

Autologous Fat Graft Enriched with Stem Cells: Evidence on Tissue Regeneration and Applications in Plastic Surgery

Mateus Soares Santos Araújo¹, Victor Rodrigues de Paula¹, Landwanadan Fonteneles Lucena¹, Rodrigo dos Santos Oliveira Alves¹, João Marcelo Vieira Moraes¹, Lorrane S. Ribeiro Silveira¹, Nathalia do Prado Dutra Santos¹, Maria do Socorro Moraes da Silva¹, Thiago Augusto Rochetti Bezerra^{2*}, Filipe JL Garcia², Milena Gabriele Coelho Freitas², Eliane Moreira Da Silva², Carlos Henrique B Figueiredo De Mendonça³, Amanda Batista Ferreira da Silva³, Maria Beatriz Mendonça Ventura⁴, Andréa Pereira da Silva⁵, Giovana Casarini Yamashiro⁶ and Nathalia de Castro Fraga⁷

¹Euro-American University Center (UNIEURO), Brasília, Federal District, Brazil

*Corresponding Author

Thiago Augusto Rochetti Bezerra, Ribeirão Preto Medical School, University of São Paulo (FMRP-USP), Brazil.

²Ribeirão Preto Medical School, University of São Paulo (FMRP-USP), Ribeirão Preto, São Paulo, Brazil

Submitted: 2026, Aug 10; Accepted: 2026, Sep 04; Published: 2026, Sep 15

³Federal University of Roraima (UFRR), Boa Vista, Roraima, Brazil

⁴São Judas University, Cubatão, São Paulo, Brazil

⁵Universidad la Integración de las Americas- UNIDAPY

⁵Universidad la Integración de las Americas- UNIDAPY

⁶Nove de Julho University (UNINOVE), São Bernardo do Campo Campus, São Bernardo do Campo, São Paulo, Brazil

⁷Medical degree from Universidade Nove de Julho (São Bernardo do Campo) Postgraduate specialization in clinical and surgical dermatology and cosmetology from IPM

Citation: Bezerra, T. A. R., Araújo, M. S. S., Rodrigues de Paula, V., Lucena, L. F., Alves, R. S. O., et al. (2026). Autologous Fat Graft Enriched with Stem Cells: Evidence on Tissue Regeneration and Applications in Plastic Surgery. *J Surg Care*, 5(3), 01-18.

Abstract

Introduction: Autologous fat grafting enriched with adipose-derived stem cells (ADSCs) represents one of the main strategies in regenerative medicine applied to plastic surgery. In addition to volumetric restoration, this technique aims to enhance biological processes related to angiogenesis, inflammatory modulation, extracellular matrix remodeling, and tissue repair, thereby expanding its applications in aesthetic and reconstructive procedures.

Objective: To analyze, through a systematic literature review, the scientific evidence regarding the regenerative mechanisms, clinical efficacy, safety, and main applications of autologous fat grafts enriched with ADSCs in plastic surgery.

Methods: A systematic review conducted in accordance with the PRISMA 2020 guidelines, including studies published between 2021 and 2026 in major international databases. A total of 132 articles were selected that addressed experimental and clinical aspects, as well as reviews on enriched lipografting, vascular stromal fraction, cell-assisted lipotransfer, nanofat, and regenerative medicine applied to plastic surgery.

Results: The studies demonstrated that ADSCs play an important role in neovascularization, graft survival, immunomodulation, and wound healing. The main clinical applications involved breast reconstruction, facial rejuvenation, and the treatment of scars, burns, and complex wounds. Despite the promising results, heterogeneity was observed among cell processing protocols, surgical techniques, and the outcomes analyzed, making direct comparisons between studies difficult.

Conclusion: The enrichment of adipose grafts with ADSCs offers high regenerative potential and growing clinical applications in plastic surgery; however, methodological standardization and long-term clinical studies remain necessary to consolidate their incorporation into clinical practice.

