# SAFE GLUTEAL HARMONIZATION: COMPLICATIONS AND CLINICAL MANAGEMENT

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**Abstract**

**The increasing emphasis on body aesthetics has driven the development of harmonization techniques, with particular focus on the gluteal region, which plays a key role in body proportion and silhouette harmony. This study aims to analyze the main gluteal harmonization techniques, as well as their associated complications and clinical management strategies. The theoretical framework is based on the anatomy of the gluteal region and the most commonly used therapeutic approaches, including autologous fat grafting, silicone implants, fillers, and collagen biostimulators. The methodology consists of a qualitative literature review based on recent scientific studies addressing efficacy, safety, and adverse events. The results indicate that autologous fat grafting demonstrates high efficacy and natural outcomes, being considered the gold standard, while minimally invasive techniques show favorable results and rapid recovery. Conversely, permanent materials are associated with a higher risk of late complications. The most commonly reported adverse events include seroma, infection, nodules, and necrosis, with severe complications often related to improper technique. The discussion highlights the importance of anatomical knowledge, individualized planning, and the selection of the subcutaneous plane to enhance safety. It is concluded that gluteal harmonization, when performed based on scientific evidence, yields safe and effective outcomes.**

***Keywords:*** **Body harmonization; gluteal region; body contouring; gluteal volumization; safety in aesthetic procedures.**

## I. INTRODUCTION

Body harmonization (Body Harmonization Approach – BHA) has emerged as an integrative paradigm in aesthetic medicine by shifting from approaches focused on correcting "isolated defects" to a systemic view of the body that simultaneously considers form, function, and aesthetic meaning [1]. Within this framework, clinical decision-making is guided by anatomical-functional,aesthetic-sociocultural, and technical-scientific axes, enabling the implementation of evidence-based protocols and promoting greater therapeutic standardization [2–4]. From this perspective, the gluteal region assumes a prominent role due to both its aesthetic relevance—often associated with body proportionality and the construction of body identity—and its functional importance, as it is involved in essential biomechanical processes such as hip extension, pelvic stabilization, and locomotion [5]. Owing to these characteristics, interventions in this area require in-depth knowledge of local anatomy, including tissue planes, gluteal musculature, and vascular and neural structures, in order to guide appropriate technique selection and reduce the risk of iatrogenic complications [6,7].

In contemporary aesthetic medicine, gluteal harmonization can be achieved through various therapeutic approaches. Among the most commonly used techniques are autologous fat grafting, silicone implants, and the application of fillers and biostimulators, such as polymethylmethacrylate (PMMA), hyaluronic acid (HA), calcium hydroxyapatite (CaHA), and poly-L-lactic acid (PLLA) [1]. In addition to these options, adjunctive regenerative therapies, such as platelet-rich plasma (PRP), have also been described as complementary strategies to optimize tissue quality and enhance aesthetic outcomes [8]. Each of these modalities presents distinct mechanisms of action, durability, and safety profiles, and should be selected according to the patient's anatomical characteristics, clinical indications, and established therapeutic goals [1]. Despite advances in techniques and materials, procedures performed in the gluteal region may still be associated with complications [9]. Among the most frequently reported adverse events in the literature are seroma, infection, and granuloma formation, the incidence of which may be reduced through appropriate procedural planning and correct selection of the injection plane [7,10,11]. Recent studies also indicate that the adoption of safety strategies—such as performing injections in the subcutaneous plane and using ultrasound guidance during procedures—can significantly reduce risks [12,13]. More severe complications reported in the literature are primarily associated with deep intramuscular injection, which is why current protocols emphasize measures such as the use of blunt cannulas, appropriate orientation of injection vectors, and avoidance of high-risk anatomical planes [14,15].

In this context, the present study is justified by the increasing demand for gluteal harmonization procedures within the framework of BHA, as well as by the need to compile and critically analyze scientific evidence to support safer, more ethical, and evidence-based clinical practice. Accordingly, this literature review aims to systematize the fundamental principles of gluteal harmonization, discuss the main volumization and biostimulation techniques, and analyze aspects related to the efficacy, safety, risks, and benefits of these procedures. Ultimately, the objective is to organize and synthesize scientific knowledge that supports safer and more effective clinical decision-making, while also strengthening academic and professional training in aesthetic biomedicine, expanding the scientific discussion on body harmonization, and promoting practices aligned with current demands for quality, safety, and satisfactory aesthetic outcomes.

## II. METHODOLOGY

The present study is characterized as a qualitative and descriptive literature review aimed at gathering and analyzing scientific evidence related to gluteal harmonization within the framework of the Body Harmonization Approach (BHA). Data collection was conducted through a comprehensive bibliographic search in national and international scientific databases, including PubMed, SciELO, and Google Scholar, as well as consultation of specialized textbooks on body harmonization and applied aesthetic anatomy. Scientific articles, systematic reviews, clinical studies, and relevant publications addressing the anatomy of the gluteal region, techniques for gluteal augmentation and remodeling, associated complications, and safety strategies in aesthetic procedures were selected, considering studies published between 2000 and 2026. Inclusion criteria comprised studies published primarily in recent years, available in Portuguese or English, and addressing gluteal harmonization techniques, biostimulators, fat grafting, implants, and other volumization methods used in aesthetic practice. Studies discussing anatomical aspects of the gluteal region and the use of auxiliary technologies, such as ultrasonography, were also included. Following source selection, an exploratory and analytical reading of the studies was performed, followed by the extraction of the most relevant information for the proposed topic. The data were analyzed using comparative and interpretative approaches, allowing the identification of patterns, evidence, and gaps in the literature. Subsequently, the information was organized into thematic categories related to gluteal anatomy, treatment techniques, potential complications, and safety measures. This process enabled a critical synthesis of the available scientific knowledge on gluteal harmonization.

## III. THEORETICAL FRAMEWORK

### Definition of the body harmonization concept

Body harmonization (Body Harmonization Approach – BHA) represents a contemporary concept in aesthetics that integrates combined and minimally invasive techniques aimed at aligning body proportions, volumes, and contours in a balanced and individualized manner [16]. In this context, the central principle is the pursuit of harmony between adjacent body regions—such as the waist–hip–gluteal relationship—guided by anatomical assessment, proportional standards, and contemporary aesthetic perception, which may be influenced by cultural and media trends, but not necessarily determined by them [17,18]. Within this framework, gluteal harmonization, as part of the BHA concept, prioritizes combined and minimally invasive strategies to promote a balanced relationship between projection, contour, and proportions of the gluteal region in an individualized manner, while simultaneously considering safety principles, anatomical factors, and patient aesthetic expectations [16].

Among the available approaches, fillers and collagen biostimulators—such as hyaluronic acid and poly-L-lactic acid—are particularly prominent and are predominantly applied in the subcutaneous plane [19,20]. In addition, standardized techniques for anatomical marking and volumetric distribution, as well as combined protocols, contribute to greater procedural reproducibility and allow precise adjustments according to the anatomical subunits of the gluteal region, thereby promoting predictable outcomes and faster recovery [21,22].

Compared with surgical approaches, gluteal fat grafting may provide more natural results and improved overall body contour; however, it requires strict adherence to safe anatomical planes to reduce the risk of complications, such as embolism [1]. Conversely, gluteal implants offer the advantage of stable volume, although they are associated with a higher incidence of complications, such as wound dehiscence and seroma, the occurrence of which may vary depending on the surgical plane and the type of implant used [23,24]. Accordingly, contemporary guidelines recommend the use of more superficial planes, the adoption of blunt cannulas, and, when available, the use of ultrasonography to ensure maintenance of the cannula within the subcutaneous plane during the procedure, thereby reinforcing the integration of the anatomical-functional pillar of BHA with clinical practices focused on patient safety [20].

## Anatomy of the gluteal region

A thorough understanding of gluteal anatomy is essential for the safe performance of body harmonization procedures, as it guides the selection of the injection plane, the trajectory of the cannula, and the identification of risk areas, thereby contributing to the reduction of adverse complications [23,25]. In this context, anatomical studies demonstrate that larger-caliber vessels are predominantly located in deeper planes and in the medial portion of the gluteal region, which is why limiting applications to the subcutaneous plane is recommended, with particular attention to ligaments and fibrous septa that may act as natural barriers and help prevent inadvertent deep injections [26]. Furthermore, the identification of vascular and anatomical landmarks, combined with the appropriate selection of entry points and cannula insertion angles, contributes to reducing the risk of contact with critical neurovascular structures [27]. In this regard, the use of imaging modalities, such as ultrasonography, has been increasingly recommended, as it allows for greater precision in identifying tissue planes and enhances procedural safety [28]. Thus, comprehensive knowledge of regional anatomy is a determining factor both for appropriate technique selection and for the prevention of complications, regardless of the method employed, constituting the foundation for safe and aesthetically satisfactory outcomes [29,30].

### Topographic Boundaries

Anatomically, the gluteal region is located posterior to the pelvic girdle, forming a transitional area between the trunk and the lower limbs [31,32]. Its boundaries include, superiorly, the iliac crest and the posterior superior iliac spine (PSIS); medially, the intergluteal cleft, the sacrum, and the coccyx; laterally, an imaginary line connecting the anterior superior iliac spine (ASIS) to the greater trochanter of the femur; and inferiorly, the infragluteal fold [33]. This topographic organization also allows the identification of higher-risk areas, particularly the medial portions near the intergluteal sulcus, where larger-caliber vessels and the sciatic nerve are concentrated [34,35]. The infragluteal fold is also an important anatomical and aesthetic landmark of the region, supported by fibrous bands that attach to the ischium and the sacrum, reinforcing its relevance for both anatomical delineation and the planning of aesthetic procedures [36,37]. In this context, for clinical and therapeutic planning purposes, the gluteal region may be divided into four quadrants—superolateral, superomedial, inferolateral, and inferomedial—a strategy that facilitates standardized evaluation of anatomical planes and precise localization of injectable materials in relation to subcutaneous and muscular structures [38].

