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Effects of Cryofrequence on Localized Adiposity: Case Study

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Abstract

Cryofrequence is the combination of cryotherapy with radiofrequency, which promotes a "thermal shock" to the tissue, working simultaneously to skin flaccidity and localized adiposity. The efficacy of dermatological and hypodermic cryofrequency treatment was evaluated. This study reports the case of a 45-year-old woman with complaints of flaccidity and fat located in the infra-umbilical region in the preoperative period of abdominoplasty. The evaluation was performed before and after treatment through evaluation protocols, ultrasound examinations and histological findings through optic microscopy, microfocal and immunohistochemical analysis. The treatment was performed in 4 sessions, with a weekly application, using the BHS 156 FULL®—BODY HEALTH BRASIL® apparatus, the parameters were temperature of −10˚C, power in 70%, duration of 8 minutes. After the surgical procedure, parts of treated and untreated abdominal tissues were removed for evaluation. In the tests performed, significant destruction of adipocytes was detected, with consequent reduction of fat and greater expression of caspase-3 in the treated tissue, being constated the macrophage increase by CD68 expression. There was improvement in flaccidity, evidenced by the significant increase in the number of fibroblasts and inflammatory cells positive for Ki67, bringing more quantity and better quality to the collagen.

Keywords

Cryofrequence, Localized Adiposity, Skin Flaccidity, Abdominoplasty

1. Introduction

Localized adiposity is the accumulation of energy reserves in adipose tissue, de-

termined by caloric intake above that required for body metabolism. This excess is an important factor that can trigger serious health problems such as coronary diseases, hypertension, diabetes, among others, as well as aesthetic issues [1] [2] [3].

Flaccidity is considered an unsightly skin condition, this is related to the decrease of skin fibroblasts, compromising the activity of the collagen and elastin proteins responsible for the support and elasticity [4]. It may be a consequence of physiological aging, due to the gradual loss of skeletal muscle mass, replaced by adipose tissue, and atrophy of subcutaneous adipose tissue, among other changes [5].

There is a great demand for different non-invasive procedures, which seek to minimize aesthetic dysfunctions with minimum risks, among them is cryofrequence. This technology combines cryotherapy with radiofrequency, working simultaneously in the treatment of flaccidity and localized fat. It features a tip that cools only the epidermis at about −10˚C, while radiofrequency heat reaches the deeper layers of the skin stimulating the formation of new collagen and elastin fibers and lipolysis [6] [7].

The energy released from this electrode leads to better circulatory and nutrient supply, besides tissue hydration, increased oxygenation, acceleration of the elimination of catabolites, lipolysis, contraction of the connective tissue and allied to this causes the contraction of the collagen fibers, improving simultaneously the changes in the external structure of the skin and allowing greater comfort to the patient during the application [7].

Although it is a novel technology without a fully understood mechanism of action, promising results have been confirmed in studies therefore appearing to be an excellent option for localized adiposity reduction and improvement of sagging without major adverse effects [8] [9]. This case report was carried out with the objective of evaluating the efficacy of the treatment of cryofrequence at the dermal and hypodermic levels, through ultrasound examinations and histological findings.

2. Case Presentation

The research was characterized as a case study of a 45-year-old woman, weighing 59.7 kg, height 1.50 m and BMI of 26.5 (overweight), presenting localized adiposity and flaccidity in the infra-umbilical region, with interest of abdominoplasty surgery (**Figure 1**). In the inclusion criteria, the participant should have localized abdominal adiposity and sagging, be in a preoperative period of abdominoplasty surgery and be able to understand and sensibility preserved locally. Among the exclusion criteria applied, it could not present contraindications for the use of equipment (cold hypersensitivity, pacemaker, dermatitis, epilepsy, cancer, use of corticosteroids, metal and/or silicone implants in the treated area) and the participant who disagreed with the procedures or did not adapt to the hours and procedures would be discontinued from the research.

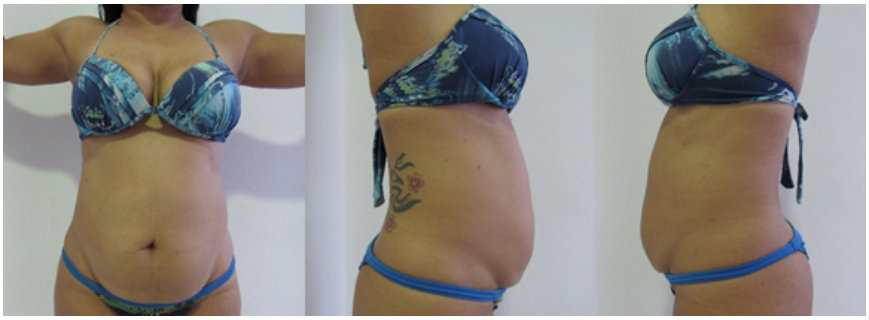

Figure 1. Photographic record of the evaluation.

