SKIN CHANGES AND NUTRIENT DEFICIENCY AFTER BARIATRIC SURGERY

A LITERATURE REVIEW ON DERMATOLOGICAL ALTERATIONS AND NUTRITIONAL DEFICIENCIES FOLLOWING WEIGHT LOSS AFTER BARIATRIC SURGERY

NUTRITION ◆ SKIN ◆ TRANSFORMATION ◆ SCIENCE

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Preface

Dear Reader

Obesity is a stigmatizing disease, especially among women, who seek treatments that may disregard body shape. Obesity causes several dermatological aberrations, including edema, ulcerations, stretch marks, cellulite, and other disorders. The etiology of skin laxity after rapid weight loss has not yet been adequately studied and is generally attributed to damage to collagen and elastin, which allows skin retraction. The objective of this e-book was to investigate, through a literature review of clinical studies, the characteristics of changes in skin elasticity and nutrients after bariatric surgery for a better understanding of these conditions and patient treatment. The results revealed that the literature data demonstrate changes in skin elasticity and nutrients after bariatric surgery. These skin changes may occur due to nutritional deficiencies, which can contribute to alterations in elastic and collagen fibers, laxity, excess skin, stretch marks, cellulite, edema, ulcerations, and infections that lead to problems in wound healing. This e-book can contribute to the understanding of the effects of obesity and significant weight loss after bariatric surgery on the skin characteristics of these patients. Treatment options include procedures that improve sagging and elasticity, and in cases of excess skin, plastic surgery to improve body contour. Thus, patients can achieve body satisfaction, improved health with a reduction in comorbidities caused by obesity, and consequently, an improved quality of social life.

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SUMMARY

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INTRODUCTION

Obesity is a serious global health problem, as the rate of obesity has increased dramatically in recent decades [1]. According to the World Health Organization (WHO), obesity is the fifth leading cause of death, along with overweight, leading to more than 2.8 million deaths annually [2].

In developed Western culture, a slim body is considered attractive, healthy, and socially acceptable. Obesity is a stigmatizing disease, especially among women, since most people do not know the cause of obesity, such as the genetic factors involved, which increases the stigma towards those with this condition, due to obesity being conceived as a moral defect or being associated exclusively with the individual's behavior. Women predominate in seeking treatment that often disregards body shape [3-5].

Obesity has been associated with an increased risk for diseases such as diabetes, cardiovascular disease, changes in musculoskeletal disorders, and even certain types of cancer. Furthermore, obesity can also cause some dermatological aberrations, affecting body structures formed by epithelial and connective tissue that make up the skin, appendages such as sweat and sebaceous glands, hair follicles, vascularization, lymphatic vessels, microcirculation, and can also affect the response to trauma, such as in wound healing. Recurrent infectious problems, hyperpigmentation, edema and ulcerations, stretch marks, cellulite, and other disorders are also common [3,4,6,7].

These dermatological changes can be caused by the process of increased flaccidity in obese individuals after weight loss. The etiology of skin flaccidity after rapid weight loss has not yet been properly studied. It generally occurs due to damage to collagen and elastin fibers, which allow skin retraction after weight loss [8]. Furthermore, the study on the effect of weight loss after bariatric surgery on the skin and extracellular matrix showed

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significant signs of damage to the components of the extracellular matrix despite being a short-term bariatric procedure study [9].

Approaches for the treatment of clinically significant obesity have been developed including diet, exercise and drugs, among others. Bariatric surgery is considered with strict eligibility criteria imposed by the National Institutes of Health for morbidly obese patients when non-surgical treatment fails to achieve weight loss [4,10].

There are several types of bariatric surgery accompanied by different levels of nutritional deficiencies and metabolic imbalances that affect the skin, either by altering its microarchitecture or by changes in its immunity and defense mechanisms, which lead to inflammation and increased susceptibility to pathogens. Vitamin and mineral deficiencies, among others, appear to play an important role in the pathogenesis of dermatological diseases after bariatric surgery [5,10].

Obesity and significant weight loss represent a new scientific field to be investigated. While studies have investigated the clinical outcomes in patients who underwent bariatric surgery and who underwent plastic surgery after weight loss through bariatric surgery, a study is needed to analyze at a microscopic level to understand the effects of obesity and significant weight loss on the skin and wound healing, and to assess the possible causes of skin laxity [3,4,5,9].

Considering this context, this e-book aimed to investigate, through a literature review of clinical studies, the characteristics of changes in skin elasticity and nutrients after bariatric surgery for a better understanding of these conditions and the treatment of patients.