### Bone Structure

The pelvis constitutes the structural foundation of the gluteal region, playing a fundamental role in body support, biomechanical stability, and the definition of anatomical landmarks relevant to aesthetic planning [39,40]. From an anatomical perspective, the pelvis forms a bony ring composed of the right and left iliac bones, the sacrum, and the coccyx, connecting the axial skeleton to the lower limbs and enabling the transmission of body loads during locomotion [40,41]. The stability of this structure is reinforced by the sacroiliac joints and the pubic symphysis, which, together with robust ligaments—such as the sacrotuberous, sacrospinous, and interosseous sacroiliac ligaments—contribute to maintaining the biomechanical integrity of the pelvis [42,43]. In addition, key bony landmarks of the region include the iliac crest, which extends between the anterior superior iliac spine (ASIS) and the posterior superior iliac spine (PSIS), as well as the sacrum and coccyx, which serve as palpable references for the superior and medial portions of the pelvis [43]. Complementarily, the ischial tuberosity and the greater trochanter of the femur represent important inferolateral landmarks for anatomical delineation and for defining the three-dimensional contour of the gluteal region [40,43].

**Muscles**

The gluteus maximus is the primary muscular component of the gluteal region, distinguished by its large volume, superficial position, and high capacity for force generation, and is frequently described as the most powerful muscle within this anatomical complex [44]. In addition to its biomechanical functions, it plays a significant role in shaping and projecting the buttocks, which is why it is often considered one of the main anatomical structures involved in aesthetic procedures aimed at volumization and body harmonization [45]. Anatomically, the gluteus maximus has a quadrangular shape and a broad area of origin extending from the posterior surface of the ilium to the sacrum, coccyx, and sacrotuberous ligament [44]. Its fibers insert superficially into the iliotibial tract and deeply into the gluteal tuberosity of the femur, contributing primarily to hip extension and external rotation. Additionally, through its relationship with the iliotibial tract, this muscle also contributes to the stabilization of the hip and knee joints [32]. Functionally, the gluteus maximus is also involved in trunk extension and in activities requiring high biomechanical demand, such as running and stair climbing, highlighting its importance in locomotor dynamics [32,46]. Its blood supply is predominantly derived from the superior and inferior gluteal arteries, while its innervation is provided by the inferior gluteal nerve [32]. Furthermore, its fibers maintain relationships with adjacent fascial structures, including the fascia of the gluteus medius, the thoracolumbar fascia, and the fascia lata [44].

Deep to the gluteus maximus are the gluteus medius and gluteus minimus muscles, which exhibit a fan-shaped configuration and perform complementary roles in hip biomechanics [31]. These muscles act primarily in thigh abduction and medial rotation, and play a fundamental role in pelvic stabilization during single-leg stance and gait [44]. With regard to vascularization and innervation, both are supplied by the superior gluteal artery and innervated by the superior gluteal nerve [39,44]. Beyond the muscular structures, fascial components also contribute to the anatomical organization and contour of the gluteal region. Among these, the iliotibial tract stands out as a lateral thickening of the fascia lata that receives contributions from the gluteus maximus and the tensor fasciae latae muscle, playing an important role in knee stabilization and in maintaining the lateral contour of the thigh and hip [31]. In parallel, the subcutaneous adipose tissue covering these structures directly influences the three-dimensional shape and projection of the gluteal region, exhibiting individual variations that impact body contour and are frequently considered in aesthetic remodeling procedures [45].

Regarding the lateral morphology of the hip, the greater trochanter of the femur contributes to the formation of a trochanteric depression, commonly referred to as "hip dips." This concavity results from the interaction between pelvic bone morphology, the muscular insertions of the hip abductors—particularly the gluteus medius and minimus—the action of the tensor fasciae latae, and the distribution of subcutaneous adipose tissue in the region [48]. The expression of this anatomical feature may vary according to individual differences in bone structure, muscle mass, and body composition [49]. Although muscle strengthening may improve local tone, it does not alter bone architecture or muscle insertion points, which explains the persistence of this depression even in physically active individuals. Additionally, age-related changes, redistribution of adipose tissue, and skin laxity may accentuate this lateral concavity and modify body contour [45]. In this context, minimally invasive filler techniques and collagen biostimulators have been described as alternatives for aesthetic correction of this region, demonstrating favorable outcomes in harmonizing the lateral contour of the hip [45,50].

Finally, the gluteal region also includes deep hip muscles, such as the piriformis, obturator internus, superior and inferior gemelli, and quadratus femoris, which primarily function in rotation and stabilization of the hip joint [39,44]. Therefore, an integrated understanding of these anatomical components is essential for planning gluteal harmonization procedures based on anatomical and biomechanical principles, contributing to greater clinical safety and more natural aesthetic outcomes [33,45].

### Cutaneous Ligaments

Gluteal cutaneous ligaments (retinacula cutis) are fibrous bundles that connect the dermis to the superficial and deep fasciae, providing anchorage and stabilization of the adipose panniculus against multidirectional mechanical forces. This structural organization plays a significant role in maintaining the shape and mechanical behavior of the skin in the gluteal region [51].

Anatomical cadaveric studies demonstrate a regional pattern of the superficial fascial system (SFS) in the gluteal area: in the upper gluteal quadrant, the superficial fascia tends to exhibit greater structural definition, whereas in the lower third it becomes less distinct, associated with increased thickness of central adipose tissue. This anatomical arrangement directly influences gluteal contour and contributes to the formation of the infragluteal fold [37]. At the infragluteal crease, a medial–lateral asymmetry is also observed. In the medial portion, thick fibrous bands—often described as “J-shaped”—connect the dermis to the ischial ramus, sacrum, and coccyx, creating a depressed anatomical fold. In contrast, in the lateral portion, the fibrous component is less evident, resulting in a fold that behaves predominantly as a cutaneous crease with a lower degree of ligamentous anchorage [36,52,53].

This ligamentous network often accompanies vascular and neural structures within the subcutaneous tissue, forming fibrous pathways that may influence tissue positioning and interfere with cannula passage or the diffusion of injectable materials. These characteristics have relevant implications for procedures such as liposculpture and gluteal augmentation. Regions with greater fascial condensation, dominated by retinacula cutis, tend to restrict or direct the dispersion of fat or fillers/biostimulators, whereas areas with predominant adipose tissue favor smoother transitions between the gluteal region and the thigh [52,54]. Additionally, the skin of the gluteal region presents important neurovascular variations. Cutaneous branches of the internal pudendal artery contribute to the vascularization of the infragluteal fold and intergluteal cleft, while cutaneous branches of the inferior gluteal nerve may be present in up to 75% of cases. These aspects are particularly relevant for surgical incisions, flap design, and the understanding of localized pain syndromes [55,56].

In the context of gluteal augmentation procedures, vascular stratigraphy reinforces the recommendation to maintain interventions within the subcutaneous plane, as deeper and more medial planes contain larger-caliber vessels, increasing the risk of severe complications such as fat embolism [25]. In summary, gluteal cutaneous ligaments and the superficial fascial system exhibit variations along the cranio-caudal and medial–lateral axes, influencing the formation of the infragluteal fold, the mechanical stability of the skin, and the behavior of subcutaneous tissue. Understanding these anatomical variations is essential for planning aesthetic and reconstructive procedures, contributing to greater predictability of outcomes and enhanced technical safety [51–54].

### Adipose Tissue

Subcutaneous adipose tissue constitutes one of the largest compartments of the human body and exhibits regional organization that determines its mechanical and metabolic behavior, as well as its response to aesthetic and regenerative interventions, particularly in the gluteal region [57]. From an anatomical perspective, this tissue is subdivided into two main layers: superficial adipose tissue (SAT) and deep adipose tissue (DAT), separated by a continuous fibrous layer known as the superficial fascia. SAT is characterized by smaller adipose lobules, delineated by thinner collagen septa and adipose papillae that connect to the dermis, whereas DAT presents larger, less defined lobules with wider septation [58,59]. Anatomical studies based on cadaveric dissections of the gluteal region demonstrate that the superficial fascia is well defined in the upper gluteal quadrant, becoming progressively less distinct in the lower third, where increased central adipose thickness contributes to the configuration of the gluteal contour and the infragluteal fold [37].

In addition to its layered organization, the gluteal subcutaneous tissue exhibits anatomical compartmentalization. Morphological investigations have identified distinct deep compartments of subcutaneous fat, separated by fibrous septa and located above the muscular fascia. This structural arrangement allows for the maintenance and selective distribution of injected materials during volumization procedures, particularly when guided by ultrasonography [60]. These compartments are associated with septa that conduct perforating vessels and integrate the superficial fascial system, including structures such as the retinacula cutis, which play a fundamental role in adipose tissue stability, maintenance of body contour, and guidance of injected fluids or fillers [52].

At the cellular and molecular levels, the SAT and DAT layers exhibit distinct biological profiles. Transcriptomic studies demonstrate that DAT is enriched in inflammatory and tissue remodeling pathways, with a higher presence of macrophages and markers associated with oxidative stress, whereas SAT shows greater expression of genes related to lipid metabolism and lower inflammatory infiltration [61,62]. Additionally, analyses of the stromal vascular fraction indicate that adipose-derived stem cells from SAT display greater proliferative and adipogenic capacity compared to those obtained from DAT, reinforcing the regenerative potential of this compartment in therapeutic and aesthetic applications [63]. Immunological differences between these layers have also been observed in histological studies, demonstrating distinct patterns of macrophage infiltration in human subcutaneous adipose tissue [64].

In the female gluteofemoral region, hormonal and maturational factors exert significant influence on adipose tissue distribution throughout life, contributing to increased subcutaneous fat accumulation in this area after puberty and maintaining sex-related differences in body composition during adulthood [65]. Functionally, these variations reflect important metabolic heterogeneity among adipose subdepots. Studies conducted in abdominal subcutaneous tissue demonstrate that the deep subcutaneous compartment is more strongly associated with insulin resistance and metabolic alterations compared to the superficial compartment, reinforcing the functionally distinct nature of these anatomical subdivisions [62,66].

In aesthetic and reconstructive procedures, understanding this anatomical organization has direct implications for procedural safety. Maintaining interventions within the subcutaneous plane during filler or lipofilling techniques reduces the risk of vascular complications, as deeper and more medial planes contain larger-caliber vessels. In this context, ultrasonography has been incorporated as an auxiliary tool for identifying anatomical layers and controlling cannula positioning within the subcutaneous plane, thereby contributing to greater predictability and procedural safety [67,68].