3. Materials and Methods

The research was carried out in the city of Natal, RN, Brazil, in the premises of Vânia Rocha Clinic, and approved (Registered under number 3.237.778) by the Ethics Committee of the Potiguar University (CEP), Natal, RN, Brazil. An ultrasound device (Eco palm Wifi, 10 MHZ, China), a semiprofessional camera (Canon, SX530 HS, Japan), a tape measure (Fiber Glass Tape, China), an adipometer (Sanny, São Paulo, Brazil) a balance (Accumed-Glicomed, Rio de Janeiro, Brazil), a binocular microscope apparatus (Olympus, model CX31, USA), and a cryofrequence apparatus (BHS 156 FULL®, BODY HEALTH BRASIL®, Brazil).

3.1. Procedures

Prior to the start of treatment, the volunteer was guided about the procedures and signed the informed consent form. Afterwards, it was submitted to the PAFAL protocol, validated by Meyer *et al.* [10], an instrument used to obtain information such as identification, anamnesis, life habits, physical examination, with measurements and tests such as weight, height, BMI, skinfolds and waist circumference. The skinfolds of the infra-umbilical region were measured three times, verified 2 cm above the iliac crest region, with result based on the mean values obtained in the measurements. The measurement of the abdominal circumference was performed 5 cm above the umbilical scar, in the supra umbilical region and 5 cm below it, in the infraumbilical region.

Subsequently, the volunteer was submitted to ultrasound examination, which was lauded by a specialist physician. The examination was performed in the infra umbilical region, at a central point in the demarcated area of 10 cm^2, with the volunteer positioned in dorsal decubitus, with the transducer only in contact with the skin, without pressure [11]. This method allowed to evaluate the thickness of the fat layer in centimeters of the infra-umbilical region before the beginning of the procedures and after the proposed treatment.

For the treatment, a 10 cm^2 area in the left infra-umbilical region was initially demarcated as shown in **Figure 2**. The right side area also received a marking of the same size and served as control.

The treatment was performed in 4 sessions, with a weekly application of cryofrequence in the left infra-umbilical region, using the BHS 156 FULL® device, of the brand BODY HEALTH BRASIL®. The parameters used were: frequency mix,

multipolar + monopolar corporal mode, with temperature of −10˚C, power in 70% and duration of 8 minutes. The reevaluation was performed after the final session with the repetition of all procedures performed before the beginning of the protocol.

Twelve days after the sessions of cryofrequence, the patient underwent total abdominoplasty, under epidural anesthesia with sedation. In preparation for surgery, the two areas were marked with gentian violet pencils to be properly identified and cut into the surgical block. The infiltration with 1:3000.00 adrenaline solution was performed under the superimposed technique. Afterwards, the dermolipectomy was performed, starting with the supra-pubic incision, displacement in the supra-aponeurotic plane to the xiphoid appendix, performing plication of the abdominal rectus muscles, removal of excess skin from the lower abdomen, synthesis by planes with nylon and mono. Negative pressure drain was maintained (Portovac 4.8). After the cutaneous flaps (**Figure 3**) were removed, they were submitted to histological analysis, where they fixed the pieces in 10% Buffered Formalin for 48 hours. They cleaved and processed according to the pathology laboratory process (dehydration, diaphanization, paraffin embedment and inclusion). The resulting paraffin blocks were cut into a 5 μm thick rotating microtome and the blades obtained were stained by Hematoxylin and Eosin (HE) techniques. They were examined in an optical microscope binocular, being blind and tabulated, verifying the amount of adipocytes, collagen fibers, presence of degenerative tissue. Microfocal microscopy was performed to check the type of collagen and also immunohistochemical analysis with the markers caspase-3, macrophage CD68 and Ki67 antigen.

3.2. Data Analysis

Qualitative data were described based on medical reports (descriptive analysis of ultrasound images) and based on the reports of the pathologist (descriptive analysis of histological images and quantification of cells), as well as the quantitative and qualitative analysis of some immunohistochemical markers. Data collection and correlation were presented in tables and figures.

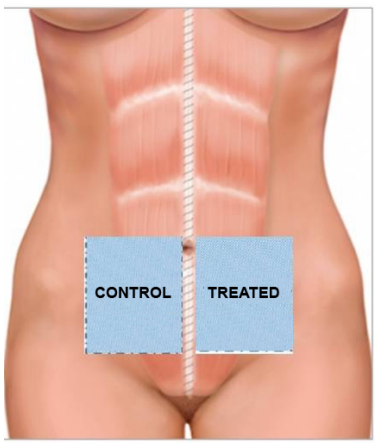

Figure 2. Sampling, control and treated scheme.