Keywords: Autologous Fat Graft, Adipose-Derived Stem Cells, Vascular Stromal Fraction, Regenerative Medicine, Plastic Surgery, Tissue Regeneration

1. Introduction

Autologous fat grafting has become an important tool in aesthetic and reconstructive plastic surgery because it enables volumetric restoration, correction of contour deformities, and improvement in the quality of the treated tissues. In addition to its structural function, adipose tissue possesses biological properties related to repair, remodeling of the extracellular matrix, and recovery of injured tissues, which has increased interest in lipografting as a regenerative strategy. This characteristic has spurred the development of techniques aimed at increasing the integration and retention of the transplanted tissue in the recipient site [1-3].

Despite its widespread use, conventional lipografting still has the limitation of variability in the retention of the transplanted volume. After transfer, some of the adipocytes undergo temporary hypoxia, reduced perfusion, and an inflammatory response—factors that can compromise cell viability and increase graft resorption. Factors related to the collection technique, the processing of the liposuction specimen, and the characteristics of the recipient tissue also influence the survival of the transplanted fat, justifying the interest in strategies capable of improving vascularization and cell preservation [4-6].

Among these strategies, the use of *adipose-derived stem/stromal cells* stands out due to their angiogenic, immunomodulatory, and regenerative potential. These cells can promote the formation of new blood vessels, modulate the inflammatory response, and contribute to the recovery of the tissue microenvironment after transplantation. The combination of these cells with fat grafts has formed the basis for techniques such as *cell-assisted lipotransfer*, which are designed to increase graft retention and improve the quality of the recipient tissue [7-9].

The vascular stromal fraction represents one of the main cellular sources used for enriching fat grafts. It is a heterogeneous population that includes progenitor cells, endothelial cells, pericytes, immune system cells, and other components involved in angiogenesis and tissue regeneration. Various isolation methods have been employed, including enzymatic and mechanical techniques, with variations in cell yield, viability, and clinical applicability—a factor that still hinders the standardization of protocols used in plastic surgery [10-12].

The regenerative effects of adipose-derived cells appear to be related not only to their persistence in the recipient tissue but also to the secretion of biologically active mediators. The release of cytokines, growth factors, extracellular vesicles, and exosomes can stimulate angiogenesis, cell migration, extracellular matrix synthesis, and modulation of the inflammatory response. These mechanisms have been studied extensively in the context of healing and recovery of tissues subjected to ischemia or chronic injury [13-15].

Early vascularization plays a decisive role in graft survival, since nutrient diffusion is limited in the early stages following transplantation.

Experimental studies demonstrate that adipose-derived cells can promote neovascularization and improve the integration of the transplanted tissue. More recent strategies also investigate the formation of three-dimensional stem cell spheroids and mitochondrial transfer mechanisms, which can modify cellular metabolism and increase the graft's resistance to hypoxic [16-18].

In plastic surgery, cell-enriched fat grafts have been studied primarily in breast reconstruction, facial rejuvenation, correction of contour deformities, and treatment of skin lesions. Clinical studies involving the vascular stromal fraction show promising results regarding volumetric retention and tissue quality, although significant differences remain between the techniques employed and the methods used to measure outcomes. Recent clinical trials and systematic reviews reinforce the potential of this approach but also highlight the need for greater methodological standardization [19-21].

The regenerative potential of autologous fat has also driven the development of preparations such as *microfat*, *nanofat*, and gels rich in extracellular matrix and vascular-stromal fraction. These techniques have been studied for skin rejuvenation, improvement of skin texture, scar correction, and treatment of damaged tissues. Mechanical fragmentation of fat yields products with a lower content of mature adipocytes and a higher relative proportion of cellular and stromal components, directing their application more toward regeneration than toward simple volumetric replacement

[22-24].

