Original Investigation

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Anatomical and Histological Characterization of the SOOF: Redefining Midface Support

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ABSTRACT

Objective: The suborbicularis oculi fat (SOOF) is a distinct fibro-adipose tissue with critical functional and aesthetic roles in the midface. Despite its clinical relevance, the precise anatomical and histological characteristics of this condition remain underdefined. This study aims to delineate the structural organization and tissue composition of the SOOF, with a focus on its relationship with the orbicularis oculi muscle (OOM) and the superficial muscular aponeurotic system (SMAS).

Methods: Tissue samples from the lateral infraorbital region, including skin, SMAS, OOM, and SOOF, were harvested post-mortem from ten body donors without prior head or neck interventions. Samples were fixed in 4.5% formaldehyde, sectioned, and stained using hematoxylin and eosin and masson's trichrome. Histological analyses focused on collagen organization, muscle integration, and vascularization.

Results: SOOF was identified as a multilayered, vascularized tissue located beneath the OOM and connected to the SMAS through fibrous septa. Masson's Trichrome staining revealed dense, well-aligned collagen bundles and interspersed muscle fibers, forming a complex ligamentous structure. These findings suggest a dynamic interface between connective and contractile elements, supporting both the structural and functional integrity of the lower eyelid and midface region.

Conclusion: The SOOF is not a passive fat pad but a myofibrous unit integrated with adjacent anatomical structures. Its anatomical continuity with the SMAS and OOM underscores its importance in facial dynamics, aging, and surgical intervention. A deeper understanding of SOOF morphology enables more precise, functionally informed approaches to midfacial rejuvenation and reconstructive surgery.

Keywords: Suborbicularis oculi fat (SOOF), superficial musculoaponeurotic system (SMAS), orbicularis oculi muscle (OOM), facial anatomy, midface rejuvenation

INTRODUCTION

Suborbicularis oculi fat (SOOF) is a distinct adipose structure located beneath the orbicularis oculi muscle (OOM) residing supraperiosteally in the inferolateral region of the orbit. It is positioned above the zygomatic arch and below the lateral half of the infraorbital rim, extending from +15 degrees medially to -87 degrees laterally relative to the caudal vertical mid-pupillary line. This fat pad plays a significant role in facial aesthetics and function, contributing to the contour and volume of the midface and lower eyelid region (1).

Previous studies emphasized the anatomical continuity between the SOOF, superficial muscular aponeurotic system (SMAS), and OOM, which plays a key role in facial surgeries. The SMAS, a fibrous, three-dimensional meshwork, provides structural support to the facial skin and muscles, including the OOM (2).

Historically, the term "SOOF" was coined in reference to lower eyelid blepharoplasty procedures, where the fat pad was often resected to prevent contour defects (3). Despite its clinical relevance, the SOOF has not been formally included in anatomical terminologies such as Nomina Anatomica, leading to ongoing debates regarding its exact anatomical boundaries and morphological characteristics (1,4). A clear understanding of SOOF anatomy is crucial because it significantly affects the success of surgeries that treat midfacial aging and conditions, such as lower eyelid ectropion and facial palsy (5). Given the variability in orbital defects and the lack of consensus in their classification,

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reconstructive approaches often rely on the surgeon's experience (6). The reconstruction of orbital defects presents a complex challenge, demanding a nuanced approach that considers anatomical layers, defect size, and location to achieve predictable, stable, and functionally sound results (7). The classification systems, although valuable, often fail to comprehensively address the status of the orbital floor and zygoma, which are critical for midface function and cosmesis (8). The primary goal of eyelid reconstruction is to establish a stable eyelid margin that ensures proper dimensions and tension in both open and closed states, and to achieve eyelid symmetry without any rough or uneven internal surfaces, while optimizing aesthetics (9).

Facial aging is strongly influenced by changes in fat compartments, especially the position and morphology of the SOOF (10). Given the close anatomical and functional relationship between the SOOF and its surrounding structures, understanding its role in facial dynamics is essential for improving surgical interventions aimed at rejuvenating the periorbital and midfacial regions (11).