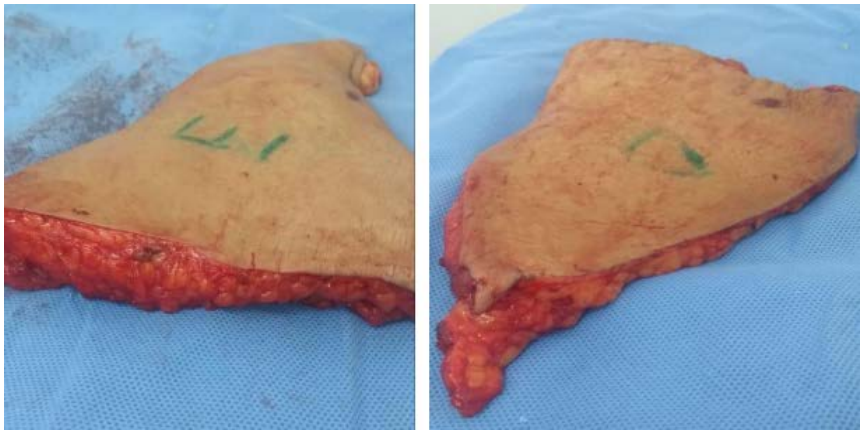

Figure 3. Surgical flaps: left and right.

4. Results

The variables measured before and after application of cryofrequence are described in Table 1. There was an average reduction of 3 cm in the infra-umbilical circumference, being maintained the same value in the supra umbilical region. Weight was observed before treatment was 59.7 kg (BMI 26.5) and after treatment 59.4 kg (BMI 26.4), with a small reduction of 300 g in total body weight. The left skinfold data showed an increase of 1.0 mm in the average obtained, and in the right side of 5.7 mm.

4.1. Ultrasonography Results

Ultrasonography data obtained before and after the last session of application of cryofrequence were recorded in Table 1. The qualitative analysis performed by the physician is shown in Figure 4 and Figure 5. The results obtained with ultrasound demonstrate reduction of the thickness of the fat layer was 0.23 cm after treatment in the left region. The thickness data on the right-side adipose layer varied 0.08 cm.

4.2. Results of Microscopic Analysis

Two tissue samples, corresponding to the treated and untreated areas, were extracted and used for the histological records. In the analysis, it was observed that the untreated side (right) presents an aspect of disorganized collagen, old and with few cells. On the treated (left) side, it is possible to observe, with more detail in the epidermis, a large number of active fibroblasts (blue arrows) and a greater amount of neoformed collagen (red arrow) (Figure 6(a) and Figure 6(b)). In longitudinal microphotography, the treated side presents degenerating adipose tissue and on the control side, the cells present normal characteristics (Figure 6(c) and Figure 6(d)).

The microfocal histological analysis presented results regarding the amount of neoformed collagen, in the treated area it is possible to observe an amount superior to the control side. In addition, a significant amount of Type III (green) col-

lagen was detected on the control side, and a large amount of Type I (red) collagen was detected on the treated side (Figure 6(e) and Figure 6(f)).

Table 1. Anthropometric data of the volunteer.

Measurement and Weight Assessment	Pretreatment	Post-treatment
Weight (Kg)	59.7	59.4
BMI	26.5	26.4
Plicometry—Right Side (mm)	19.6	25.3
Plicometry—Left Side (mm)	23.3	24.3
Perimetry—Supra Umbilical (cm)	82	82
Perimetry—Infra Umbilical (cm)	90	87
Ultrasonography—Right Side (cm)	1.22	1.14
Ultrasonography—Left Side (cm)	1.21	0.98

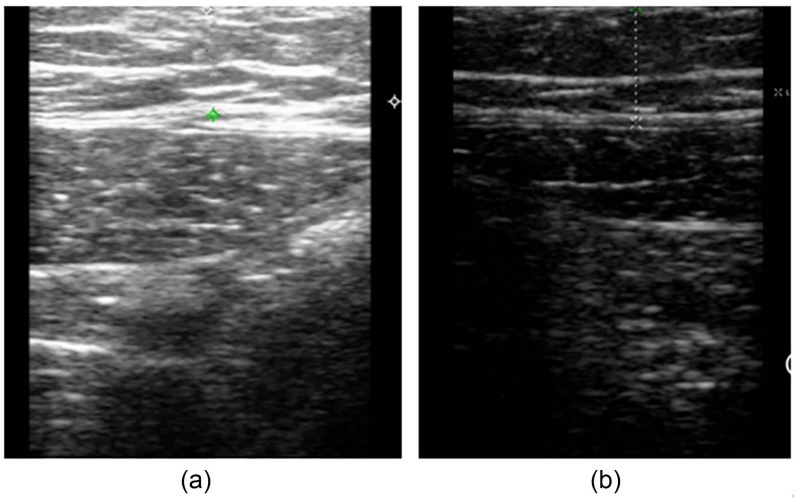

Figure 4. Ultrasonography—Left side: Pretreatment (a) and Post-treatment (b).