In breast reconstruction, lipografting is used both to correct irregularities and to enhance results following reconstructive procedures. The possibility of combining stromal cells or the vascular-stromal fraction with the graft has sparked interest due to the potential to increase fat retention and promote the recovery of tissues previously subjected to surgery or radiation therapy.

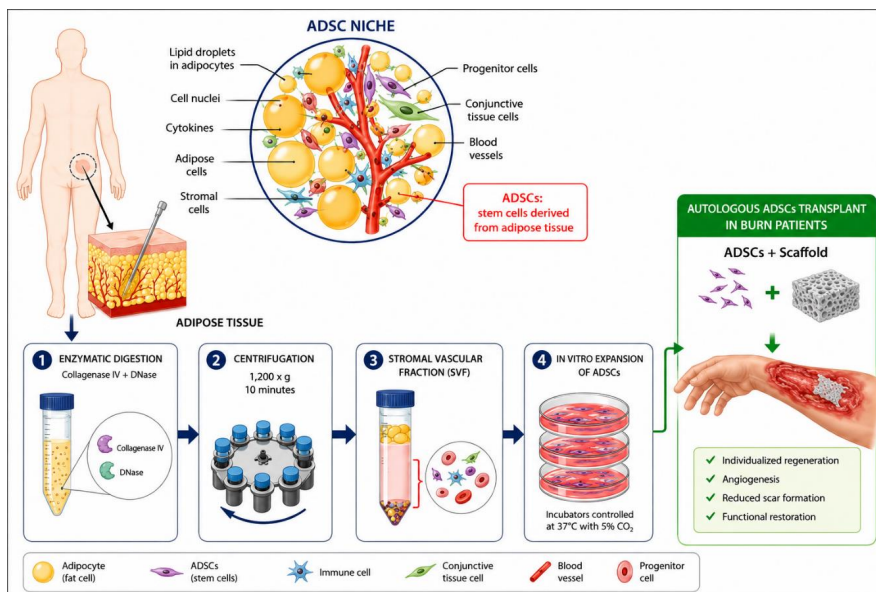
However, in addition to volumetric efficacy, oncological safety remains an essential aspect in the evaluation of these techniques, especially in patients treated for breast neoplasms [25-27]. Another relevant application involves the treatment of scars, burns, and fibrotic tissues. The use of autologous fat and adipose-derived cells can contribute to increased vascularization, reorganization of collagen fibers, and improved local elasticity. These effects justify the investigation of lipografting as an adjunctive tool in atrophic and hypertrophic scars, post-burn lesions, and changes caused by radiation therapy, expanding its use beyond aesthetic volume correction [28-30].

Despite the promising results, limitations remain that prevent the adoption of a single protocol for adipose-derived cell enrichment. The heterogeneity of methods for obtaining the vascular stromal fraction, the variable cell concentration, differences in processing

procedures, and the diversity of clinical outcomes make direct comparisons between studies difficult. Furthermore, regulatory issues related to cell handling and the definition of the permissible degree of processing must be considered when translating these techniques into clinical practice [11,20,31].

A schematic representation of the collection, isolation, expansion, and clinical application of adipose-derived stem cells (ADSCs) is shown in figure 1.

Adipose tissue contains a cellular niche composed of adipocytes, stromal cells, progenitor cells, connective tissue cells, and blood vessels, within which ADSCs are found. After adipose tissue collection, enzymatic digestion with collagenase IV and pronase is performed, followed by centrifugation to obtain the vascular stromal fraction (VSF), which is rich in stem cells and other regenerative cells. The isolated ADSCs can be cultured and expanded *in vitro* in an incubator at 37 °C, under an atmosphere containing 5% CO₂, thereby increasing the availability of cells for therapeutic use. Subsequently, these cells can be combined with biomaterials (*scaffolds*) and used in autologous grafts, promoting tissue regeneration, angiogenesis, wound healing, and functional recovery of injured tissues, as demonstrated in the example of their application in patients with burns.