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CHAPTER I

Obesity - Epidemiology, Etiology and Risk Factors

Obesity has become a prominent public health problem worldwide. According to the World Obesity Atlas, overweight and obesity will affect nearly 3 billion adults by 2030 [1]. Considered a cause of morbidity and mortality in the population, excess weight in obese individuals can contribute to the development of psychological morbidity, metabolic changes, cancer, and cardiovascular, dermatological, and musculoskeletal diseases [11,12].

Among dermatological changes, most obese patients present with skin distension forming stretch marks, plantar hyperkeratosis, increased risk of skin infections, poor wound healing [10,13], malignant melanoma, and increased risk of inflammatory dermatoses, such as psoriasis, as well as some rarer disorders [12,14]. Cutaneous aspects also show histological changes in skin architecture, and thus modifications in the components that provide the structure of the dermis have been investigated [14,15].

Primary care professionals recognize that obesity is a major contributor to the burden of chronic diseases. Effective weight management can be challenging in treating these diseases, considering that the pathophysiology drives weight gain in susceptible individuals and hinders weight loss and maintenance. Primary care professionals should be aware of the following practical recommendations [16]:

- Body mass index (BMI) is a valuable part of the electronic health record, but it is a screening measure, not a diagnostic measure. The diagnosis of obesity is confirmed by the presence of abnormal excess body fat that impairs health.

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Parameters such as patient genetics, ethnicity, and waist circumference should be considered as part of the BMI characteristics.

- ❖ Consider comorbidities and health risks when determining the intensity of the treatment approach.
- ❖ Modest or moderate weight loss can produce health benefits. Regarding more serious complications, greater weight loss may be necessary. For patients with severe obesity and complications, bariatric surgery should be considered.
- ❖ For the diet to be successful, there are several approaches, such as prescribing a diet that the patient can adhere to with health benefits; to this end, a successful lifestyle change requires skills training. Patients should have access to counseling sessions with at least 14 sessions over 6 months and annual follow-up.
- ❖ Medications approved for chronic weight management can help patients adhere better to the diet plan and can help sustain hard-won weight loss. Medications should be prescribed and success assessed between 12 and 16 weeks. In case of success, medications should be continued.
- ❖ Obesity is a complex chronic disease, so lifelong management is indicated.

Studies report that socioeconomic status in childhood influences body mass index, waist circumference, and obesity in adults, with differences between genders [16,17]. Thus, exposure to famine early in life, fetal or before the age of 50, can increase BMI, the risk of overweight and obesity, especially for women. Similarly, a higher socioeconomic status among men and a lower socioeconomic status among women were associated with higher adiposity indicators [16]. In cross-sectional and Asian studies, the risk of overweight and obesity in individuals exposed to famine caused by natural disasters is higher than in the unexposed group [17].

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Different approaches have been described for the treatment of obesity, such as diet, exercise, and medication, among others. However, bariatric surgery has been considered in cases where non-surgical procedures have not shown improvement in comorbidities, as well as weight reduction. Thus, bariatric surgery may be indicated for the treatment of obese patients with comorbidities associated with mortality [3,4].

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CHAPTER II

Surgical Interventions for Patients with Obesity

Bariatric surgery is an effective procedure superior to conventional weight loss therapy [18]. Thus, this surgical procedure has helped thousands of patients move towards a healthier life, dealing with the comorbidities of morbid obesity [10]. This surgery leads to substantial long-term weight loss, with improvement in these comorbidities due to the reduction in BMI, metabolic and functional factors of cardiovascular disease, including hypertension, lipid disorders, non-alcoholic fatty liver disease, musculoskeletal pain, in addition to reducing mortality from diabetes, cardiovascular diseases, and cancers [10,18,19].

The safety of this procedure has been well studied and is not significantly greater than that of routine abdominal surgeries. The acute complications of this surgery are infection, bleeding, and anastomotic leakage [19]. The guidelines from the American Heart Association / American College of Cardiology / The Obesity Society (AHA / ACC / TOS) strongly recommend that physicians be proactive in identifying and referring patients who could benefit from bariatric surgery. These recommendations include a Body Mass Index (BMI) greater than or equal to 40 or a BMI greater than or equal to 35 for adult patients with obesity-related comorbidities as basic criteria for surgery [2].