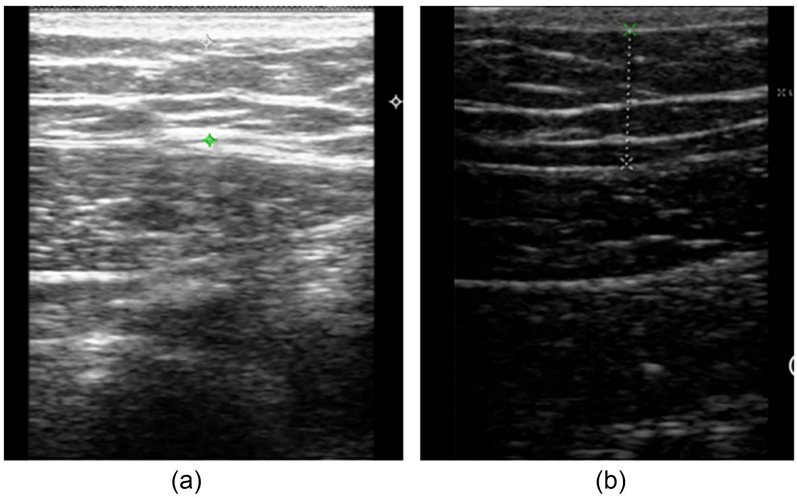

Figure 5. Ultrasonography—Right side: Pretreatment (a) and Post-treatment (b).

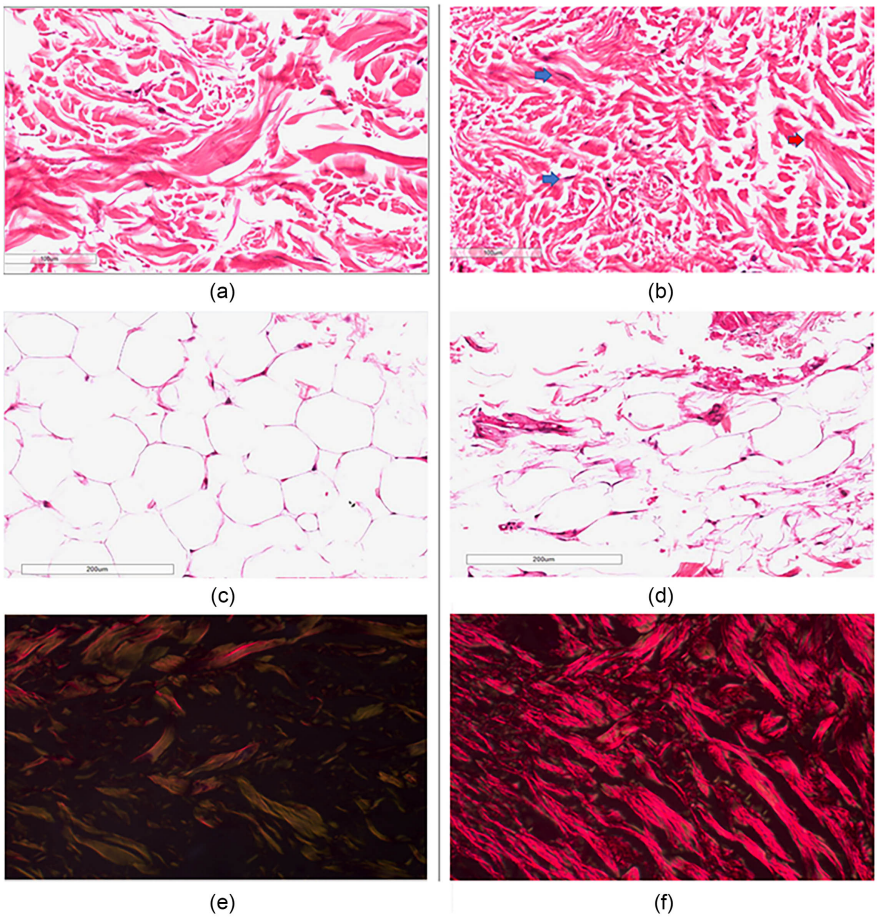

Figure 6. Microscopic analysis of the material collected during abdominoplasty. Longitudinal micrograph HE 100× (a) untreated region and (b) treated region. Longitudinal micrograph HE 200× (c, d) referring to adipose tissue. (e, f) Longitudinal microfocal histology referring to the type of collagen.