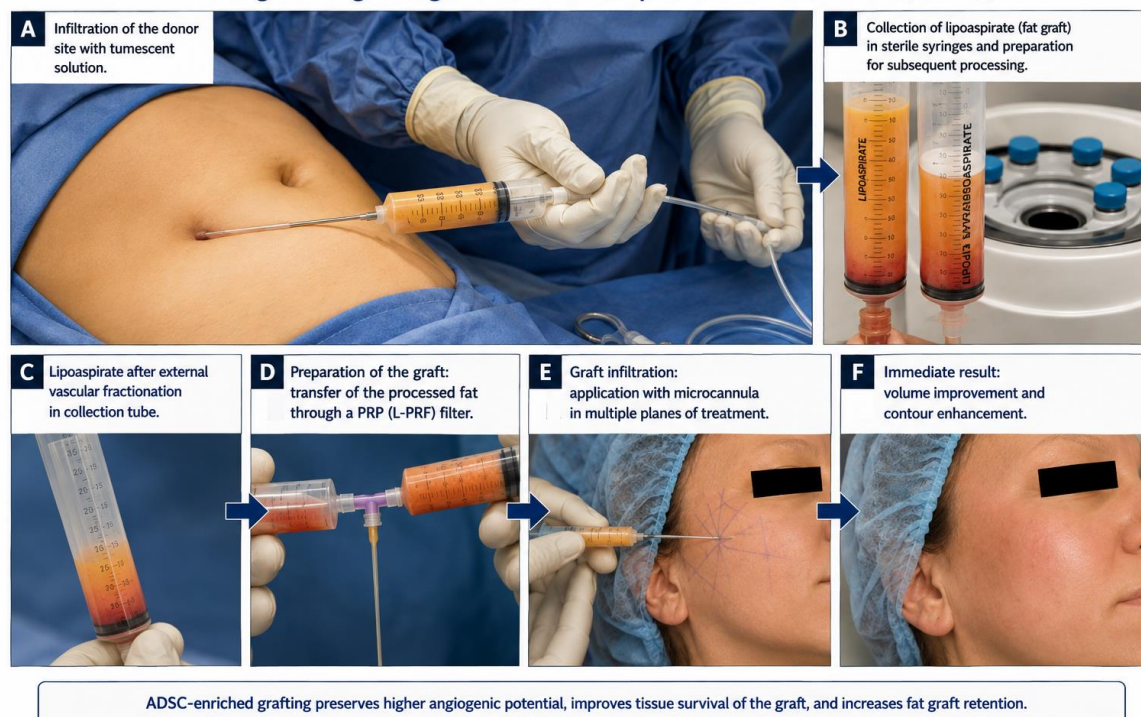
Source: Niche with ADSCs (Irina Kerkis with modifications, available online: http://www.rbc.org.br/detalhe_artigo.asp?id=734)

Figure 1: Isolation, Expansion, And Therapeutic Application of Adipose-Derived Stem Cells (ADSCs) for tissue Regeneration in Burn Patients

Figure 2 illustrates, in sequence, the main steps of autologous fat grafting enriched with adipose-derived stem cells (ADSCs), from the collection of adipose tissue via liposuction to its clinical application. Initially, adipose tissue is obtained and processed to isolate the vascular stromal fraction (FVS), which is rich in stem cells and other regenerative components. Next, the FVS is combined with the processed fat to obtain the enriched graft, which

is applied using microcannulas at different anatomical levels. The figure also illustrates the immediate clinical appearance following the procedure, highlighting the improvement in tissue contour provided by enriched lipografting. This diagram summarizes the biological rationale behind the technique, emphasizing its ability to promote angiogenesis, graft integration, tissue repair, and increased survival of the transplanted fat.

Autologous fat grafting enriched with adipose-derived stem cells (ADSCs)



Source: Prepared by the authors (2026), with illustrative images generated by artificial intelligence for educational purposes, based on the evidence described in the scientific literature regarding autologous fat grafting enriched with adipose-derived stem cells (ADSCs).