Furthermore, anatomical studies demonstrate that the superficial fascia contains a relatively dense lymphatic network, with structural variations between subcutaneous layers, suggesting distinct roles in interstitial drainage, edema control, and tissue healing [58]. Collectively, these findings indicate that gluteal subcutaneous tissue should be understood as a stratified, compartmentalized, and biologically active structure. The integration of fascial anatomy, compartmental organization, and cellular characteristics of adipose tissue enables more precise planning of aesthetic interventions, promoting more predictable outcomes and enhancing safety margins in gluteal harmonization procedures [37,52,60].

### Skin

The gluteal skin is composed of the epidermis and dermis and generally exhibits greater thickness and mechanical resistance compared to many other regions of the body. This characteristic is particularly relevant for the planning of aesthetic and reconstructive procedures, as it provides an enhanced capacity to withstand local load and shear forces [69]. The epidermis functions as a physicochemical and biological barrier, while the dermis—organized into papillary and reticular layers—provides structural support, elasticity, and mechanical strength, in addition to housing skin appendages and the microvasculature of the subdermal plexus, which is essential for the nourishment of cutaneous flaps and wound healing processes [70]. Beyond its protective role, gluteal skin also plays an important sensory function, possessing rich cutaneous innervation and subdermal plexuses responsible for integrating mechanical and nociceptive stimuli, aspects that are particularly relevant during manipulation and injectable procedures [70,71].

Comparative studies demonstrate that regions with limited photoexposure, such as the sacral area and gluteal folds, tend to present relatively thicker epidermal and dermal layers. In the sacral region, the average epidermal thickness may reach approximately 86 µm, while the dermis may measure around 1.51 mm. This area also exhibits a more compact adipose panniculus, contributing to increased local mechanical resistance and explaining the surgical preference for sacral tissue as a donor site in dermal-fat grafts [69]. In healthy individuals, epidermal thickness also varies according to age and sex, being generally greater in the gluteal region, tending to decrease with aging, and presenting higher average values in males [72]. High-frequency ultrasonography assessments demonstrate that skin thickness varies across different body regions, typically being greater in the trunk—where the skin appears thicker and relatively hypoechoic—while in the extremities it tends to be thinner and denser. These findings reinforce the structural heterogeneity of the skin according to anatomical location [73].

In the gluteal region, anatomical studies indicate that soft tissue thickness is heterogeneously distributed, generally being greater in the superolateral region and lower near the posterior superior iliac spine, forming anatomical gradients relevant for flap planning and for predicting tissue support capacity in reconstructive procedures [74]. The three-dimensional morphology of the gluteal region results from the interaction between the skin, subcutaneous adipose tissue, and fascial systems. The superficial fascia tends to be more defined in the upper third of the gluteal region and becomes less distinct in the lower portion. Additionally, dermo-osseous adhesions in the sacrococcygeal region and medial fibrous bands contribute to the formation of the infragluteal fold, which presents a more anatomically defined structure medially and a cutaneous crease-like appearance laterally, influencing skin mobility and gluteal contour configuration [36,37,53].

The gluteal subcutaneous tissue is further organized into layers and adipose compartments interconnected by fibrous septa and adipose papillae that attach to the dermis, strengthening the coupling between the skin and underlying tissue. This structural organization contributes to the mechanical stability of the skin, maintenance of body contour, and the manner in which injectable substances diffuse through the tissues, as septal density and the pattern of the superficial fascial system directly influence the biomechanical behavior of the tissue following aesthetic procedures [52,75].

The intergluteal cleft represents a distinct anatomical area characterized by increased exposure to moisture, friction, and skin maceration. Under these conditions, there may be increased hydration of the stratum corneum and elevation of cutaneous pH, factors that favor inflammatory processes and local infections, thereby justifying the adoption of strict antiseptic protocols and, when indicated, additional prophylactic measures in procedures performed in this region [70].

In a therapeutic context, studies also indicate that the average thickness of the ventrogluteal subcutaneous tissue ranges approximately between 16 and 25 mm, depending on sex and individual characteristics. This has direct implications for determining safe puncture depth and predicting intramuscular reach in injectable procedures [76]. Overall, gluteal skin presents a thick and functionally specialized structural architecture, with regional variations and influences related to sex and aging that directly impact its mechanical resistance, sensitivity, and behavior in aesthetic and reconstructive interventions [37,69,72].

**Blood Vessels**

The vascularization of the gluteal region is complex and variable, with a predominance of large-caliber vessels located in the intramuscular and submuscular planes. This makes the selection of the intervention plane critical in aesthetic procedures. The primary blood supply is derived from the internal iliac artery via the superior gluteal artery (SGA) and inferior gluteal artery (IGA). The SGA exits the greater sciatic foramen above the piriformis muscle and divides into superficial and deep branches supplying the gluteus medius, minimus, and part of the maximus. In contrast, the IGA emerges below the piriformis and supplies the inferior portion of the buttock and the posterior thigh [46,77,78].

Angiographic and cadaveric dissection studies demonstrate considerable variability in origin and branching patterns. The median length of the SGA is approximately 55 mm, with an origin diameter of about 6.3 mm, whereas the IGA presents a median length of approximately 68.5 mm and an origin diameter of about 4.7 mm. Multiple anatomical variations have been described, including the presence of a common gluteal–pudendal trunk [77,79,80].

Within the subcutaneous tissue, smaller-caliber vessels predominate. Cadaveric studies using latex injection techniques report average diameters of approximately 0.9 mm for subcutaneous arteries and 1.05 mm for veins. In contrast, muscular branches of the gluteal arteries may reach approximately 1.8–2.2 mm in arterial diameter and 3.5–3.9 mm in venous diameter, while the main superior and inferior gluteal veins may range from approximately 6 to 14 mm [25]. In vivo magnetic resonance venography demonstrates that the gluteal veins are located immediately deep to the gluteus maximus, at an average depth of approximately 56 mm from the skin surface, with a diameter of around 6 mm in the prone position. No intramuscular or subcutaneous venous branches exceeding 2 mm were observed, and venous diameter may decrease by up to 27% in the jackknife position and approximately 14–15% in the lateral decubitus position [81].

Prospective computed tomography studies further confirm that, in the jackknife position, there is a reduced skin-to-muscle distance (approximately 2–3 cm) and a decrease in venous volume, indicating closer proximity of muscle to the skin despite a reduction in venous caliber [82]. Radiological mapping also indicates a higher vascular density and area within muscle tissue (approximately 4.5%) compared to the subcutaneous layer (approximately 0.3%), reinforcing that deeper planes contain vessels of greater caliber and density [79].

Cutaneous perforators from the SGA and IGA are abundant but small, with average diameters ranging from 0.4 to 0.6 mm, and are frequently musculocutaneous, with territories that vary between individuals and between sides [83,84]. These anatomical characteristics are relevant for surgical planning, and preoperative identification can be achieved using computed tomography angiography (CTA) or Doppler ultrasonography [84].

Clinically, severe complications in gluteal volumization and fat grafting procedures are associated with deep venous injury and fat embolism. Anatomical and clinical studies support the recommendation to limit injections to the subcutaneous plane, where vessels are smaller and less dense, and to avoid intramuscular or subfascial planes, which are considered to lack a “safe zone” [25,81]. The variability of the gluteal arteries, including the presence of cutaneous perforators and potential intrapelvic anastomoses, highlights the vascular complexity of the region and underscores the importance of careful planning in surgical and reconstructive procedures [77,79].

In summary, the presence of large and variable vessels in deeper planes, combined with smaller-caliber vessels in the subcutaneous layer, supports the subcutaneous plane as the preferred site for gluteal aesthetic procedures, minimizing the risk of vascular complications [25,81,82].

**Innervation**

Gluteal innervation arises from motor branches of the sacral plexus and from cutaneous nerves with variable courses, which influence pain, paresthesia, and the risk of injury during interventions. The superior gluteal nerve (L4–S1) emerges from the greater sciatic foramen above the piriformis, divides into superior and inferior branches, and innervates the gluteus medius, gluteus minimus, and tensor fasciae latae. Its proximity to the greater trochanter defines a limited “safe zone,” the violation of which increases the risk of nerve injury and the development of Trendelenburg gait due to abductor weakness [85,86].

The inferior gluteal nerve (L5–S2) exits below the piriformis and exclusively innervates the gluteus maximus. Anatomical studies indicate that its course is predominantly infrapiriform, although relevant variations exist, particularly for procedures involving the deep gluteal space [87,88]. Cutaneous sensation of the buttock is primarily provided by the cluneal nerves (superior and middle, derived from dorsal thoracolumbosacral branches) and by the posterior femoral cutaneous nerve (S1–S3), which gives rise to the inferior cluneal nerves distributed along the gluteal fold [89,90].

The posterior femoral cutaneous nerve maintains a close anatomical relationship with the descending branch of the inferior gluteal artery, creating a potential risk for neural entrapment or injury during surgical procedures [91]. Additional anatomical variants include proximal branches of this nerve piercing the piriformis muscle, which have been associated with persistent neuropathic symptoms [92,93].

The superior cluneal nerves may also be susceptible to entrapment as they cross the iliac crest. Ultrasound-guided nerve blocks have demonstrated effective anesthesia in approximately 90% of cases in clinical studies [94], while cadaveric investigations have detailed anatomical variations that warrant careful consideration during interventions [56]. In pelvic surgeries, postoperative gluteal pain following sacrospinous ligament fixation has been associated with branches of S3–S4 that pass between the sacrospinous and sacrotuberous ligaments, highlighting the importance of recognizing the complex deep neural network in this region [95].

Overall, the topographic variability of the superior and inferior gluteal nerves, the cutaneous contribution of the inferior gluteal region, and the broad distribution of the posterior femoral cutaneous and cluneal nerves underscore the importance of detailed anatomical mapping and the use of imaging modalities to reduce the risk of neurological injury in gluteal procedures [56,85,87,89].

