1016/j.jdermsci.2018.06.010.
 9. Bass LS, Kaminer MS. Insights into the pathophysiology of cellulite: a review. *Dermatol Surg.* 2020;46(1):77-85, doi: 10.1097/DSS.0000000000002388.
 10. Bauer J, Hoq N, Mulcahy J, Tofail SAM, Gulshan F, Silien C, Podbielska H, Akbar M. Implementation of artificial intelligence and non-contact infrared thermography for prediction and personalized automatic identification of different stages of cellulite. *EPMA J.* 2020;11(1):17-29, doi: 10.1007/s13167-020-00199-x.
 11. Ngamdokmai N, Waranuch N, Chootip K, Jampachaisri K, Scholfield CN, Ingkaninan K. Cellulite Reduction by Modified Thai Herbal Compresses; A Randomized Double-Blind Trial. *J Evid Based Integr Med.* 2018; 23(11):25-35, doi: 10.1177/2515690X18794158.
 12. Wilczynski S, Koprowski R, Deda A, Janiczek M, Kuleczka N, Błońska-Fajfrowska B. Thermographic mapping of the skin surface in biometric evaluation of cellulite treatment effectiveness. *Skin Res Technol.* 2016; 23(1):61-69, doi: 10.1111/srt.12301.
 13. Sylwia M, Krzysztof MR. Efficacy of intradermal mesotherapy in cellulite reduction – Conventional and high-frequency ultrasound monitoring results. *J Cosmet Laser Ther.* 2017;19(6): 320–324, doi: 10.1080/14764172.2017.1334927.
 14. Klassen AF, Kaur MN, de Vries CEE, Poulsen L, Breitkopf T, Pusic A. The BODY-Q cellulite scale: A development and validation study. *Aesthet Surg J.* 2021;41(2):206-2017, doi:10.1093/asj/sjaa100.
 15. Fiedmann DP, Vick GL, Mishra V. Cellulite: a review with a focus on subcision. *Clin Cosmet Investig Dermatol.* 2017;10:17-23, doi:10.2147/CCID.S95830.
 16. Brauer JA, Christman MP, Bae YSC, Bernstein LJ, Anolik R, Shelton R, et al. Three-dimensional analysis of minimally invasive vacuum-assisted subcision treatment of cellulite. *J Drugs Dermatol.* 2018;17(9):960-965.
 17. Bauer J, Grabarek M, Migasiewicz A, Podbielska H. Non-contact thermal imaging as potential tool for personalized diagnosis and prevention of cellulite. *Journal of Thermal Analysis Calorimetry.* 2018;133:571-578, doi:10.1007/s10973-018-7232-9.
 18. Atamoros FMP, Pérez DA, Sigall DA, Romay AAA, Gastelum JAB, Salcedo JAP, et al. Evidence-based treatment for gynoid lipodystrophy: A review of the recent literature. *J Cosmet Dermatol.* 2018;17(6):977-983, doi:10.1111/jocd.12555.
 19. Longhitano S, Galadari H, Cascini S, Shaniko K, Chester J, Farnetani F, et al. A validated photonumeric cellulite severity scale for the area above the knees: the knee cellulite severity score. *Journal of the European Academy of Dermatology and Venereology.* 2020;34(9):2152-2155, doi: 10.1111/jdv.16269.
 20. Davis DS, Boen M, Fabi SG. Cellulite: Patient Selection and Combination Treatments for Optimal Results-A Review and Our Experience. *Dermat Surg.* 2019;45(9):1171–1184, doi:0.1097/DSS.0000000000001776.
 21. Stefania G, Bruno B, Luigi CP, Roberto D, Michela G, Ginevra, M, et al. Multicenter study of vacuum-assisted precise tissue release for the treatment of cellulite in a cohort of 112 Italian women assessed with cellulite dimples scale at rest. *J Cosmet Laser Ther.* 2019;21(7-8):404–407, doi:10.1080/14764172.2019.1683209.
 22. Rudolph C, Hladik C, Hamade H, Frank K, Kaminer MS, Hexsel D, et al. Structural Gender Dimorphism and the Biomechanics of the Gluteal Subcutaneous Tissue: Implications for the Pathophysiology of Cellulite. *Plast Reconstr Surg.* 2019;143(4):1077-1086, doi:10.1097/PRS.0000000000005407.
 23. Mirrashed F, Sharp JC, Krause V, Morgan J, Tomanek B. Pilot study of dermal and subcutaneous fat structures by MRI in individuals who differ in gender, BMI, and cellulite grading. *Skin Res Technol.* 2004;10(3):161-168, doi:10.1111/j.1600-0846.2004.00072.x.
 24. Amore R, Amuso D, Leonardi V, Sbarbati A, Conti G, Albini M, et al. Treatment of dimpling from cellulite. *Plast Reconstr Surg Glob Open.* 2018;6(5):e1771, doi:10.1097/GOX.0000000000001771.
 25. Ibrahim O, Haimovic A, Lee N, Kaminer MS. Efficacy Using a Modified Technique for Tissue Stabilized-Guided Subcision for the Treatment of Mild-to-Moderate Cellulite of the Buttocks and Thighs. *Dermatol Surg.* 2018;44(10):1272-1277, doi:10.1097/DSS.0000000000001542.
 26. Tokarska K, Tokarski S, Wozniacka A, Sysa-Jedrzejowska A, Bogaczewicz. Cellulite: a cosmetic or systemic issue? Contemporary views on the etiopathogenesis of cellulite. *Postepy Dermatol Alergol.* 2018;35(5):442-446, doi:10.5114/ada.2018.77235.
 27. Hexsel D, Camozzato FO, Silva AF, Siega C. Acoustic wave therapy for cellulite, body shaping and fat reduction. *J Cosmet Laser Ther.* 2017;19(3):165-173, doi:10.1080/14764172.2016.1269928.
 28. Sadick N. Treatment for cellulite. *Int J Womens Dermatol.* 2019;5(1):68-72, doi:10.1016/j.ijwd.2018.09.002.
 29. Knobloch K, Kraemer R. Extracorporeal shock wave therapy (ESWT) for the treatment of cellulite – A current metaanalysis. *International Journal of Surgery.* 2015;24:210-217, doi:10.1016/j.ijvsu.2015.07.644.

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