4.3. Results of Immunohistochemical Analysis

Immunohistochemical analysis showed greater expression of caspase-3 in the adipose tissue on the treated side, indicating the presence of apoptosis, consequently, a greater degeneration of this tissue ($t \leq 0.05$). The analysis of CD68 expression, the treated side showed an increase in the number of macrophages ($t \leq 0.05$), as demonstrated by the CD68 reaction, which represents an activation of apoptosis and also activation of inflammatory cells, especially macrophages that phagocytose the apoptotic tissue. Analysis of Ki67 expression showed that on the treated side there was a significant increase in the number of fibroblasts and Ki67 positive inflammatory cells ($t = 0.05$), indicating a greater activity in the dermis of the treated area compared to the control side, corroborating with the greater production of type I collagen (**Figure 7**).

5. Discussion

This study indicated a reduction of 3 cm in the circumference of the infra-umbilical region, a 1.0 mm increase in skinfold measurements and a reduction

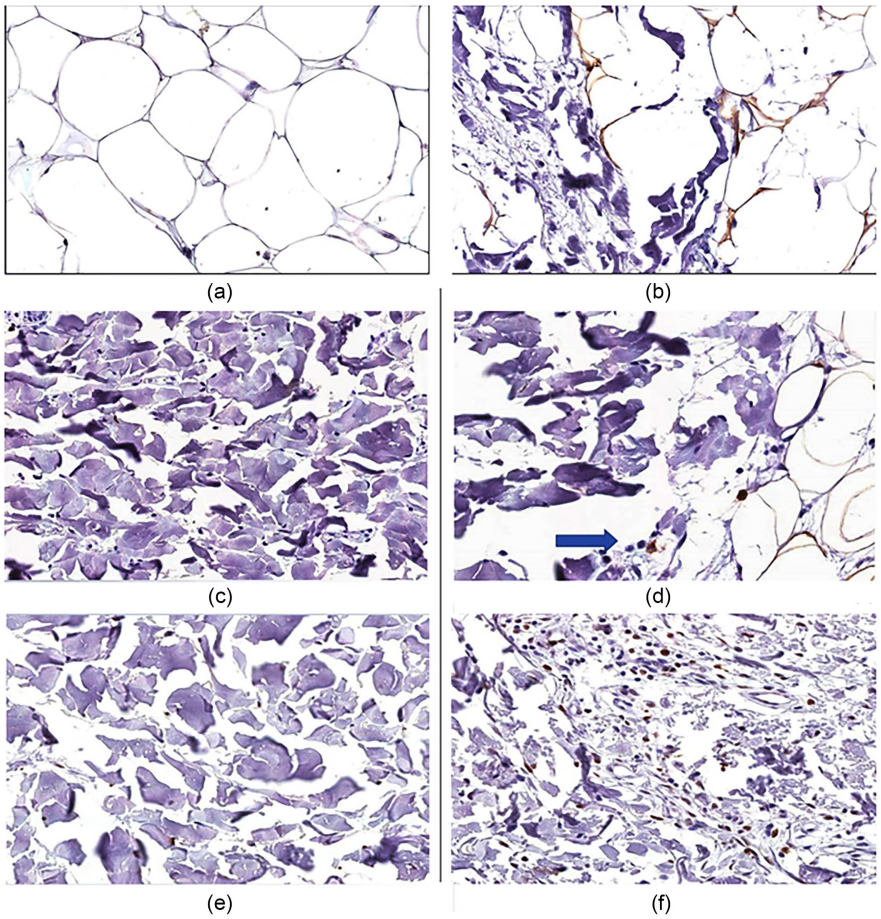

Figure 7. Microscopic analysis of the material collected during abdominoplasty. Expression of Caspase-3 in adipose tissue in (a) untreated region and (b) treated region. CD68-positive macrophages (c, d) in adipose tissue. (e, f) Ki67 positive cells.

of 0.23 cm in the ultrasound images for the treated side, however the weight and BMI did not change in an expressive manner, thus maintaining constant body weight suggests that the reduction of fat layer thickness was due to local treatment [12]. The results reinforce the study by Silva *et al.* [8], in which 30 patients with localized flank fat were submitted to 8 sessions of cryofrequence, showing a reduction in the circumference of the treated area, with a mean decrease of 2.44 mm, and also in the analysis of the ultrasound images that demonstrated a reduction of the fat layer of 0.19 cm at the end of the protocol.

Depending on the intensity of exposure to cold, the treatment induces the degeneration of adipose tissue by two mechanisms: activation of apoptosis and also activation of inflammatory cells, especially macrophages that phagocytose the apoptotic tissue, justifying the decrease of the fat layer found in the results through ultrasonographic evaluation [13]. The study by Meyer *et al.* [14] investigated the effects of cryolipolysis on the elimination of adipocytes through ultrasound imaging, macroscopic and histological analysis. Areas with cell and macrophage infiltrates were found, suggesting an inflammatory condition, with a significant destruction of the adipocytes, with consequent reduction of fat

layer.