METHODS

Ethical approval was obtained from the University of Health Sciences Türkiye, Hamidiye Scientific Research Ethics Committee (number: 2025/7- 7/23, date: 27.03.2025). This study strictly adhered to the principles outlined in the Declaration of Helsinki, ensuring the highest standards of research integrity and ethical conduct. Given that our study utilizes cadaveric specimens, obtaining a consent form is not necessary, allowing us to focus entirely on the research objectives without legal constraints.

Whole-graft tissue blocks of the skin, SMAS, OOM, and SOOF from the lateral infraorbital region were collected post-mortem from ten body donors, and fixed in 4.5% formaldehyde. The donor sites showed no visible scars or tissue damage, and the medical history revealed no surgical intervention or radiation of the head and neck area. SOOF was localized macroscopically using the method described by Hwang et al. (12), in which tissue blocks were removed.

Histological Analysis

Following fixation in 4.5% formaldehyde, tissue blocks measuring 1×2×1 cm^3 were processed for paraffin embedding. Serial sections were obtained in the vertical plane at a thickness of 5 μm, and every tenth section was collected for histological evaluation. Masson's trichrome staining was applied to the selected sections. Photomicrographs were captured using a Zeiss Axiocam camera attachment at × 5 and × 40 objective magnifications. The sections were examined under a Zeiss Scope A1 microscope (Germany), and additional micrographs were acquired. All micrographs were edited and assembled using Adobe Photoshop 2024 (Adobe Inc., San Jose, California, United States).

In developing this work, the authors harnessed the capabilities of OpenAI's ChatGPT, Jenni, and Grammarly to create insightful summaries of relevant research articles. These artificial intelligence (AI)-generated summaries were rigorously evaluated against manually crafted summaries by field experts, ensuring accuracy and relevance. Upon validating their quality, these summaries were seamlessly integrated into the literature review section of the manuscript. The authors carefully reviewed and refined the content, assuming full responsibility for the integrity of the publication. The strategic use of these AI tools significantly enhanced the efficiency of the literature review process and greatly enriched the depth and breadth of the research insights collected.

Statistical Analysis

This qualitative study offers a compelling exploration of the histological characteristics of specific tissue samples obtained from cadavers, grounded in carefully formulated hypotheses-driven observations. Given its qualitative focus, the study does not rely on quantitative measurements or comparisons; instead, it provides an in-depth evaluation of the morphological and histological structures observed within the tissue samples. Consequently, conventional parametric or non-parametric statistical analyses are not applicable in this context. The results are articulated descriptively, drawing on the expertise of anatomists and histologists, and are thoughtfully interpreted with respect to the existing body of literature. This approach not only enhances the validity of the findings but also enriches the overall understanding of the tissue characteristics studied.

RESULTS

Hematoxylin and Eosin (H and E) Staining

At low magnification (x5), full-thickness skin sections, including the epidermis, dermis, and subcutaneous tissue, were examined. The SOOF region was identified by its anatomical location beneath the OOM, appearing as a deep fat pad. In this area, collagenous septa were noted as dense, eosinophilic bundles extending from the dermis into the submuscular adipose tissue. These fibrous septa displayed a stratified architecture and functioned as anchoring structures between the deep dermis and the underlying fat compartments. The fibrous septa extended to the upper layers of the OOM and divided the fat into lobules that contained muscle fibers. These septa reached the surface of the OOM, forming the fibro-muscular septa of the infraorbital SMAS, thus establishing a direct anatomical connection between the SOOF and the SMAS (Figure 1). Unlike the fibrous structures within the SMAS, the septa of the SOOF exhibited a smoother surface and aligned parallel to the fibers of the OOM.

Additionally, vascular structures, including small to medium-sized blood vessels, were observed interspersed among the collagen fibers and adjacent to muscle fascicles. Muscle bundles beneath the collagenous framework displayed a striated morphology, with peripheral nuclei indicative of skeletal muscle tissue. The SOOF ligament complex demonstrated a well-organized, fibrous composition, maintaining continuity with the surrounding muscular and vascular elements.