Figure 2: Autologous fat Grafting Enriched with Adipose-derived Stem Cells (ADSCs): Collection, Processing, Preparation, and Clinical Application Steps

Given this evidence, autologous fat grafting enriched with stem cells represents an interface between plastic surgery and regenerative medicine, combining volumetric restoration with biological stimulation of tissue repair. Understanding the cellular mechanisms involved, the effects on angiogenesis and healing, and the results obtained in different clinical applications is essential for establishing more precise indications and more reproducible protocols. Thus, a critical analysis of the available evidence can help define the actual benefit of cell enrichment compared to conventional lipografting and identify the aspects that still require higher-quality clinical investigation [1,3,9].

1.1. General Objective

To conduct a systematic literature review to analyze the available scientific evidence on the efficacy, biological mechanisms, and clinical applications of autologous fat grafting enriched with adipose-derived stem cells (ADSCs) in tissue regeneration and plastic surgery.

1.2. Specific Objectives

To evaluate the evidence related to the regenerative mechanisms promoted by adipose-derived stem cells, including angiogenesis, modulation of the inflammatory response, extracellular matrix remodeling, wound healing, and survival of the adipose graft. To investigate the main clinical applications of autologous fat grafts enriched with ADSCs in aesthetic and reconstructive

plastic surgery, analyzing their efficacy, safety, clinical outcomes, limitations, and future prospects in comparison with conventional lipografting.

2. Methodology

This systematic review was conducted in accordance with the recommendations of **the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020)**, following the steps of study identification, screening, eligibility assessment, and inclusion.

The methodological strategy was designed to gather and critically synthesize the available scientific evidence on the use of **autologous fat grafts enriched with adipose-derived stem cells (ADSCs)** in tissue regeneration and in various applications of plastic surgery.

The literature search strategy was conducted in the **PubMed/MEDLINE, Scopus, Web of Science, Embase, and Cochrane Library** databases, as these are considered the leading international sources of biomedical literature. The search included studies published between **January 2021 and June 2026**, a period selected because it encompasses the most recent evidence related to enriched lipografting techniques, regenerative medicine, and cell therapies applied to plastic surgery.

Controlled descriptors from the **Medical Subject Headings (MeSH)** and free-text terms combined using Boolean operators (**AND** and **OR**) were used. The search strategy included the following terms: "**Autologous Fat Grafting**," "**Fat Graft**," "**Cell-Assisted Lipotransfer**," "**Adipose-Derived Stem Cells**," "**Adipose Stem Cells**," "**Stromal Vascular Fraction**," "**Nanofat**," "**Microfat**," "**Regenerative Medicine**," "**Plastic Surgery**," "**Tissue Regeneration**," "**Wound Healing**," "**Breast Reconstruction**," "**Facial Rejuvenation**," "**Scar Treatment**," and "**Burn Reconstruction**."

We included studies published in English, Portuguese, or Spanish that investigated the use of autologous fat grafts enriched with adipose-derived stem cells, vascular stromal fraction, or *cell-assisted lipotransfer* techniques, involving applications in aesthetic and reconstructive plastic surgery or regenerative medicine. Eligible studies included randomized clinical trials, prospective and retrospective studies, observational studies, cohort studies, experimental studies, systematic reviews, and meta-analyses that reported results related to tissue regeneration, graft survival, angiogenesis, wound healing, extracellular matrix remodeling, complications, or clinical efficacy.

Excluded were editorials, letters to the editor, opinion pieces, conference abstracts without a full-text publication, book chapters, dissertations, theses, duplicate studies, articles published before 2021, studies without a full-text version available, and studies that addressed exclusively conventional adipose grafting techniques without evaluating the involvement of adipose-derived stem cells, the vascular-stromal fraction, or associated regenerative strategies.