In the case of cryofrequence, using the cooling associated with the heat of radiofrequency, doubts already exist regarding the real physiological effect in the adipose tissue. The study of Silva [9], used 6 sessions applied to 15 patients and the results found in this study showed reduction of the fat layer through circumference measurements and ultrasound images, noting that cryofrequence (cryotherapy with radiofrequency) was effective in reduction of measures.

Radiofrequency technology has the ability to selectively heat subcutaneous adipose tissue, inducing apoptosis in these cells, and limiting the amount of energy in other regions, minimizing the risk of overheating [15]. The effectiveness of this technology was demonstrated in a study with 35 volunteers who performed 4 radiofrequency sessions. During the treatment, the temperatures reached 46˚C for fat layer and 42˚C on the skin, when analyzing the results an average decrease of 4.93 cm of waist circumference was observed, with mild to moderate erythema reported as a side effect [16]. On the other hand, the use of cryofrequency does not reach high temperatures due to the cooling of the tip, which brings greater comfort during its application.

Through the immunohistochemical analysis, we seek to better understand the process of reduction of adipose tissue by means of the combination found in the cryofrequence. The caspase marker (cysteine-dependent aspartates pecific proteases) has the ability to recognize and cleave substrates that have aspartate residues, which is fundamental in the cellular apoptosis process [17]. In this study caspase-3 was found in the tissue treated, signaling and confirming apoptosis, the presence of macrophages that phagocyte to degenerating cells, explaining the reduction of measurements by the action of cryofrequence lipolysis.

There have not yet been published studies demonstrating apoptosis and the process of adipose cell degeneration when using cryofrequence, only studies using radiofrequency or cryolipolysis. One study evaluated the radiofrequency results in two women using biopsies. The histological analysis showed that the apoptotic index (pre and 1-hour post) showed an average increase of 487% [18]. The study by Boey and Wasilenchuk [19] in analyzing the effects of cryolipolysis found that in the histological analysis there was an increase in the inflammatory response, with a peak in 30 days with dense infiltrate of inflammatory cells and reduction in adipocyte size, suggesting that induced apoptosis by cold caused gradual and progressive destruction of fat cells in the treatment areas.

The presence of macrophages has been associated with a greater degeneration of adipose tissue. The CD68 protein, considered a classic marker of human macrophages, works in the elimination of cellular residues, promoting phagocytosis and mediating the recruitment and activation of macrophages in specific targets [20] [21]. The immunohistochemical analysis of this study demonstrated that in the treated side tissue there was an increase in the number of macrophages, as demonstrated by the CD68 reaction, corroborating with studies [22], which demonstrated that between 14 and 30 days after tissue exposure adipose to cold,

macrophages begin to envelop and digest adipocytes that have suffered apoptosis, thus facilitating their elimination from the body. Clinically, this corresponds to a decrease in the thickness of the subcutaneous fat layer. Although cryofrequence is not a treatment that exclusively uses the cold, the combined cooling to the radiofrequency heat is present.

Another marker analyzed was a significant increase in the number of fibroblasts and Ki67 positive inflammatory cells, indicating a higher activity in the dermis of the treated region compared to the control side. In treated skins, Ki67 expression in fibroblast nuclei, connective tissue cells and inflammatory cells may indicate increased proliferation of these cells [23].

The human dermis consists primarily of type I collagen, however, changes in morphological and biomechanical properties may lead to sagging and the advancement of age leads to a decrease in the synthesis of this type of collagen and evidence of type III collagen, reducing adhesion between cells and fibers [24]. In the microfocal histological analysis, it was possible to notice that there was a production of type I collagen after the application of cryofrequence, with greater firmness and better quality, consequently improving sagging, while the control side showed a significant amount of Type III collagen.

In this way, the radiofrequency induces the thermal damage to stimulate changes in the collagen conformation and in the production of neocolagenesis. The presence of type I collagen on the treated side indicates an improvement in skin firmness and elasticity, confirming the study by Zelickson *et al.* [25], which through histological analysis demonstrated changes in the areas of collagen fibers, with increased diameter and amount of collagen type I after 8 weeks of treatment with radiofrequency.

Although it is a case study, a limiting factor, this research has its relevance, because it analyzes different methodologies, the evolution of the clinical picture of a patient submitted to treatment with cryofrequence. It is suggested to carry out other studies with a larger number of volunteers. It is necessary to better understand the process of association of cryotherapy and radiofrequency simultaneously for the treatment of adipose tissue, because, in isolation, these physical agents have proven their effectiveness, but together, there is still a shortage of information in the literature.