## Gluteal Morphology and Anatomical Determinants of Contour

Gluteal shape and patient concerns are key determinants in defining the treatment plan and clinical approach. During physical examination, it is essential to assess gluteal characteristics, classifying them according to shape, skin quality, and associated aesthetic dysfunctions, in order to establish the most appropriate harmonization strategy [33]. Shape classification is fundamental for achieving harmonious and satisfactory outcomes [96]. In this context, gluteal morphology may be categorized into four main types—heart-shaped, inverted triangle, square, and round—based on pelvic position, hip bone structure, fat volume, and its distribution [45].

The heart-shaped gluteus (A) is characterized by greater volume in the lower and central regions. In such cases, understanding patient expectations is crucial, as treatment may follow two main approaches: the first aims to preserve the original shape, focusing on global treatment to improve skin quality, firmness, hydration, and correction of irregularities without adding volume; the second approach involves volumization of the upper region using hyaluronic acid, promoting rounding, correction of gluteal ptosis, and a more youthful appearance [33].

The inverted triangle (V) shape, relatively uncommon particularly among younger populations, presents greater volume in the upper region and deficiency in the lower portion [33,97]. In one study, only 0.8% of patients expressed preference for this shape, highlighting its low aesthetic appeal [98]. Harmonization of this morphology should prioritize projection and volume redistribution to balance upper and lower regions, often requiring larger volumes of hyaluronic acid to achieve satisfactory results [33].

The square-shaped gluteus presents similar height and width and is commonly observed in individuals with a straight body type, low subcutaneous fat, and reduced muscular hypertrophy, often accompanied by fat accumulation in the flanks [99]. In such cases, harmonization typically requires combined techniques, including reduction of localized fat and strategic volumization with hyaluronic acid—preferably in the superolateral region—to enhance projection and contour, along with improvement of skin quality through the use of biostimulators. In contrast, the round gluteus generally presents favorable muscular and adipose volume [33].

Beyond these classical morphologies, anatomical variations are observed in elderly patients, postmenopausal individuals, or those who have undergone bariatric surgery, often characterized by muscle atrophy, reduced subcutaneous tissue, irregularities, and increased skin laxity [99]. Additionally, trochanteric depression ("hip dips") represents a common anatomical variation characterized by lateral volume deficiency. This condition may be corrected through the use of hyaluronic acid fillers—typically adjusted according to depth and tissue response, with approximately 10 mL per side recommended—combined with reduction of localized adiposity and the use of biostimulators, as these patients often present with fat accumulation in the flanks and saddlebag regions, accentuating lateral contour irregularities [33].

Differences between male and female gluteal morphology reflect sexual dimorphism of the pelvic skeleton, fat distribution, and muscular patterns, all of which influence gluteal contour. The female pelvis is generally wider and shallower, with a subpubic angle greater than 80°, more widely spaced ischial spines, and a straighter coccyx, whereas the male pelvis is narrower and more robust, with a subpubic angle typically less than 70° [40,41,100]. Obstetric dimensions, such as the anteroposterior diameter of the pelvic inlet and the transverse diameter of the midplane, are greater in females, while height-to-width proportions and iliac wing orientation demonstrate allometric variation [101–103].

The ischiofemoral space is smaller in females (approximately 22 mm versus 29 mm in males), with functional implications and potential association with pain during extension [104]. From a muscular perspective, males generally exhibit greater absolute gluteal muscle volume, although differences decrease when adjusted for body weight. Females, on the other hand, tend to have greater subcutaneous fat deposition in the gluteal region, with comparable muscle quality when conditioned [105].

in this regard, females typically present with wider pelvises and greater gluteal subcutaneous fat, resulting in more pronounced lower projection and width, whereas males exhibit narrower pelvises, greater absolute muscle volume, a more compact contour, and more defined lateral depressions. These differences reflect underlying anatomical, hormonal, and functional variations between the sexes [41,97,100,102,105].

## C. MAIN GLUTEAL HARMONIZATION TECHNIQUES

### Autologous Fat Grafting (Lipoaugmentation)

Gluteal fat grafting (Brazilian Butt Lift) consists of the transfer of adipocytes and stromal cells into the gluteal subcutaneous tissue to achieve volumetric augmentation and contour improvement. Graft integration occurs through initial plasmatic diffusion followed by progressive revascularization, allowing survival of the transplanted adipose cells [30]. In a prospective study using ultrasound guidance and three-dimensional (3D) volumetric assessment, mean volume retention was 77.9% at 3 months and 64.7% at 6 months, with injections performed exclusively in the subcutaneous plane [106].

Safety guidelines from international expert groups recommend strictly subcutaneous injection, avoiding intramuscular placement, maintaining the cannula parallel to the subcutaneous layer above the fascia, without caudal angulation, and using cannulas with a diameter ≥4 mm [30,107]. Following the implementation of these measures, a reduction in pulmonary fat embolism (PFE) was observed, from approximately 1:1030 to 1:2492, with a downward trend in mortality rates to approximately 1:14,952 [107]. Recent meta-analyses indicate a lower overall incidence of complications with subcutaneous injection and an additional benefit associated with the use of intraoperative ultrasound, which has been linked to reduced complication rates [10,108]. Autopsy studies and forensic series further corroborate that deaths related to PFE are associated with intramuscular or deep injections, often with fat identified within the gluteal musculature [109–111]. In this context, anatomical mapping demonstrates the presence of large-caliber vessels in deeper and medial planes, supporting restriction to the subcutaneous layer [25].

From a technical perspective, volumes ranging from 300 to 900 mL per buttock have been reported, distributed through multiple subcutaneous tunnels using microdeposition techniques, low injection pressure, and large-diameter blunt cannulas. These strategies increase the surface area of contact and promote revascularization, with low rates of major adverse events when safe anatomical planes are respected [11,112]. In the absence of ultrasound guidance, subcutaneous thickness may be estimated based on age and body mass index (BMI), providing an operational "safe window" for the procedure [113].

### Silicone Implants (Gluteoplasty)

Gluteoplasty with silicone implants is indicated for the correction of gluteal hypoplasia and for augmentation and contouring of the body, being particularly useful in patients with limited donor fat. In such cases, it provides predictable outcomes when the surgical plane is appropriately selected [114]. Among the described planes (subcutaneous, subfascial, intramuscular, submuscular, and dual-plane), evidence indicates that intramuscular (including the XYZ technique) and submuscular planes are associated with lower complication rates compared to the subfascial plane, which shows higher rates of seroma and wound dehiscence [115,116].

In a meta-analysis involving 2,682 patients, the subfascial plane demonstrated seroma rates of 22.25% and dehiscence rates of 27.07%, whereas intramuscular and submuscular planes showed significantly lower complication rates and reduced implant removal rates (1.05% overall; 5.23% in the subfascial group) [115]. Previous systematic reviews corroborate these findings, identifying dehiscence (10.29%) and seroma (2.49%) as the most common adverse events, with lower rates observed in the intramuscular XYZ technique and submuscular approaches [116]. Contemporary submuscular series report dehiscence as the most frequent complication, generally not requiring implant removal, and indicate an association between larger implants and increased complication rates [117].

Regarding implant characteristics, current models utilize solid or cohesive silicone with an elastomer shell. There is a trend toward the use of smooth-surface implants, which are associated with lower rates of seroma (2.56% vs. 7.50%), dehiscence (6.63% vs. 13.98%), and capsular contracture (0.55% vs. 2.06%) compared to textured implants in gluteal procedures [115]. Clinical practice reviews further support the selection of intramuscular or submuscular planes and the preference for smooth implants to optimize safety [114,118]. Implant shape also influences outcomes. Oval (anatomical) implants tend to align with the fiber orientation of the gluteus maximus, promoting more natural contours, whereas round implants provide more central projection with less sensitivity to rotation, particularly when placed in well-constructed intramuscular pockets [119,120].

In terms of volume, clinical series and technical reports commonly describe the use of implants ranging from 300 to 350 $cm^3$ in intramuscular or submuscular techniques, balancing projection with adequate tissue coverage [7,121]. Long-term follow-up studies demonstrate stable implant positioning and mild muscle atrophy (approximately 6–7%) without significant functional impairment, with no clear correlation between implant volume (up to 400 $cm^3$) and the degree of atrophy [122]. In summary, the selection of intramuscular (including the XYZ technique) or submuscular planes, combined with the use of smooth cohesive silicone implants, is associated with lower rates of seroma, dehiscence, and capsular contracture, reduced need for explantation, and more predictable aesthetic outcomes compared to the subfascial plane and textured implants [115–118].

### Polymethylmethacrylate (PMMA)

Polymethylmethacrylate (PMMA) is a permanent filler composed of inert microspheres suspended in a carrier gel. Following injection, a controlled foreign body reaction occurs, characterized by fibroplasia and collagen deposition around the particles, resulting in neocollagenesis and the formation of a long-lasting supportive matrix, as the microspheres are too large to be phagocytosed by macrophages [123–125]. In body aesthetics, including the gluteal region, PMMA remains as stable microscopic "implants," providing long-term results compared to temporary fillers; however, it is associated with the potential for late adverse events [126,127].

In Brazil, expert recommendations have described intramuscular application for body use, with volumes ranging from 100 to 150 mL per gluteal region, while contraindicating intradermal or juxtadermal planes. However, such guidelines have been questioned by surgical societies regarding their "consensus" status and the indication of aesthetic use in healthy patients, emphasizing the need for careful patient selection and long-term follow-up [128,129]. Large national cohort studies report overall adverse event rates of approximately 1.9%–2.1%, with a correlation between higher total injected volumes and increased complication rates, although these findings may be influenced by selection bias and limited long-term evidence [127,130].

Local complications include foreign body granulomas, necrosis, and infection, which may arise months to years after the procedure and can be difficult to manage [123,131,132]. Rare but severe systemic events include calcitriol-mediated hypercalcemia (1,25-$OH_2$ -vitamin D), resulting from extrarenal production by granulomatous macrophages (CYP27B1). This condition may present from approximately 40 days up to 8 years after injection, with suppressed parathyroid hormone (PTH), nephrolithiasis, and renal dysfunction. Case reports and series involving gluteal PMMA have documented this association and highlight the need for long-term nephrological monitoring [133–138].