The selection of studies was conducted in two stages. Initially, titles and abstracts were reviewed to identify potentially eligible studies. Subsequently, the selected articles were analyzed in full to confirm compliance with the previously established inclusion and exclusion criteria. The screening was conducted by two independent reviewers, with any discrepancies resolved by consensus following a re-evaluation of the studies.

From the included articles, information was extracted regarding

the authors, year of publication, country of origin, study design, sample size, type of intervention, technique used to obtain ADSCs or the vascular stromal fraction, fat processing method, anatomical area treated, outcomes assessed, main results, complications observed, and methodological limitations.

Data synthesis was performed **qualitatively and narratively**, taking into account the heterogeneity of the methodological designs, surgical techniques, cell processing methods, and clinical outcomes found in the literature. The studies were organized into thematic categories, covering the biological mechanisms involved in tissue regeneration, strategies to increase graft survival, and applications in aesthetic plastic surgery, breast reconstruction, facial rejuvenation, scar treatment, burn treatment, and other regenerative indications.

The study selection process was documented using a **PRISMA 2020 flowchart**, showing the number of records identified, studies removed due to duplication, articles excluded during screening, full-text articles assessed for eligibility, and studies included in the systematic review. Since this research was based exclusively on previously published data, without direct involvement of human subjects or access to individualized information, **there was no need to submit it to the Research Ethics Committee**, in accordance with Resolution No. 466/2012 of the National Health Council.

3. Results and Discussion

The process of identifying, selecting, assessing eligibility, and including studies was conducted in accordance with the **PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)** guidelines. Initially, studies were identified in the major international databases, and duplicate records were subsequently removed. After reviewing the titles and abstracts, articles that did not meet the previously established criteria were excluded. Potentially eligible studies were reviewed in full for methodological evaluation, resulting in the inclusion of **132 articles** that comprised the qualitative synthesis of this systematic review. The details of this process are presented in **Figure 3**.