In conclusion, the technology of cryofrequence can treat both flaccidity and localized adiposity, a fact evidenced by the histological and immunohistochemical findings from this research. The amount of adipose tissue on the treated side was much lower and statistically significant reduction occurred when counting sample cells. A greater amount of collagen on the treated side was perceived, in addition to a higher quality of this collagen.

Conflicts of Interest

The authors state that they have no interest in the subject discussed in the article or in the products/items mentioned. They declare that this article is unique and

that work, in part or in full, or any other work with substantially similar content has not been submitted to another journal.

References

[1] Guirro, E. and Guirro, R. (2004) Fisioterapia Dermato-Funcional: Fundamentos, Recursos, Patologias. 3rd Edition, Manole, Brazil, 437-463.

[2] Borges, F.D. and Scorza, F.A. (2016) Terapêutica em estética: Conceitos e técnicas. 1st Edition, Phorte, São Paulo, 584 p.

[3] Datsch, A., Franzin, R., Angeli, S., Costa, P. and Silva, T. (2012) Uso da crioterapia como ferramenta do consumo de O_2 no tratamento da adiposidade localizada: Relato de caso. *Perspectivas Online*, **5**, 31-38.

[4] Nery, R.D., de Souza, S.C. and Piazza, F.C. (2013) Estudo comparativo da técnica de radiofrequência em disfunções esteticas faciais. *Revista Interdisciplinar de Estudos em Saúde*, **2**, 120-138.
https://periodicos.uniarp.edu.br/index.php/ries/article/view/150

[5] Bergfeld, W.F. (1999) A Lifetime of Healthy Skin: Implications for Women. *International Journal of Fertility and Women's Medicine*, **44**, 83-95.
https://pubmed.ncbi.nlm.nih.gov/10338266/

[6] Inácio, R.F., Bernardi, D. and Romano, L.H. (2017) Análise comportamental do tecido adiposo frente ao tratamento de radiofrequência: Revisão bibliográfica. *Revista Saúde em Foco*, No. 9, 4-11.
http://ehrmed.com.br/wp-content/uploads/2016/10/Analise-comportamental-do-tecido-adiposo-frente-ao-tratamento-de-Criofrequencia.pdf

[7] Tagliolatto, S. (2015) Radiofrequência: Método não invasivo para tratamento da flacidez cutânea e contorno corporal. *Surgical & Cosmetic Dermatology*, **7**, 332-338.
https://www.redalyc.org/pdf/2655/265544156009.pdf

[8] da Silva, R.M., da Silva, M.W., de Medeiros, S.F., de Brito Guerra, S.S., da Silva Nobre, R. and Meyer, P.F. (2018) Effects of Cryofrequency on Localized Adiposity in Flanks. *Manual Therapy, Posturology & Rehabilitation Journal*, **16**, Article No. 551.
https://app.periodikos.com.br/journal/mtprehab/article/doi/10.17784/mtprehabjournal.2018.16.551

[9] Silva, M.C. (2016) Avaliação do uso da criofrequência como terapêutica para a redução da adiposidade abdominal. https://core.ac.uk/download/pdf/185256899.pdf

[10] Mendonça, A.G., Rodrigues, R.D., Corradi, D.P., Cruz, L.B., Meyer, P.F., Antunes, M.D. and Agne, J.E. (2008) Protocolo de avaliação fisioterapêutica em adiposidade localizada. *Fisioterapia Brasil*, 26-31.

[11] Azzi, A.J., Lafrenière, A.S., Gilardino, M. and Hemmerling, T. (2019) Ultrasonography Technique in Abdominal Subcutaneous Adipose Tissue Measurement: A Systematic Review. *Journal of Ultrasound in Medicine*, **38**, 877-888.
https://doi.org/10.1002/jum.14789
https://onlinelibrary.wiley.com/doi/abs/10.1002/jum.14789

[12] Ferraro, G.A., De Francesco, F., Cataldo, C., Rossano, F., Nicoletti, G. and D'Andrea, F. (2012) Synergistic Effects of Cryolipolysis and Shock Waves for Noninvasive Body Contouring. *Aesthetic Plastic Surgery*, **36**, 666-679.
https://doi.org/10.1007/s00266-011-9832-7
https://link.springer.com/article/10.1007/s00266-011-9832-7

[13] Avram, M.M. and Harry, R.S. (2009) Cryolipolysis™ for Subcutaneous Fat Layer Reduction. *Lasers in Surgery and Medicine*, **41**, 703-708.

https://doi.org/10.1002/lsm.20864

[14] Meyer, P.F., Furtado, A.C., Morais, S.F., de Araujo, N., Gonzaga, L., Silva, R.M. and Medeiros, M.L. (2017) Effects of Cryolipolysis on Abdominal Adiposity of Women. *Cryoletters*, **38**, 379-386. https://www.ingentaconnect.com/content/cryo/cryo/2017/00000038/00000005/art00005