In this respect, bariatric surgeries are divided into three categories: restrictive procedures, malabsorptive procedures, and a combination thereof. Restrictive surgeries do not alter the qualitative or quantitative absorption of nutrients and include vertical banded and non-adjustable ring gastroplasty, laparoscopic adjustable gastric banding, and sleeve gastrectomy. Malabsorptive surgery encompasses procedures that cause

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malabsorption of macro and micronutrients such as biliopancreatic diversion with or without duodenal switch [14].

Mixed procedures consist of Roux-en-Y gastric bypass (RYGB) surgery, which combines the procedures described above and induces changes in the neuro-hormonal pathways that regulate energy balance. In this type of procedure, an isolated part of the stomach is directly connected to the middle part of the small intestine, resulting in decreased gastric capacity, decreased acid secretion, and lack of nutrient absorption from the duodenum and proximal jejunum [4,10]. Malabsorption after RYGB is limited to micronutrients, and vitamin and mineral supplementation is necessary to prevent deficiencies. Complications of RYGB are diverse and include distension of the remaining stomach, stomach stenosis, marginal ulcer formation, cholelithiasis, ventral hernias, internal hernias, hypoglycemia, dumping syndrome, metabolic and nutritional disorders, and weight regain [14].

In the long term, complications after bariatric surgery include nutritional deficiencies, including vitamins and minerals, and anemia. Some patients may develop dumping syndrome after meals, and some patients may experience postprandial hypoglycemia after RYGB. In addition, about 25% of patients require plastic surgery to relieve excess skin tissue [19].

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CHAPTER III

Nutrient deficiency and skin changes

Inadequate eating habits contribute to obesity and lead to vitamin deficiencies [20]. Food insecurity is related to poverty, which in turn has traditionally been associated with malnutrition. The nutritional transition in Brazil may be shaping the differential deleterious effect of food insecurity on the accumulation of body fat throughout life. Severe food insecurity has been associated with obesity among adult women and moderate food insecurity with overweight among female adolescents; however, it is not yet established among male or female children [21].

Data from the literature show that most obese individuals have vitamin deficiencies due to differences in the intake of fruits and vegetables in the diet, resulting from alterations in the physiology of micronutrient metabolism, with greater fat mass leading to increased sequestration of lipophilic vitamins in adipose tissue. Fat-soluble vitamins include vitamins A, D, E, and K, which are necessary for various bodily functions, such as bone metabolism, blood clotting, immune response, antioxidant activity, and other actions necessary for the prevention of many diseases. Water-soluble vitamins include the B complex vitamins and vitamin C (ascorbic acid), which are essential for metabolism, participating in various metabolic pathways and involved in energy production reactions, redox reactions, and the transfer of carbon units [20].

The assessment of vitamin status is of fundamental importance in obese individuals. Obese individuals are particularly deficient in fat-soluble vitamins (A, D, E, and K) and, among the water-soluble vitamins, folic acid and vitamins B12 and C. However, some vitamins have been less evaluated in cases of obesity. Adipose tissue is

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considered an endocrine and metabolic organ, which in excess leads to alterations in the body's homeostasis, as well as vitamin deficiencies that can aggravate the pathological state [20].

Regarding dermatological changes, body composition appears to interfere with the synthesis and metabolism of 25(OH)D. The prevalence of vitamin D deficiency, a precursor molecule of this compound, is higher in obese individuals, resulting in a high concentration of fat in subcutaneous and visceral tissues than in non-obese individuals, who have less fat accumulation in these tissues [22,23].

Vitamin C is necessary for the post-translational modification of pro-collagen polypeptides to form a resistant and flexible molecule [24,25]. Defective collagen synthesis is one of the most common symptoms attributed to scurvy, leading to fatigue, reducing the willingness to exercise, and contributing to the worsening of obesity [20,24,25].

Also, vitamin B12 deficiency can result in hyperpigmentation of the skin, changes in the mucous membranes, and dark brown discoloration on the back of the hands and feet, skin folds, and nails with uniform pigmentation or longitudinal bands. Furthermore, atrophic glossitis, angular cheilitis, and aphthous stomatitis are found in patients with vitamin B12 deficiency. Pigmentation changes can be caused by an increased number of melanocytes in the basal layer, melanin granules in the basal layer, dermal blood vessels, collagen distortion, and fragmented elastic fibers in the reticular dermis [10].

Weight loss after bariatric surgery or dieting is usually accompanied by an improvement in body image, and in most operated individuals, these feelings remain at a stable level in the long term. In clinical practice, however, despite the highly satisfactory weight loss, some individuals still disregard their body image and seek body contouring procedures to improve their physical appearance [26].