Masson's Trichrome Staining

Masson's Trichrome staining effectively highlighted the connective tissue elements. The collagen fibers within the SOOF ligament complex stained prominently blue, allowing clear differentiation from the surrounding muscular (red) and vascular components (Figure 2). These collagen bundles extended vertically and obliquely beneath the OOM, suggesting their supportive role in maintaining facial soft tissue integrity. The fibrous structures were organized in a multilayered configuration, with several fibers converging at the interface between muscle and fat. Vascular channels, filled with erythrocytes, were frequently detected between the collagen bundles, confirming the vascularized nature of the SOOF region.

At higher magnification (x40), Masson's Trichrome staining (Figure 2) provided a detailed visualization of the ultrastructural organization within the SOOF ligaments. Collagen fibers were stained blue, showing a dense and orderly fibrillar structure. Notably, muscle fibers were observed interspersed among these collagen structures (Figure 3). This coexistence of muscle and collagen fibers underscores the complex myofibrous nature of the SOOF ligament. The proximity and partial integration of muscle fibers within the collagen matrix suggest an interactive structure between connective and contractile tissues, which may contribute to the structural stability and functional mobility of the SOOF. The collective staining characteristics and microanatomical arrangement of the SOOF ligaments support their classification as specialized, vascularized, collagenous structures with embedded muscle elements. These components serve a dual role, providing positional support and mechanical coordination for the lower eyelid and midface region.

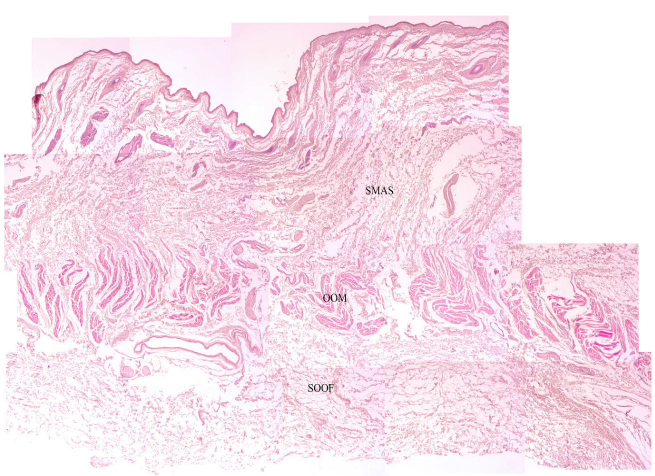

Figure 1. Hematoxylin and eosin stained micrograph of the connection between SOOF, OOM and SMAS (SOOF, suborbicularis oculi fat; OOM, orbicularis oculi muscle; SMAS, superficial musculoaponeurotic system) (Composed by stitching images taken at x50 magnifications.)
SOOF: Suborbicularis oculi fat, OOM: Orbicularis oculi muscle, SMAS: Superficial muscular aponeurotic system

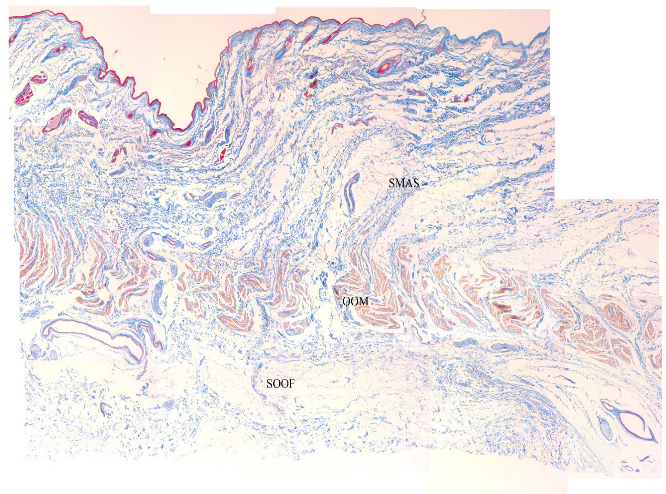

Figure 2. Masson's Trichrome-stained section illustrating the anatomical relationship between the SMAS, OOM and the SOOF. Collagenous structures are stained blue, highlighting dense fibrous septa extending from the dermis into the submuscular adipose tissue. These septa pass through and around the OOM, dividing the SOOF into lobular compartments. (SOOF, suborbicularis oculi fat; OOM, orbicularis oculi muscle; SMAS, superficial musculoaponeurotic system) (Composed by stitching images taken at x50 magnifications.)
SOOF: Suborbicularis oculi fat, OOM: Orbicularis oculi muscle, SMAS: Superficial muscular aponeurotic system

