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Recommendations on Ensuring Safety in Lower Limb Fat Grafting: Physiological Insights, Risk Assessment and Advanced Surgical Techniques

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Introduction

In recent years, interest in calf augmentation and reshaping has developed alongside the advancements in body contouring surgery—particularly high-definition liposuction and fat grafting techniques—which are now routinely treating the entire body. While lower extremity fat grafting has traditionally been dominated by buttock augmentation, this paradigm shift has put the patients' focus also on calf enhancement and demand for calf reshaping is growing.

However, despite this rising interest, scientific research on the safety, feasibility and long-term outcomes of calf fat grafting remains limited, and it seems necessary to establish evidence-based guidelines that address both technical execution and safety concerns.

This paper aims to bridge the existing knowledge gap by reviewing the most advanced and recently published literature on this topic. By combining current scientific findings with practical surgical insights, these recommendations seek to provide a comprehensive guide for optimizing outcomes while ensuring the highest standards of patient safety in fat grafting to the calf.

Literature Review

In 2022 in their systematic meta-analysis, Escandón et al. [1] gathered 48 studies involving 2455 patients. However, the authors primarily focused on surgical techniques and volumetric restoration rather than the critical aspect of safety. This seems to reflect a broader trend in literature, where most publications on calf augmentation emphasize procedural methodology and aesthetic outcomes while overlooking key safety considerations.

Melita et al. [2] published their retrospective review in 2019 in which they identified different options of calf augmentation techniques, with a total of 2629 cases, including 265 patients who underwent fat grafting. Noticeably, the complication rate for fat grafting was the

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lowest among all surgical techniques, recorded at 1.509%. Reported complications were minor, including hyperpigmented scarring and transient hypoesthesia, with no documented cases of fat embolism or recipient/donor site seroma. However, the plane of fat grafting was not specified and, in most cases, remained unknown. A key limitation of fat grafting to the calf noted by the authors was the lower graft retention and the necessity for multiple treatment sessions to achieve optimal volume and aesthetic outcomes. While fat grafting demonstrates a favorable safety profile, the need for staged procedures presented logistical and financial obstacles for patients and surgeons alike.

Beyond the findings of this particular review—which did not specify the plane of fat grafting—other authors were sometimes more precise in describing the injection plane and related outcomes. In the majority of papers reviewing patient outcome, fat grafting was performed in the subcutaneous plane [3], whereas a smaller subset of studies underwent combined subcutaneous and intramuscular graft placement [4, 5] or in non-well-defined layer referred to as "different layers" [6].

Historically, calf augmentation has been assumed to follow the same principles as other lower limb procedures, without necessarily accounting for its unique anatomical and biomechanical characteristics, which warrant a distinct approach [7].

In the last 5 years, there has been a noticeable increase in published cases focusing on gastrocnemius volume enhancement, muscle contouring and definition, driven by the rising popularity of high-definition liposuction and fat grafting. Notably, a paradigm shift describing intramuscular fat grafting techniques in various muscles of the body has triggered an increasing number of reports placing the fat intramuscularly also in the calf—with or without ultrasound guidance. For instance, one study presented a series of 102 cases in which fat grafting was performed exclusively within the gastrocnemius muscle. These studies primarily examined the risk of venous thrombosis and the presence of large-caliber vessels in the calf region. The authors acknowledged the absence of dedicated safety studies on the potential volumetric and consequently, hemodynamic impact of intramuscular fat grafting as a limitation of their study, but did not investigate this further.

Even though no cases of compartment syndrome or other major complications were reported in this study, they highlighted this gap of knowledge as a significant aspect requiring further investigation in the future [8].

The first study investigating compartment pressures following calf augmentation—comparing both intramuscular and subcutaneous techniques—was published in 2021 [9]. This study demonstrated a significant immediate postoperative increase in intramuscular compartment pressure, with mean values exceeding 20 mmHg at 24 h after aesthetic calf augmentation and getting close to the critical threshold for compartment syndrome ($\geq$30 mmHg). In contrast, pressures within the subcutaneous compartment remained between 2 and 19 mmHg, irrespective of the volume of fat grafted. Furthermore, no statistically significant increase in subcutaneous compartment pressure was observed at the 24-h postoperative mark, unlike the intramuscular compartment where elevated pressures persisted throughout the same observation period.

In 2024, Dr. Glenner and colleagues validated the findings of the previous study by measuring post-grafting pressure increments in both the intramuscular and subcutaneous layers in a series of eight fresh cadaveric lower extremities specimens. Their results confirmed a significant rise in intramuscular pressure, markedly greater than that observed in the subcutaneous layer. Based on these results, the authors concluded that intramuscular fat grafting to the gastrocnemius should be performed with caution due to the heightened risk of embolism, thrombosis and compartment syndrome. Conversely, subcutaneous fat injections in the calf region appear to be a safer alternative, as pressure increases remain localized and do not transmit to deeper structures [10].

Conclusion

Based on current literature, it is essential to adopt calf augmentation techniques that do not carry the risk of creating thromboembolic events, arterial occlusion or compartment syndrome. These complications can arise from alterations in intracompartmental volume or pressure, potentially leading to tissue ischemia, necrosis or the need for salvage procedures that may compromise limb function. A safe and effective approach must respect the physiological constraints of the region—notably the inherently non-compliant quality of the surrounding fascia and the fact that fat grafting causes more tissue inflammation and edema compared to calf implant surgery.

The Following Recommendations Aim to Ensure Patient Safety in Calf Fat Grafting Procedures

1. Favor Subcutaneous Fat Grafting:
   Subcutaneous and suprafascial fat placement is associated with lower compartment pressures and a significantly reduced risk of serious complications, such as compartment syndrome and vascular events.
2. Avoid Intramuscular Injections:
   Intramuscular fat grafting to the gastrocnemius should

be approached with extreme caution due to elevated risks of embolism, thrombosis and increased compartment pressure.

3. Limit Graft Volume:
   Excessive fat volume, especially if inadvertently placed in closed fascial compartments, may increase pressure, compromise tissue perfusion and lead to necrosis. Conservative grafting is advised.
4. Assess Patient-Specific Risk Factors:
   Consider comorbidities that may predispose patients to poor wound healing, thrombosis or abnormal inflammatory responses.
5. Use Ultrasound Guidance Cautiously:
   While helpful for anatomical navigation, ultrasound does not eliminate the risks associated with intramuscular fat grafting and may provide a false sense of safety. Its use should not justify deeper injection planes in the calf.
6. Monitor for Postoperative Compartment Syndrome:
   Be vigilant for early signs of compartment syndrome, especially in the first 24–48 hours postop. Persistent pain, tension and neurovascular compromise warrants urgent evaluation.
7. Stage Procedures When Needed:
   When large volume enhancement is desired, consider staging the procedure to allow safe graft integration and minimize pressure-related complications.
8. Educate Patients on Realistic Outcomes:
   Ensure patients understand the limitations of fat retention and the possible need for secondary procedures to achieve desired volume and symmetry.
9. Prioritize Safety over Aesthetic Ambition:
   Aesthetic goals should not override anatomical and physiological boundaries. Patient safety must remain the priority for patients.

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