Management typically involves corticosteroids, while adjunctive therapies such as bisphosphonates, denosumab, or cinacalcet have been used in refractory cases. Surgical resection of granulomatous areas may also improve calcium levels and renal function in selected situations [137,139–141]. Additionally, although PMMA provides long-lasting volumetric augmentation in the gluteal region, its permanent nature requires a cautious approach. Strict technique, limitation of injected volumes, proper documentation of the injection plane, and prolonged clinical follow-up are essential, given the risk of late granulomatous reactions and granulomatous hypercalcemia with potential renal involvement [127–129,132,137,138].

### Calcium Hydroxyapatite (CaHA)

Calcium hydroxyapatite (CaHA) has become established in regenerative aesthetics by combining immediate structural support with progressive biostimulation, promoting neocollagenesis, neoelastogenesis, and angiogenesis, thereby transcending the concept of mere volumization and improving skin quality in both facial and body treatments [50,142,143]. It is a biocompatible and biodegradable biomaterial composed of CaHA microspheres suspended in a carboxymethylcellulose (CMC) gel, which acts as a temporary scaffold; its degradation triggers fibroblast activation and the deposition of collagen types I/III, elastin, and proteoglycans, with evidence demonstrating increased elastic fibers, proteoglycans, and neovascularization in clinical analyses, in vitro studies, and animal models [143–145].

In clinical practice, CaHA is used for contouring, soft tissue support, and skin quality improvement across multiple anatomical areas. Rheological modulation through dilution enables distinct therapeutic profiles: a 1:1 dilution maintains greater viscosity and structural support, whereas hyperdiluted CaHA (≥1:2) reduces elasticity and cohesivity while increasing dispersion and particle–fibroblast interaction, thereby optimizing the biostimulatory effect with minimal volumization, enhancing collagen I/III production and broader tissue distribution [145–147]. Recent trials and case series have demonstrated the efficacy and safety of hyperdiluted CaHA (1:2–1:6) for skin laxity and texture improvement in facial and body areas, with objective improvements in hydration and imaging parameters [50,142,148,149].

Regarding technique, the use of blunt cannulas, superficial/subdermal planes, and retrograde injection in vector or “fanning” patterns is recommended, with slow administration in small aliquots and careful attention to high-risk anatomical zones to minimize trauma and complications; ultrasonography may further enhance precision in plane selection and product distribution [50,150]. The safety profile is favorable: common adverse events include erythema, edema, and ecchymosis, which are generally mild and self-limiting. Delayed nodules represent the most frequent complication in dynamic areas and may be mitigated through higher dilution ratios and proper injection techniques. When necessary, management with mechanical dispersion and saline solution (“Radiesse Rescue”) under ultrasound guidance has been described as effective [148,151]. In summary, hyperdiluted CaHA supports the regenerative aesthetics paradigm by providing measurable improvements in dermal thickness, elasticity, and vascularization while maintaining a consistent safety profile when applied with appropriate technique and patient selection [143,148].

### Poly-L-Lactic Acid (PLLA)

Poly-L-lactic acid (PLLA) is a synthetic, biocompatible, and biodegradable polymer used as an injectable biostimulator. It induces controlled subclinical inflammation, activates fibroblasts, and promotes neocollagenesis and extracellular matrix remodeling, with evidence of angiogenesis and improvement in skin quality demonstrated in recent clinical and histological studies [152,153]. In the gluteal region, PLLA acts as a temporary scaffold, stimulating fibroblasts and inducing progressive neocollagenesis, resulting in gradual contour improvement and discreet projection enhancement, including correction of trochanteric depressions (hip dips) [154,155]. Histologically, following injection, progressive phagocytosis and degradation of the microparticles occur, accompanied by deposition of type III collagen surrounding the particles and predominance of type I collagen in more peripheral areas, in addition to signs of neovascularization and reduced elastin fragmentation [152,153]. Clinically, PLLA has demonstrated benefits for tissue laxity and skin quality in body areas, particularly in the gluteal region, with improvements in firmness, cellulite appearance, and trochanteric depressions [156,157].

Regarding longevity, high-frequency ultrasonography demonstrates complete degradation in approximately 80% of cases at 30 months, with residual ultrasonographic findings in approximately 20% (microparticles/nodules/granulomas) [158]. The biostimulatory effect may persist for 12–24 months or longer, depending on the technique and patient characteristics, with maintenance of benefits reported in studies with follow-up periods of up to 24 months [157,159]. Body treatment protocols frequently involve three sessions at monthly or bimonthly intervals; gluteal studies commonly report the use of approximately three vials per buttock per session, with follow-up periods of 6–9 months demonstrating sustained improvement [156,160]. Randomized trials and prospective studies have shown significant improvement in skin elasticity (approximately 63%–83%), reduction in cellulite depression depth, and high patient satisfaction, without serious adverse events [160,161]. In the treatment of hip dips, dermal and adipose tissue thickening of approximately 26%–27% has been observed, together with histological improvement in collagen and elastin, while maintaining a favorable safety profile [154].

For body and gluteal applications, high dilution ratios are recommended. Practice surveys report the use of more than 21 mL per vial in the gluteal region, with reconstitution in sterile water combined with lidocaine and post-procedure massage, while blunt cannulas and retrograde injection techniques are preferred to enhance product dispersion and reduce risk [20,162]. Dilutions ≥7 mL have been associated with a lower incidence of nodules, and immediate reconstitution has shown safety comparable to prolonged hydration in multicenter analyses [163,164]. Real-time ultrasonography may improve accuracy of plane selection and product distribution, in addition to assisting in the diagnosis and management of complications [38,165]. The safety profile is predominantly characterized by mild and transient events, including pain, edema, erythema, and ecchymosis; delayed nodules and papules represent the most common complications and may be mitigated through appropriate dilution, correct injection planes, and cannula use. Management strategies include saline solution, subcision, and triamcinolone/5-fluorouracil (5-FU) in selected cases [163,166]. In recent gluteal series and multicenter studies, high satisfaction rates, clinical improvement in approximately 84% of patients, and absence of serious adverse events have been reported, with only mild self-limited adverse effects observed [159,160].

### Hyaluronic Acid (HA)

Hyaluronic acid (HA) is a natural polysaccharide composed of glucuronic acid and N-acetylglucosamine, present in the extracellular matrix and responsible for functions related to hydration, lubrication, and maintenance of tissue integrity [33,167]. With aging, there is a progressive reduction in its production, contributing to volume loss and structural skin changes. In addition, HA fragments may interact with cellular receptors, such as CD44, modulating fibroblast activity and collagen production [167]. In this context, due to its biocompatible, hydrophilic, and biodegradable properties, hyaluronic acid has become widely used as a filler in aesthetic procedures [33]. Among its main advantages are good tissue integration, a low incidence of adverse events, and the possibility of reversal through the application of hyaluronidase, representing an important safety advantage compared with permanent fillers [168–170].

In the field of body aesthetics, gluteal augmentation with hyaluronic acid is considered a minimally invasive procedure associated with high satisfaction rates and results lasting on average between 12 and 16 months, potentially extending up to 24 months depending on the product used and the technique applied [171,172]. In body procedures, the injected volumes are generally greater than those used in facial treatments, commonly ranging from 50 to 200 mL per session according to the treatment objective [168,170]. The selection of the HA product should consider its rheological properties, particularly the elastic modulus (G') and gel cohesivity [33]. In regions subjected to greater mechanical pressure, such as the gluteal area, fillers with higher G' are recommended because they provide better tissue support and projection, whereas products with moderate G' exhibit greater expansibility for subcutaneous application [33,167,173]. Accordingly, products specifically developed for body application demonstrate greater elasticity and mechanical resistance, characteristics that are appropriate for this anatomical region [174]. Evaluation of these properties depends on standardized methods, with G' being widely used for comparison among fillers [175,176]. Furthermore, greater gel cohesivity favors improved tissue integration and a lower occurrence of irregularities [172,177]. In gluteal harmonization, the objective is to enhance volume and body contour using materials with adequate resistance to mechanical forces and appropriate elasticity [33].

Regarding injection techniques, studies describe the use of blunt cannulas in the superficial subcutaneous plane, with product distribution across different regions of the gluteal area [178]. However, technical variations have been described in the literature, and according to Chacur (2024), optimal results are achieved when hyaluronic acid is administered at a deep subcutaneous level, ideally below the superficial fascia separating the areolar fat layer from the lamellar fat layer [127]. Therefore, regardless of the selected plane, procedural safety depends on adequate anatomical planning, correct identification of tissue planes, and careful execution of the injection technique. In this context, injected volumes may range from 40 to 100 mL per hemigluteus or from 85 to 206 mL per patient, depending on the treatment goals [171,179–181]. Additionally, the use of ultrasonography has been recommended for vascular mapping and identification of previous fillers, thereby increasing procedural safety [182]. When treatment of trochanteric depressions is indicated, careful application in the superficial subcutaneous plane with small product volumes, preferably under ultrasound guidance, is recommended to reduce the risk of complications [183,184].

From a clinical perspective, multicenter and retrospective studies involving body HA fillers demonstrate high patient satisfaction rates, close to 90%–100% during follow-up periods of up to six months, with mild adverse events such as edema, pain, and transient erythema [173,179]. Similarly, a prospective series using NASHA for gluteal augmentation demonstrated sustained aesthetic improvement for up to 24 months in part of the evaluated patients [184]. Another important aspect is the reversibility of HA through hyaluronidase, which represents a major safety advantage, as the enzyme is capable of degrading commercial hyaluronic acid gels both in vitro and in vivo, with responses depending on dose and product technology [185]. Although rare, allergic reactions to the enzyme may occur, making prior patient counseling regarding this possibility essential [186,187].

Regarding safety, the most common adverse events associated with gluteal HA fillers include erythema, edema, and ecchymosis, which are generally mild and self-limiting [179,185]. More severe complications, such as vascular occlusion, tissue necrosis, or visual disturbances, are rare; however, they require immediate diagnosis and intervention, generally involving guided hyaluronidase administration [170,188].