[15] Downie, J. and Kaspar, M. (2016) Evaluated by Magnetic Resonance Imaging (MRI): Case Study. *Journal of Drugs in Dermatology*, **15**, 491-495. https://files.btlnet.com/product-document/25d68e60-1ce4-4bc9-87f6-4226f4d20937/BTL_Vanquish_ME_CB_Contactless-abdominal-fat-reduction-evaluated-by-MRI_25d68e60-1ce4-4bc9-87f6-4226f4d20937_original.pdf

[16] Fajkošová, K., Machovcová, A., Onder, M. And Fritz, K. (2014) Selective Radio-frequency Therapy as a Non-Invasive Approach for Contactless Body Contouring and Circumferential Reduction. *Journal of Drugs in Dermatology*, **13**, 291-296. https://www.aiderm.com/wp-content/uploads/2014/10/Journal-of-drugs-in-dermatology-VANQUISH-Article.pdf

[17] Grivicich, I., Regner, A. and Rocha, A.B. (2007) Morte celular por apoptose. *Revista brasileira de cancerologia*, **53**, 335-343. https://doi.org/10.32635/2176-9745.RBC.2007v53n3.1801 https://rbc.inca.gov.br/revista/index.php/revista/article/view/1801

[18] McDaniel, D. and Lozanova, P. (2015) Human Adipocyte Apoptosis Immediately Following High Frequency Focused Field Radio Frequency: Case Study. *Journal of Drugs in Dermatology*, **14**, 622-623. https://jddonline.com/articles/human-adipocyte-apoptosis-immediately-following-high-frequency-focused-field-radio-frequency-case-st-S1545961615P0622X/

[19] Boey, G.E. and Wasilenchuk, J.L. (2014) Enhanced Clinical Outcome with Manual Massage Following Cryolipolysis Treatment: A 4-Month Study of Safety and Efficacy. *Lasers in Surgery and Medicine*, **46**, 20-26. https://doi.org/10.1002/lsm.22209 https://onlinelibrary.wiley.com/doi/full/10.1002/lsm.22209

[20] Moreno-Navarrete, J.M., Ortega, F., Gómez-Serrano, M., García-Santos, E., Ricart, W., Tinahones, F., Mingrone, G., Peral, B. and Fernández-Real, J.M. (2013) The MRC1/CD68 Ratio Is Positively Associated with Adipose Tissue Lipogenesis and with Muscle Mitochondrial Gene Expression in Humans. *PLoS ONE*, **8**, Article ID: e70810. https://doi.org/10.1371/journal.pone.0070810 https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0070810

[21] Ramalho, R. and Guimarães, C. (2008) The Role of Adipose Tissue and Macrophages in Chronic Inflammation Associated with Obesity: Clinical Implications. *Acta médica portuguesa*, **21**, 489-496. https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/1635

[22] Nelson, A.A., Wasserman, D. and Avram, M.M. (2009) Cryolipolysis for Reduction of Excess Adipose Tissue. *Seminars in Cutaneous Medicine and Surgery*, **28**, 244-249. https://doi.org/10.1016/j.sder.2009.11.004 https://www.ingentaconnect.com/contentone/fmc/scms/2009/00000028/00000004/art00007

[23] Gasparri, F., Mariani, M., Sola, F. and Galvani, A. (2004) Quantification of the Proliferation Index of Human Dermal Fibroblast Cultures with the ArrayScan™ High-Content Screening Reader. *Journal of Biomolecular Screening*, **9**, 232-243. https://doi.org/10.1177/1087057103262836 https://journals.sagepub.com/doi/abs/10.1177/1087057103262836

[24] Paasch, U., Bodendorf, M.O., Grunewald, S. and Simon, J.C. (2009) Skin Rejuvena-

tion by Radiofrequency Therapy: Methods, Effects and Risks. *JDDG: Journal der Deutschen Dermatologischen Gesellschaft*, **7**, 196-203.
https://doi.org/10.1111/j.1610-0387.2008.06780.x
https://onlinelibrary.wiley.com/doi/full/10.1111/j.1610-0387.2008.06780.x

[25] Zelickson, B.D., Kist, D., Bernstein, E., Brown, D.B., Ksenzenko, S., Burns, J., Kilmer, S., Mehregan, D. and Pope, K. (2004) Histological and Ultrastructural Evaluation of the Effects of a Radiofrequency-Based Nonablative Dermal Remodeling Device: A Pilot Study. *Archives of Dermatology*, **140**, 204-209.
https://doi.org/10.1001/archderm.140.2.204
https://jamanetwork.com/journals/jamadermatology/article-abstract/480241