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Clinical evidence of macroscopic differences in the structure of connective tissue proper (dermis) and adipose tissue (hypodermis), in color and texture, has been observed by plastic surgeons in body contouring procedures in post-bariatric obese patients [27-30]. These differences may occur due to malabsorption and nutritional deficiencies observed after bariatric surgery, resulting from reduced food intake and absorption of macro and micronutrients [14,31].

Some skin changes can be expected one year after weight loss; after that, little change is likely to occur, and surgical procedures may be necessary to meet patients' needs and restore body image [32,33]. Thus, therapeutic interventions for obesity through medication or surgical interventions are increasingly common. All these treatment modalities also have dermatological side effects [5].

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CHAPTER IV

Skin Complications Related to Bariatric Surgery and/or Weight Loss

The skin changes observed in obesity affect both the epidermis and the underlying dermis and hypodermis, as well as lymphatic flow and collagen formation [4,5,7]. These changes can affect wound healing, cause lymphedema, cellulite, and other skin-related conditions. Poor wound healing in obese individuals may result from obesity-related comorbidities that can contribute to decreased tissue perfusion. Thus, treating complications arising from skin changes observed in obesity can be even more challenging for both the patient and the professional [34].

About 90% of post-bariatric patients with massive weight loss tend to exhibit negative secondary effects due to the large amount of redundant skin. In addition to aesthetic problems, this leads to functional problems, dermatoses, and difficulties with personal hygiene [14]. These patients present histological alterations of the skin, since weight loss affects the microarchitecture, such as the components of the extracellular matrix, which acquires poor organization of collagen, elastin degradation, and scar formation within macroscopically normal areas [9,14].

In the wound healing process in post-bariatric patients, abnormal elastic and collagen fibers are visualized. Complications may be caused by deterioration of the extracellular matrix, probably attributed to constant inflammation that results in a degrading effect on the skin [10].

In addition, after gastric bypass (Roux-en-Y bypass or Fobi-Capella surgery), nutritional deficiencies resulting from this type of procedure occur, which indirectly alter the immunity and integrity of the skin through different mechanisms [9]. Considering

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nutritional deficiencies, insufficient nutritional support, such as that provided to intensive care unit patients, can facilitate the development of skin conditions, with skin infections being the most common in these patients [10]. However, a relationship between nutritional status, increased collagen in the wound, and elastic fiber content appears to be partially involved [27,35].

It has been reported that after weight loss, collagen production decreases and subcutaneous fat begins to show poorly defined lobules and more fibrous attachments [10]. A large remodeling of collagen with an increase in Picrosirius staining has also been observed and corresponds to increased collagen degradation and a significant decrease in cross-linking [36].

The connective tissues proper to the dermis and adipose tissue are important in all plastic surgery procedures because they are involved in healing and possible postoperative complications such as necrosis, liponecrosis, seromas, among others. The skin of patients after plastic surgery who had previously undergone bariatric surgery showed changes in adipose tissue with thickening of the fibrous septa and retracted adipocytes with thickening of the plasma membrane. Dermal changes that may have occurred as a compensatory reaction similar to tissue expansion were collagen thickening, vascular network hypertrophy, and loss of elastic fibers [27].

Another change observed in obese patients after massive weight loss is decreased blood flow, considering that these patients have increased fibrosis in the subcutaneous arteries of low resistance [10], although weight loss induced by bariatric surgery can result in almost complete regression of microvascular fibrosis [13,35,37]. Regarding the vascular system, the hormone leptin promotes endothelial cell proliferation and angiogenesis.

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This hormone is strongly correlated with obesity, as it is secreted by adipocytes and regulates energy homeostasis and food intake. Thus, it is believed that increased leptin levels in those with obesity have toxic effects on the vascular system and lead to capillary leakage and necrosis [7]. Proteoglycans containing heparan sulfate have also been linked to cell proliferation and angiogenesis processes, as well as other biological activities such as inflammation and hemostasis. Heparan sulfates are linked to different proteins in the nucleus and can be found on the cell surface and in the extracellular matrix, such as the basement membrane, thus interacting with a wide range of proteins that induce these biological processes.

After bariatric surgery, the patient's skin shows lower concentrations of heparan sulfate and perlecan, and an increase in type III collagen. Perlecan, in turn, is a primary component of the basement membrane that interacts with several growth factors, such as vascular endothelial growth factor (VEGF)-A, essential for epidermal formation and angiogenesis [14].