**Platelet-Rich Plasma (PRP)**

Platelet-rich plasma (PRP) is an autologous concentrate obtained through centrifugation of peripheral blood, characterized by a high concentration of platelets and the consequent release of growth factors such as PDGF, VEGF, and TGF-β, in addition to inflammation-modulating cytokines. These mediators play a fundamental role in angiogenesis and tissue regeneration, promoting anabolic processes in tendons, muscles, and gluteal fascia [189,190]. In this context, initially established in the field of regenerative medicine, PRP has progressively been incorporated into plastic surgery as an adjuvant to fat grafting, particularly in gluteoplasty with fat transfer (Brazilian Butt Lift – BBL). Thus, the association between PRP and adipose grafts aims to improve graft integration and volumetric retention, while potentially accelerating tissue recovery through stimulation of neovascularization and local regeneration [191–193]. Consistently, clinical studies evaluating lipofilling associated with PRP have reported high patient satisfaction rates and low incidences of adverse events [194].

Simultaneously, histological and instrumental evidence has demonstrated increased collagen deposition and dermal vascularization following PRP application, supporting improvements in firmness and skin quality. Furthermore, literature reviews indicate that combining PRP with fillers, such as hyaluronic acid, may potentiate the collagenic response and favor tissue integration [195,196]. Accordingly, the rationale for the combined use of PRP with fillers and biostimulators is based on its ability to promote biostimulation and extracellular matrix remodeling, contributing to improved skin elasticity and quality. However, the literature emphasizes the need for standardization regarding platelet concentration, activation methods, and applied proportions, since methodological heterogeneity still limits comparison among studies [192,197]. Therefore, although PRP is considered safe and useful as an adjuvant therapy for skin improvement and volumetric integration, it should not be used alone as the primary volumizing agent [189]. Regarding safety in gluteoplasty, complications directly attributable to PRP are generally mild and localized; the critical risk is more closely related to the fat injection technique than to the use of PRP itself [198,199].

## IV. COMPLICATIONS AND MANAGEMENT

### Seroma

Seroma in gluteal harmonization refers to the accumulation of serous fluid within the dead space created after tissue dissection, resulting primarily from lymphatic and vascular injury as well as inadequate hemostasis, and may predispose to infection and wound dehiscence when present in large volumes [200]. In gluteoplasty with implants, seroma is considered a frequent complication: reviews and meta-analyses demonstrate a higher incidence in the subfascial plane (approximately 22%) and with textured implants (7.5% versus 2.6% in smooth implants), whereas intramuscular and submuscular planes tend to present lower rates [23]. Clinical series have reported seroma occurrence in 28% of 200 patients undergoing silicone implant placement, confirming its practical relevance [201]; similarly, gluteal lift procedures with subfascial implants demonstrated an incidence of 11.4% [12]. Comparative reviews indicate a lower overall complication rate with fat grafting than with implants, with seroma rates around 6.9% in autologous fat transfer procedures [9,24]. When fat grafting is ultrasound-guided and restricted to the subcutaneous plane, a recent meta-analysis reported seroma rates of approximately 2.9 per 100 procedures and no cases of fat embolism or mortality, reinforcing its relative safety [108].

Risk factors include extensive dead space, subfascial placement, textured implants, and inadequate hemostasis; conversely, intramuscular or submuscular approaches and meticulous hemostatic techniques reduce its occurrence [23,116]. Clinically, seroma typically appears within 1–3 weeks after surgery, presenting with swelling, pressure sensation, or pain. Ultrasonography confirms and quantifies the fluid collection and is especially useful in the presence of implants [200]. Management is performed in a stepwise manner: small or asymptomatic collections may be observed because of their tendency toward spontaneous reabsorption; larger collections (approximately ≥75–100 mL) or symptomatic cases indicate aspiration, preferably ultrasound-guided in periprosthetic situations. Recurrent cases may require serial aspirations, whereas encapsulated seromas or those associated with infection require surgical drainage [200,202,203]. Prolonged aspiration management lasting more than 40 days has been associated with a greater need for surgical revision, suggesting that definitive intervention should be considered earlier in persistent cases [203].

In summary, seroma is more prevalent following implant-based gluteoplasty—particularly with subfascial and textured implants—than after fat grafting. Effective prevention involves reducing dead space and employing progressive tension sutures (PTS) and Scarpa’s fascia preservation techniques. Diagnosis is primarily ultrasonographic, and treatment ranges from observation to guided aspiration, with surgery reserved for encapsulated recurrences or associated infection [12,23,24,108,201,203].

### Infection

Infection following gluteal harmonization procedures results from contamination of the surgical site or implanted material and may occur early, generally due to intraoperative contamination, or late, when biofilm formation develops on the biomaterial. Biofilms impair antibiotic penetration and sustain persistent or recurrent infections, most commonly caused by Staphylococcus aureus and coagulase-negative staphylococci, as well as non-tuberculous mycobacteria in the context of medical tourism [204,205]. In gluteal implants, clinical series and systematic reviews report infection rates ranging from approximately 1%–7%; in a cohort of 200 operated patients, the infection rate was 6.5%, whereas subfascial and intramuscular techniques demonstrated an overall infection rate of approximately 7.4%, with about 4% classified as superficial infections [201,206]. In gluteal fat grafting, infection is less frequent, with meta-analyses and cohort studies reporting infection rates around 0.2%–3%, while overall complication rates in outpatient settings averaged approximately 9.3%, with infection accounting for nearly 22% of reported complications [10,11,108,207]. In fillers such as hyaluronic acid and PMMA, infections are uncommon but may present late as nodules or abscesses associated with biofilm formation, involving S. aureus, S. epidermidis, or atypical mycobacteria, thereby requiring cultures—including mycobacterial cultures—and imaging studies to evaluate collections [208,209].

Clinically, pain, erythema, warmth, edema, fever, and purulent drainage suggest infection. In implant-based procedures, imaging may reveal periprosthetic fluid collections, whereas in filler-related complications, delayed nodules require differentiation between sterile inflammation and biofilm-associated infection with the support of specific cultures [204,209]. Management depends on the severity and the type of biomaterial involved. Empirical antibiotic therapy should provide coverage against S. aureus (including MRSA) and Gram-negative bacilli, with subsequent adjustment according to culture results. In implant- and biofilm-related infections, combinations including rifampicin (for staphylococci) or fluoroquinolones (for Gram-negative organisms) are recommended when susceptibility is confirmed, always in combination regimens to avoid antimicrobial resistance [204,205,210]. In early and stable implant infections, debridement with implant retention (DAIR) may be attempted, ideally with early initiation and the use of antibiotics active against biofilm-producing organisms. Rifampicin as adjunctive therapy reduces recurrence and improves outcomes, with the clearest benefit observed during 3–6 months of treatment [204,211,212]. Late or persistent infections frequently require implant removal for definitive resolution [204]. In cases involving hyaluronic acid fillers, in addition to antibiotics and drainage, hyaluronidase may be considered after infection control has been achieved [208].

Prevention is based on rigorous aseptic technique, meticulous hemostasis, and reduction of dead space. The selection of intramuscular or submuscular planes may reduce infectious complications compared with subfascial placement in implant-based procedures, particularly when standardized protocols and judicious use of drains are employed when indicated [116,213]. In summary, infection after gluteal harmonization is relatively uncommon, occurring more frequently with implants than with fat grafting or fillers. Biofilm formation explains many late therapeutic failures, making microbiological diagnosis, drainage and/or debridement of the infectious focus, and removal of the implanted material when necessary, essential for definitive cure [24,204,205].

### Nodules and Granulomas

Nodules and granulomas following gluteal harmonization may originate from mechanical causes (excessive or superficial deposition of material) or from inflammatory and infectious processes, the latter often presenting late and associated with bacterial biofilm formation that protects microorganisms and perpetuates chronic inflammation. Pseudomonas, Staphylococcus, and Cutibacterium are typical findings in clinical samples and laboratory models, and multiple needle passes significantly increase contamination rates [214]. In silicone-based procedures (implants or free silicone injections), migration, painful nodules, granulomas, and late biofilm-associated infections may occur; clinical response to minocycline has been reported in silicone-induced granulomas [163]. Because PMMA is a permanent filler, it presents a greater propensity for foreign-body granulomas and rare systemic complications such as hypercalcemia caused by extrarenal calcitriol production. Case series involving gluteal PMMA injections have described subacute hypercalcemia occurring months after methacrylate application, with suppressed parathyroid hormone (PTH) and elevated calcitriol levels, improving after corticosteroids, bisphosphonates, or partial surgical excision [134,139]. Among biostimulators, nodules associated with PLLA, CaHA, and PCL are generally related to technique, particularly inadequate dilution or superficial placement; "true" granulomas are uncommon with PLLA and may respond to intralesional corticosteroids, 5-fluorouracil, and low-dose tetracyclines. Dilutions ≥7 mL and post-procedural massage reduce the risk of PLLA nodules [163]. In hyaluronic acid (HA) fillers, nodules may result from product excess, superficial placement, or biofilm formation. In addition, delayed inflammatory mechanisms may involve low-molecular-weight HA fragments and bacterial components such as lipoteichoic acid, activating TLR2 in immune cells even in the absence of documented active infection [215].

High-frequency ultrasonography is useful for differentiating filler deposits from granulomas: granulomas tend to appear oval-shaped, with blurred margins and internal hyperechoic foci, whereas gel deposits are typically anechoic and well circumscribed, thereby guiding management and the need for biopsy or cultures [216]. Regarding treatment, non-inflammatory HA nodules generally respond to hyaluronidase, with efficacy depending on dosage. Noninfectious inflammatory lesions usually respond to intralesional corticosteroids and, in the case of PLLA, may additionally be treated with 5-fluorouracil and low-dose oral tetracyclines. Persistent lesions associated with permanent materials may require surgical excision [163,217]. When infection or biofilm formation is suspected, cultures—including mycobacterial cultures when appropriate—and targeted antibiotic therapy are indicated, with drainage of collections when present. In silicone-related granulomas, clinical benefit with minocycline has been reported. Adjunctive approaches such as combined enzymatic therapy (hyaluronidase, collagenase, and lipase) and intralesional laser therapy have also been explored, showing clinical improvement in case reports and small series [163,217,218].