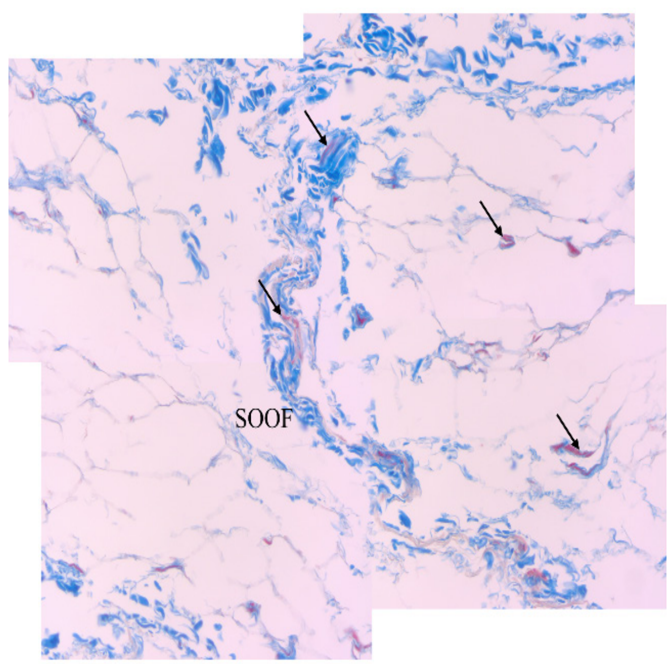

Figure 3. Representative histologic section of the SOOF region stained with Masson's Trichrome. Collagen fibers appear intensely blue within the SOOF ligament and forming multilayered bundles adjacent to the suborbicular fat pads. (SOOF, suborbicularis oculi fat; arrow, muscle fiber) (Composed by stitching images taken at x400 magnifications.)

DISCUSSION

SOOF is located between the OOM and the infraorbital SMAS. This anatomical arrangement creates a three-dimensional fibrous network that encircles adipose structures, allowing SOOF to act as a cushion that reduces friction during OOM movements. When the OOM contracts, the movement is transmitted through the SMAS to the skin, while SOOF is simultaneously displaced. Histological studies reveal that SOOF comprises a mixture of fibrous and adipose tissues, distinguishing it from the more homogenous orbital fat. The fibrous component consists of interconnected chambers filled with adipocytes, supporting earlier findings on three-dimensional tissue formations (1,13).

Research by Rohrich et al. (14), demonstrated that methylene blue injected into the sub-OOM plane spreads throughout the SOOF, indicating its division into medial and lateral anatomical regions. The fibrous structure surrounding the adipose tissue can be more clearly visualized using 3D reconstruction techniques, especially when methylene blue is injected before imaging (14).

The histomorphological similarities between SOOF and SMAS suggest these structures may function as cohesive units. However, the absence of muscle fibers within SOOF indicates functional differences between these tissues. For example, removing SOOF may lead to poor long-term outcomes because the lack of continuous muscle contraction after excision hinders the muscle's functional role, potentially resulting in ptosis. Additionally, procedures that lift SOOF, particularly when combined with lateral tarsal strip techniques, have effectively treated conditions such as congenital and Bell's palsy, lower eyelid retraction, and midface sagging. In contrast, malar fat repositioning and facelift surgeries may yield short-term successful results but lack long-term stability. This instability may be attributed to the thinner, atrophic cheek tissues in patients with congenital facial paralysis, which makes them more malleable after surgical intervention (15-17).