Literature data show increasing recognition of the role of genetic factors in the etiology of obesity. Although in the vast majority of cases these influences are polygenic, some obese children suffer from monogenic disorders, which may present only with obesity. However, most of the time, they usually exhibit other syndromic alterations [11]. Thus, its etiology acquires a multifactorial character.

The molecular mechanisms responsible for the dysfunction of extracellular matrix remodeling in obese individuals after bariatric surgery and/or weight loss have been investigated [38]. The authors investigated the expression of some genes involved in this mechanism by comparing the skin of obese individuals and normal skin. The skin of obese patients with extensive weight loss after bariatric surgery showed increased expression of peroxisome proliferator-activated receptor gamma coactivator (PGC-1beta), which may

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result in decreased expression and activity of matrix metalloproteinase 9 (MMP9) and increased collagen types III and IV. These molecular changes may contribute to the formation of sagging skin folds observed in these patients and impair wound healing. Although it is not known whether PGC-1beta can control the production of collagen precursors in fibroblasts as it does in macrophages, the data suggested a potential role for this cofactor in collagen production in the skin [39].

Other authors have shown that collagen deposition depends on the balance between its secretion by fibroblasts and its degradation, and that collagen types III and IV are mainly metabolized by MMP9 [38]. Patients undergoing abdominoplasty after massive weight loss present with loose, soft skin lacking a sufficient collagen fiber network [40]. These patients with significant weight loss have poor skin elasticity, decreasing resistance layers such as the dermis and epidermis, and low collagen quality. Furthermore, patients with massive weight loss who have undergone plastic surgery procedures have a higher risk of complications such as hematomas and seromas. Another undesirable outcome that cannot be easily measured is skin relaxation after plastic surgery in these weight-loss patients [41].

It was also observed that the amount of collagen in the linea alba above the umbilical region in morbidly obese patients was lower than in non-obese individuals of the same age group, confirming the reduction of collagen fibers in obese patients, who, after weight loss, may present excess and folds of skin with loss of elasticity [42].

Matsumoto et al. (2014) [43] investigated the expression level of the heme oxygenase-1 gene (heme oxygenase-1, HMOX1), a marker of oxidative stress in humans, considering that in animals there was an increase in oxidative stress levels due to hypertrophy of subcutaneous adipose cells, which produce collagenolytic enzymes resulting in structural changes in the dermis [44-46]. HMOX1 expression was

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significantly lower in the abdomen and thigh in overweight men compared to individuals in the control group. Thus, the authors evidenced increased levels of oxidative stress and decreased dermal collagen density in the thigh, abdomen, and arm.

In addition, the echogenicity of the upper and lower dermis of the abdomen and the lower part of the thigh dermis was significantly lower in the overweight group than in the control group. Thus, these findings suggest the fragility of the dermis in overweight men, which may have been caused by the accumulation of subcutaneous adipose tissue [43].

The parameters of thickness and echogenicity of the dermis in young people between 20 and 30 years of age with overweight and obesity after weight loss were studied, and the authors observed a decrease in thickness and an increase in echogenicity of the dermis in the thighs of 83.3% of the individuals investigated. Thus, the dermal structure in the thighs of young overweight individuals can be improved after weight loss and reach the level of structure observed in those of individuals with normal weight [43]. Thus, it can be shown that the skin of patients with massive weight loss is weakened due to the lower density and thickness of collagen fibers and damage to their elastic fibers [47].

As the abdomen, flanks, thighs, upper arms, buttocks, and breasts increase in size, stretch marks may occur, especially when the increase is rapid, due to the rupture of the dermal layer of the skin [48,49]. In the initial process of stretch marks, the skin is stretched, and thin, red, shiny stripes appear, which may be accompanied by itching; over time, they become whitish and acquire a different texture from normal skin [34,48].

Another skin alteration caused by obesity is dryness of the skin with increased transepidermal water loss as a result of a change in the epidermal barrier. Dry skin often

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causes itching, contributes to decreased effectiveness of the skin's barrier function, and causes skin breakdown; it can contribute to the appearance of stretch marks [7,12,34].