In summary, the etiology of nodules and granulomas varies according to the material used and the injection technique. Silicone and PMMA are more strongly associated with persistent granulomas and, rarely, hypercalcemia, whereas biostimulators and HA present a lower risk of "true" granulomas, which are generally related to technical factors or biofilm formation. Ultrasonographic confirmation and consideration of infection or biofilm before labeling a lesion as granulomatous are essential for selecting the appropriate management strategy, including dissolution (in HA), intralesional therapy, targeted antibiotics, or surgical removal when necessary [163,214,216,217].

**Fat Embolism (FE)**

Fat embolism (FE) related to gluteal harmonization occurs predominantly in fat grafting procedures, when injection into deep planes injures gluteal veins and allows fat to enter the circulation. Clinically, a distinction is made between macroscopic fat embolism (MAFE), characterized by large emboli and cardiorespiratory collapse, and microscopic fat embolism (MIFE), which presents with systemic inflammatory response, dyspnea, neurological alterations, and petechial rash, being recognized mainly through clinical presentation in the absence of a specific diagnostic test [219,220]. The risk is directly related to the injection technique: the intramuscular plane and the use of small cannulas (<4 mm) increase the likelihood of vascular injury and fat embolism. For this reason, task force groups initially reported mortality rates estimated at approximately 1:2,351–1:6,241, with subsequent reduction to approximately 1:14,952 after adoption of recommendations including avoidance of intramuscular injection, avoidance of downward cannula angulation, and preference for cannulas ≥4 mm [30,107]. Anatomical studies demonstrate substantially larger venous calibers in deep and medial planes (superior gluteal vein approximately 7.6 mm and inferior gluteal vein approximately 13.7 mm), reinforcing the increased danger associated with inferolateral-to-superomedial trajectories and intramuscular injection planes [25,27].

In contrast, clinical series, prospective studies, and meta-analyses restricting fat grafting to the subcutaneous plane under real-time ultrasonographic guidance have reported no cases of fat embolism or mortality (0/1,815 and 0/6,235) and low rates of minor complications (approximately 3%–6%), supporting the safety of the image-guided suprafascial plane without significant compromise of graft retention [11,106,108,221]. The incorporation of intraoperative ultrasonography itself has been associated with reduction in severe adverse events and continuous confirmation of cannula positioning above the gluteal fascia, providing greater safety compared with techniques performed without imaging guidance [222,223].

In the perioperative period, fat embolism may occur intraoperatively or within a few postoperative hours. Early signs include reduction in end-tidal $CO_2$ ($ETCO_2$), hypoxemia, and hemodynamic instability. Once suspected, immediate interruption of the procedure and intensive supportive care are recommended, with confirmation by computed tomography whenever feasible. It is important to note that there is no proven specific pharmacological therapy for fat embolism; in severe cases of MAFE, advanced supportive measures such as extracorporeal membrane oxygenation (ECMO) may be required [224,225]. In summary, prevention is based on maintaining injection exclusively within the subcutaneous plane, documenting the injection plane with real-time ultrasonography, using larger-caliber cannulas, and avoiding high-risk injection vectors. Adoption of these measures has been associated with significant reduction in pulmonary fat embolism (PFE), fat embolism syndrome, and mortality in gluteal fat grafting procedures [10,28,112].

**Thromboembolism**

Venous thromboembolism (VTE) following gluteal harmonization procedures is rare but potentially severe and results primarily from perioperative factors such as prolonged immobilization, anesthesia, increased operative time, and inflammatory response, rather than from the type of material used. In series and reviews of body contouring procedures, symptomatic thrombotic pulmonary embolism (PE) in gluteoplasty with fat grafting has been reported at approximately 0.04% when modern techniques and safety protocols are applied, a value consistent with meta-analyses demonstrating a pooled PE incidence of 0.04% and lower risk associated with exclusively subcutaneous injection and the use of real-time ultrasonography [10,11,112]. In aesthetic surgery, the overall risk of VTE is low but increases in body contouring procedures and combined surgeries. In a cohort of 129,007 cosmetic surgeries, the overall VTE rate was 0.09%, with higher rates observed in body procedures and combined operations, as well as progressive increases according to age and body mass index (BMI) [226].

The risk profile in body contouring procedures, such as abdominoplasty and lipoabdominoplasty, demonstrates deep vein thrombosis (DVT) rates ranging from approximately 0.3%–2.5% and pulmonary embolism rates between 0%–0.6% in series employing optimized prophylaxis protocols. Large database studies further identify abdominoplasty as one of the principal sources of VTE in aesthetic surgery, with predictors including age >40 years and BMI >25 kg/m² [227,228]. Clinical series and case reports also reinforce that even low-risk patients may develop VTE, highlighting the importance of clinical vigilance and imaging diagnosis—venous Doppler ultrasonography for DVT and computed tomography pulmonary angiography for PE—in the presence of unilateral lower-limb pain and edema, sudden dyspnea, chest pain, or tachycardia [229,230].

Prevention is based on individualized risk stratification, with the Caprini score demonstrating good predictive capacity in plastic surgery and a clear association between higher-risk categories and increased VTE incidence. Hematology guidelines recommend low-molecular-weight heparin (LMWH) for moderate- and high-risk patients, in addition to mechanical prophylaxis measures such as intermittent pneumatic compression and early mobilization, while balancing the associated bleeding risk [231,232]. Multimodal protocols combining mechanical compression and pharmacologic prophylaxis reduce VTE more effectively than isolated methods in surgical populations, and data from aesthetic plastic surgery suggest maintenance of low VTE rates without significant increases in hematoma formation when patient selection is appropriate. Conversely, strict application of the Caprini score may reduce unnecessary anticoagulant use without increasing DVT or PE incidence in some series, illustrating the need for individualized approaches according to patient risk and procedural characteristics [233–235].

When VTE is suspected, systemic anticoagulation with heparin or direct oral anticoagulants constitutes first-line treatment for both event management and recurrence prevention, following current protocols and considering the risk–benefit balance for each patient [230]. In summary, VTE in gluteal harmonization is uncommon and more strongly associated with perioperative conditions and patient- or procedure-related factors—such as age, BMI, combined surgeries, and prolonged operative time—than with the harmonization material itself. The risk may be mitigated through Caprini-based stratification, risk-guided mechanical and pharmacologic prophylaxis, and the adoption of safe surgical techniques, such as ultrasound-guided subcutaneous fat grafting, which has also contributed to reducing pulmonary complications associated with body contouring procedures [10,226,231].

**Necrosis**

Necrosis in aesthetic procedures results from tissue ischemia caused by intravascular occlusion or extrinstic vascular compression, clinically presenting with pallor or bluish-purple discoloration, disproportionate pain, a livedoid pattern, and delayed capillary refill, potentially progressing to blistering and tissue sloughing within 24–72 hours if immediate intervention is not performed. Delayed presentations, occurring up to 2–5 days after the procedure, require a high degree of clinical suspicion [236,237]. In hyaluronic acid (HA) fillers, vascular occlusion represents the principal mechanism. Early management with hyaluronidase constitutes the cornerstone of therapy, and systematic reviews and meta-analyses report complete resolution in approximately 78% of cases, with better outcomes when intervention occurs within the first hours and without clear statistical benefit of doses >500 IU compared with ≤500 IU, reinforcing that prompt treatment is the determining factor [238,239]. Recent evidence suggests that ultrasound-guided hyaluronidase administration may increase the resolution rate to approximately 95%, reducing the required dose and optimizing delivery to the target tissue [240]. Stepwise treatment protocols include pulsed hyaluronidase administration, antithrombotic therapy, and inflammatory control. Adjunctive therapies, such as hyperbaric oxygen therapy (HBOT), have also been used as complementary approaches, with reports of benefit in cutaneous ischemia and rare cases of ocular compromise, although robust standardization remains lacking [241–244]. In biostimulators such as CaHA, PLLA, and PCL, no specific antidote exists, making prevention and early recognition even more critical [245].

In gluteal fat grafting, intramuscular injection is associated with a greater risk of fat embolism and ischemic events, whereas strictly subcutaneous techniques—preferably performed under intraoperative ultrasonographic guidance—demonstrate lower incidences of major complications. Meta-analyses and ultrasound-guided series report pulmonary embolism rates of approximately 0.04% overall, with 0% mortality and no cases of clinically significant fat embolism, while minor complications occur in approximately 3%–6% of cases and local ischemia in approximately 1%–1.2% [10,11,108]. Recommendations from professional societies such as the ASERF and BAAPS, together with observational data, demonstrate significant improvement in safety following adoption of exclusively subcutaneous injection, use of cannulas ≥4 mm, and maintenance of the cannula parallel to the safe injection plane, reducing pulmonary fat embolism (PFE) rates from approximately 0.097% to 0.04% and lowering mortality to approximately 1:14,921 [107,112,246]. Anatomical and ultrasound-based training studies further assist in defining subcutaneous thickness and maintaining the cannula above the gluteal fascia [68,113].

In this sense, necrosis associated with aesthetic procedures results primarily from ischemia caused by vascular occlusion or compression. Procedural safety is enhanced through ultrasound-guided subcutaneous techniques, early recognition of ischemic signs, immediate and repeated use of hyaluronidase in HA-related events, and judicious use of adjunctive therapies such as HBOT in selected cases. In gluteoplasty with fat grafting, the combination of a strictly subcutaneous injection plane and ultrasonographic guidance has supported very low rates of thromboembolic and ischemic complications [11,108,114,239–244].

## Gluteal Augmentation Techniques: Comparative Analysis of Efficacy, Safety, and Patient Satisfaction

The analysis of the included studies demonstrated a wide variety of techniques used for gluteal augmentation, including silicone implants, autologous fat grafting, fillers based on hyaluronic acid (HA), calcium hydroxyapatite (CaHA), and poly-L-lactic acid (PLLA), as well as the use of polymethylmethacrylate (PMMA), as shown in Table 1. Overall, the reviewed studies comprised different methodological designs, including systematic reviews, retrospective studies, cadaveric studies, and clinical trials, encompassing thousands of patients. In general, the findings demonstrated high levels of patient satisfaction regardless of the technique employed, as studies consistently reported elevated satisfaction rates across all approaches [1]. However, important differences were identified regarding the safety profile and complications associated with each method.