Structural findings indicate that SOOF forms a fibro-adipose cushion along the inferolateral orbital border, connecting to the OOM through fibrous septa. These findings support that SOOF and SMAS share similar functional properties, underscoring the need for more region-specific and tailored facial rejuvenation procedures (1,18). Age-related fat redistribution, such as the loss of deep cheek fat and accumulation of fat in the lower jaw, necessitates a versatile treatment approach that combines liposuction and fat transfer techniques. This approach aligns with the understanding that different fat compartments may lose or gain volume in various ways over time, explaining the need for distinct procedures for the same individual (19).

The location and dynamic nature of SOOF offer valuable insights for periorbital rejuvenation in a region that presents surgical challenges. SOOF augmentation has emerged as an effective method to smooth the orbital-cheek junction and restore volume. Fat transfer or SOOF injections are widely used to address volume loss in this area (20). However, having precise anatomical knowledge is essential for the accurate placement of these injections. For example, placing fillers subperiostally is often anatomically inaccurate, as fat compartments cannot be accessed directly in this way. The position of the tear trough and the extent of lid retraction are essential elements to consider during lower lid blepharoplasty. Conservative and surgical methods have been developed to rejuvenate the periorbital region, but few effectively treat the lower eyelid's medial third (21). Subdermal laminar implantation of a collagen-elastin matrix offers a novel approach to enhance facial contours and skin quality in the infraorbital and upper midface regions, as demonstrated by clinical and histological results. These results suggest that collagen matrices can serve as an auxiliary tool in both aesthetic and reconstructive surgical procedures (22). Restoring a youthful appearance frequently requires a multifaceted approach, addressing concerns such as radial lip lines, reduced bony support in the maxilla and mandible, and the descent of adipose tissue that contributes to the formation of jowls (23). Minimally invasive techniques, including liposuction, laser therapy, platysmotomy, and the use of filaments, have gained popularity for correcting age-related changes in the face and neck, highlighting the need, for objective visualization of the affected anatomical structures to ensure their effectiveness and prevent complications (24).

Understanding the structural and functional characteristics of SOOF facilitates a deeper comprehension of how mimetic muscle contractions impact the lower face. These insights enable a more comprehensive evaluation of the roles of various tissues in facial aging, particularly the interplay between deep and superficial fat compartments. These findings support the use of individualized approaches tailored to each patient's facial morphology and aging pattern.

Study Limitations

The cadavers used for training purposes presented challenges with obtaining sufficient tissue samples as defined in the methods section. Repeated thawing and refreezing during various anatomy courses sometimes compromised the fixation process, leading to tissue artifacts that affected histological measurements.

As a result, we opted not to perform quantitative assessments and instead, provided a detailed description of the tissue characteristics, highlighting our commitment to delivering meaningful insights despite these limitations.

CONCLUSION

This study highlights the SOOF as a structurally complex, fibro-adipose and vascularized unit with direct anatomical continuity to the OOM and the SMAS. Unlike passive fat pads, SOOF is a structurally integrated zone that combines connective and muscle tissue, supporting the midface and lower eyelid. These findings highlight the importance of preserving or targeting the SOOF in facial rejuvenation. Anatomically precise, compartment-specific techniques are preferable to generalized lifting, as they ensure stable and aesthetically successful outcomes.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the University of Health Sciences Türkiye, Hamidiye Scientific Research Ethics Committee (number: 2025/7- 7/23, date: 27.03.2025).

Informed Consent: Given that our study utilizes cadaveric specimens, obtaining a consent form is not necessary, allowing us to focus entirely on the research objectives without legal constraints.

Footnotes

Author Contributions: Surgical and Medical Practices - B.Z.K., B.K., F.T.K.; Concept - B.Z.K., B.K., F.T.K.; Design - B.Z.K., B.K., F.T.K.; Data Collection and/or Processing - B.Z.K., B.K., F.O., F.T.K.; Analysis and/or Interpretation - B.Z.K., B.K., F.O., F.T.K.; Literature Search - B.Z.K., B.K., F.O., F.T.K.; Writing - B.Z.K., B.K.

Conflict of Interest: The authors have no conflicts of interest to declare.

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