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CHAPTER V

Histological Characteristics of the Skin in Healthy Individuals

The skin is the largest organ in the human body and acts as the first line of defense, protecting internal organs against external trauma and pathogenic infections. It consists of an outer layer, the epidermis, and a thicker, inner layer, the dermis. Underlying the dermis is the subcutaneous tissue, hypodermis, or superficial fascia. The dermis, consisting of connective tissue proper, forms the largest part of the skin and separates the epidermis from the subcutaneous tissue. It consists of the papillary dermis and the reticular dermis. The dermal papillae found in the dermis project upwards into recesses in the epidermis. Unlike the epidermis, the dermis is more fibrous than cellular and contains blood vessels. Like all connective tissue, the dermis is of mesodermal origin, but it also contains structures of ectodermal origin, such as hair follicles and sebaceous and sweat glands originating from the invagination of the epidermis [50-53].

The dermis also contains blood and lymphatic vessels, autonomic and sensory nerve fibers, and sensory corpuscles. Few cells are found in the dermis, including histiocytes, fibroblasts, and mast cells. The main function of the dermis is to act as a resistant matrix and provide support to nerves and blood vessels. Two types of fibers are found in the dermis, predominantly collagen (97.5%) and elastin (2.5%). Collagen fibers run parallel to the skin surface, while elastin fibers form a network. Collagen fibers are responsible for the resilience of the dermis. Collagen is an important component of connective tissue, and 80% of the total collagen in the body is found in the dermis and bones. Fibroblasts, the main type of skin cell, produce collagen, mainly types I and III [51].

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The second most important structural element of the skin is elastic fibers, consisting of the protein elastin and microfibrils (fibrillin). This material, also synthesized by fibroblasts in the skin, allows the skin to be stretched, compressed, and contracted, returning to its original shape. The elastic fibers located in the papillary dermis have microfibrils passing vertically through the dermoepidermal junction DEJ; they form oxytalan fibers that combine with elaunin fibers. The elastic fibers found in the reticular dermis layer run parallel to the skin surface between the collagen fibers. The network that elastic fibers form in young skin is lost as one ages. The skin loses its elasticity and has a flaccid appearance. With extrinsic photoaging, elastin fibers accumulate, a condition known as "elastosis". The fibers become thicker and more coiled, altering the properties of the fibers [51].

Viscoelasticity, a reversible deformation property, allows the skin to stretch to a certain physiological limit under physical stress and then return to its resting state once the load is removed. Sliding and realigning collagen fibers allows the skin to deform while maintaining its integrity and preventing damage, while elastic fibers will return the skin to its resting state after the external force is removed. In addition to mechanical stress, biological (cancer and aging) and environmental (sunlight and ultraviolet, UV) factors are also capable of altering the architecture and structural properties of collagen and elastin networks in the skin [5,51,52].

The loss of fibroblasts, elastin, and collagen is related to the onset of sagging with loss of skin elasticity. Considering that elasticity results from the three-dimensional structure formed by collagen and elastin fibers found in the dermis, its loss causes the network of elements to become less dense, reducing the firmness between cells. Changes can occur due to aging or exposure to radiation [54-57], nutritional deficiencies, obesity, weight gain, and loss [7,34].

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Below the dermis, we find the hypodermis or subcutaneous tissue composed of adipose cells, nerves and larger blood vessels. It is through this layer that the dermis connects with the deep fascia. The thickness of this layer varies according to the different parts of the body, being greater in the abdomen and buttocks, where adipose tissue is found, and also varies according to nutritional status [4,5].

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FINAL CONSIDERATIONS

Conventional behavioral and pharmacological therapies applied for long-term weight loss have shown limited success in severe obesity, leading to increased interest in bariatric surgery. Massive weight loss after surgery leads to bodily changes such as excess loose and constricted skin, causing physical discomfort and psychosocial problems. Furthermore, this procedure also leads to dermatological changes mainly caused by malabsorption and nutritional deficiencies, which can contribute to alterations in elastic and collagen fibers, sagging, excess skin, edema, ulcerations, and infections that lead to problems in wound healing. This e-book shows the effects of obesity and significant weight loss after bariatric surgery on the skin characteristics of these patients, which can be treated with procedures that improve skin laxity and elasticity. Early recognition of nutritional deficiencies and replacement of vitamins and trace elements can contribute to better outcomes after bariatric surgery. In cases of excess skin, these patients may undergo plastic surgery to improve the appearance of body contour. Thus, patients find satisfaction with their bodies, improved health with a reduction in comorbidities caused by obesity, and consequently, an improved quality of social life.

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SKIN CHANGES AND NUTRIENT DEFICIENCY AFTER BARIATRIC SURGERY

A LITERATURE REVIEW ON DERMATOLOGICAL ALTERATIONS AND NUTRITIONAL DEFICIENCIES FOLLOWING WEIGHT LOSS AFTER BARIATRIC SURGERY

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