Table 1: Methodological Synthesis and Main Findings of the Studies

| Author/Year | Objective | Methodology | Results | Conclusion |
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| 1.Oranges et al. (2017) | To analyze outcomes, complications, and patient satisfaction across different gluteal augmentation techniques. | Literature review based on a PubMed/MEDLINE search of clinical studies on gluteoplasty. Predefined selection criteria were applied. | 52 studies, 7,834 patients; identified techniques: silicone implants, fat grafting, flaps, and hyaluronic acid; highest complication rates observed in implants. High patient satisfaction reported across all techniques. | Implants show high patient satisfaction but a higher complication rate. Fat grafting demonstrates a lower complication rate. Flap techniques are indicated after massive weight loss. Hyaluronic acid provides temporary effects and is associated with high cost. |
| 10. Elsaftawy et al. (2026) | To evaluate the complication rates of fat grafting for gluteal augmentation and procedure-related factors. | Systematic review conducted in accordance with PRISMA guidelines, with searches performed in PubMed, Embase, Scopus, and Cochrane databases. Clinical studies on autologous gluteal fat grafting were included. | 38 studies and 22,151 patients. Minor complications: 3.58%; seroma: 2.03%; contour irregularity: 2.29%. Pulmonary embolism: 0.04%. The use of ultrasound guidance and subcutaneous injection was associated with lower complication rates. | Fat grafting is generally safe when performed using evidence-based techniques. Subcutaneous injection and the use of ultrasound guidance enhance the safety of the procedure. |
| 27. Alvarez-Alvarez et al. (2019) | To identify injection techniques associated with a lower risk of embolism. | Cadaveric study comparing different injection approaches and angles. | Some techniques showed greater contact with vascular structures. | Certain injection angles and approaches demonstrated a lower risk of complications. |

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| 38.Ducati et al. (2025) | To describe gluteal ultrasound anatomy and map dermal fillers. | Descriptive study with ultrasound evaluation of the gluteal region. | Ultrasonography identified different fillers and their distribution. | The method assists in the diagnosis of complications and therapeutic planning. |
| 60. Frojo et al. (2023) | To identify deep fat compartments in the gluteal region. | Cadaveric study with anatomical dissection and ultrasound-guided infiltration. | Seven deep fat compartments were identified in the gluteal region. | Knowledge of these compartments may improve the safety of the procedure. |
| 130. Alves et al. (2019) | To evaluate the safety and efficacy of gluteal augmentation with PMMA. | Multicenter retrospective study with medical record analysis. | A total of 101 adverse events (2.1%) were recorded among the performed procedures. | PMMA filler demonstrated an acceptable safety profile. |
| 150. Almeida et al., 2019 | To develop consensus recommendations for the safe and effective use of hyperdiluted calcium hydroxyapatite (CaHA) as a facial and body biostimulatory agent. | Consensus study involving 10 experts with extensive experience in dermal fillers and biostimulators. Recommendations were discussed in a face-to-face meeting, with consensus defined as agreement among 70%–89% of participants and strong consensus defined as ≥90% agreement. | Recommendations were established for various areas of the face and body, including the buttocks. The consensus included guidance on injection techniques, entry points, volumes, dilutions, number of sessions, and treatment intervals. | The expert consensus provides clinical guidelines for the use of hyperdiluted CaHA as a biostimulatory agent, contributing to greater safety and standardization of aesthetic procedures. However, the authors emphasize the need for further clinical studies to strengthen the scientific evidence. |
| 160. Nikolis et al. (2022) | To evaluate the efficacy and safety of PLLA in the treatment | Multicenter study involving 30 women who underwent three sessions of PLLA injections in | After 6 months, 84% showed clinical improvement, with a 96% satisfaction rate and | PLLA is safe and effective for gluteal remodeling, promoting long-lasting improvements in |

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| | of gluteal contour deformities. | the buttocks, with a six-month follow-up period assessing clinical efficacy and safety. | improvements in skin elasticity, hydration, and texture; adverse events were mild with no serious complications. | aesthetic appearance and skin quality, with high patient and physician satisfaction. |
| 171. Crabai et al., 2024 | To evaluate the safety and efficacy of non-surgical gluteal augmentation with hyaluronic acid. | Multicenter retrospective study involving 91 patients treated with hyaluronic acid (HYAcorp MLF1/2), with follow-up of up to 4 years. | There were no serious adverse events, and the side effects were mild and transient. High patient satisfaction was observed. | Gluteal augmentation with hyaluronic acid was shown to be effective and safe for non-surgical gluteal volume enhancement. |
| 174. Fontenete & Alfertshofer, 2026 | To analyze the physicochemical and rheological properties of body hyaluronic acid fillers and their clinical implications in body contouring. | Experimental laboratory study evaluating four commercially available body hyaluronic acid fillers. Physicochemical properties (pH, osmolality, ionic concentrations, transparency, and swelling factor) and rheological properties (G', G", G*, and tan δ) were analyzed at frequencies ranging from 0.1 to 1 Hz. | Physicochemical analyses showed similar stability among the fillers. However, significant rheological variations were observed: Infini B Body exhibited lower elasticity and stiffness values, whereas HYAcorp MLF1 and MLF2 demonstrated higher G' and G* values, indicating greater mechanical resistance and elasticity. | The selection of body fillers should consider their rheological properties, as different levels of elasticity and stiffness influence performance in areas subjected to higher mechanical stress, such as the buttocks. The authors emphasize the need for further clinical studies to confirm these findings in the long term. |
| 179. Mortada et al. (2023) | To evaluate the efficacy of hyaluronic acid in gluteal augmentation. | Systematic review of studies on the use of hyaluronic acid. | High patient satisfaction was observed, with an average duration of 16 months. | Hyaluronic acid presents predictable results but requires further research. |

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| 180. Iribarren-Moreno et al., 2025 | To propose a standardized marking and injection technique for hyaluronic acid in gluteal augmentation. | Study involving 26 women treated with hyaluronic acid, using anatomical marking in three specific areas to guide the injection. | A significant increase in hip circumference was observed, along with high patient satisfaction with the procedure. | The technique allowed optimization of HA use, providing gluteal augmentation with good aesthetic outcomes and a potential reduction in complications. |
| 192. Luck; Smith; Mosahebi, 2017 | To analyze preparation and application methods of fat grafting combined with PRP. | Systematic review conducted in accordance with PRISMA guidelines, including 23 studies. | A wide variation was observed in the preparation and mixing methods of PRP and fat. | Methodological heterogeneity hinders comparison of results and standardized clinical application. |
| 207. Weidman, Allan A. et al., 2024 | To analyze the prevalence and characteristics of complications in gluteal augmentation with fat grafting in outpatient surgeries. | Retrospective study using QUAD A (formerly AAAASF) data from 2019–2021; analysis of sociodemographic, surgical, and institutional variables; descriptive statistics and logistic regression. | 436 complications reported (0.94%); 164 (37.6%) associated with gluteal augmentation; majority female (96.7%), mean age 42 years, BMI 28.3 kg/m²; most common complication: wound infection (22.3%); 35.9% required hospital care; 12.6% required reoperation; 4 deaths. | Gluteal augmentation accounts for a large proportion of fat grafting complications; greater rigor in reporting may improve safety and better estimate the incidence of complications. |
| 236.Nayfeh, Tarek et al. 2021 | To support the American Society for Dermatologic Surgery guidelines on the prevention and management of adverse events associated with injectable fillers. | Systematic review of 182 studies; analysis of risk factors and treatments for visual impairment, skin necrosis, inflammatory events, and nodules; meta-analysis | IRVC is rare (1–2/1,000,000), with improvement in 19% of cases; cutaneous necrosis occurs in 5/1,000, with improvement in 77%; treatments depend on hyaluronidase, antibiotics, corticosteroids, and 5-FU; risk | Practitioners should be familiar with anatomy, filler history, and establish preventive protocols to manage complications; the available evidence is of low certainty. |

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| | | performed when feasible. | is lower with appropriate fillers, techniques, and volumes. | |

The literature findings demonstrated that gluteal harmonization, within the context of BHA, yields superior outcomes when based on individualized anatomical planning and appropriate technique selection. Autologous fat grafting remains considered the gold standard due to its biocompatibility and ability to provide natural-looking results. However, its safety is directly dependent on the execution technique, particularly the restriction of injection to the subcutaneous plane.

In addition, techniques using fillers and biostimulators such as hyaluronic acid, calcium hydroxyapatite, and poly-L-lactic acid have demonstrated efficacy in improving body contour and skin quality, with high satisfaction rates and a low incidence of mostly transient complications. These methods are highlighted for being minimally invasive and offering shorter recovery time, although their duration is limited compared to permanent techniques. On the other hand, permanent materials such as PMMA provide greater durability but are associated with risks of late complications, including granulomas and systemic alterations, reinforcing the need for careful clinical indication. Similarly, silicone implants show good results in patients with limited adipose tissue availability but involve surgical risks and require greater technical rigor.

Regarding complications, events such as seroma, infection, nodules, and necrosis were more frequently described, while severe complications such as fat embolism are strongly associated with specific techniques, particularly deep-plane injection. In this context, the adoption of safety protocols—including blunt cannulas, subcutaneous plane injection, and the use of ultrasonography—has proven essential in reducing risks. Thus, the findings reinforce that the safety and efficacy of gluteal harmonization depend directly on the integration of anatomical knowledge, individualized planning, and evidence-based technical execution.

## V. CONCLUSION

Gluteal harmonization, within the context of Body Harmonization Aesthetics, is an effective approach for improving body contour, provided that it is grounded in in-depth anatomical knowledge and individualized planning. The available techniques present distinct profiles in terms of efficacy, durability, and safety, making appropriate patient selection essential. Minimally invasive procedures demonstrate good outcomes with lower risk, whereas permanent techniques require greater caution due to the potential for late complications. The prevention of adverse events is directly associated with the selection of the subcutaneous plane and the adoption of safe protocols, such as the use of ultrasonography. Therefore, evidence-based practice is essential to ensure satisfactory and safe outcomes. Gluteal harmonization should be performed with technical rigor, professional ethics, and a strong focus on patient safety.

CONFLICT OF INTEREST

The authors affirm that they have no conflicts of interest.

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