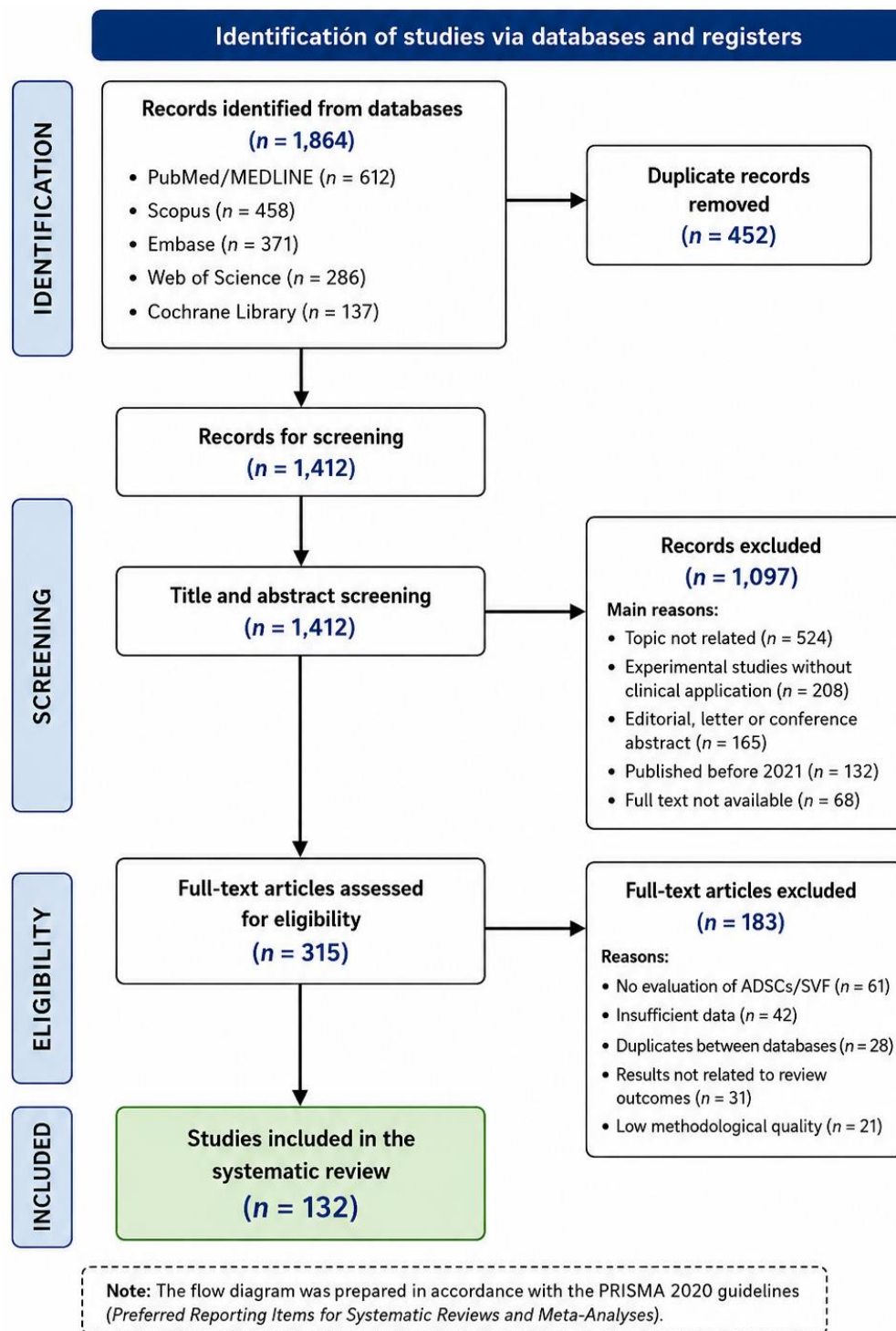


Figure 3: PRISMA 2020 Flow Diagram of the Study Selection Process

Analysis of the 132 selected publications allowed the findings to be organized into themes directly related to the overall objective of this review, covering the biological basis of enriched adipose grafts, regeneration mechanisms, processing methods, use of the vascular stromal fraction, cell-assisted lipotransfer, nanofat, breast applications, treatment of scars and burns, wound healing, the

use of exosomes, and facial applications. The selected literature ranges from mechanistic and preclinical studies to clinical trials, systematic reviews, and meta-analyses, allowing for an evaluation of both the regenerative basis of the technique and its main applications in plastic surgery.

Table 1 summarizes the main areas of evidence and their selected references. relationship to the study's central objective, incorporating the

Analysis axis	Aspects addressed in the literature	Relationship to tissue regeneration	Main applications in plastic surgery	Representative references
Biological foundations and regenerative medicine	Characterization of adipose tissue as a source of stromal and progenitor cells; regenerative capacity of ADSCs; graft retention; aging of adipose tissue; cellular involvement in the integration of transplanted fat.	The literature investigates angiogenesis, cell survival, adaptation to the hypoxic microenvironment, interaction between adipocytes and stromal cells, and mechanisms that promote graft integration.	Biological basis for regenerative lipografting, reconstruction, rejuvenation, and correction of soft tissue defects.	[1-3,6,9,16,17,32-34]
Graft survival and technical optimization	Comparison of processing methods, cannula sizes, external expansion, mechanical stress, platelet-rich plasma, and other approaches to increase fat retention.	These studies focus on preserving the transplanted tissue, reducing reabsorption, and creating conditions conducive to neovascularization and adipocyte survival.	Aesthetic and reconstructive lipografting, breast augmentation, facial filling, and correction of contour irregularities.	[4-6,35-40]
Cell-assisted lipotransfer and vascular stromal fraction	Combination of autologous fat with ADSCs or vascular stromal fraction; comparison between conventional and enriched lipografting; cell isolation methods; mechanical or enzymatic processing.	The SVA provides a heterogeneous population of stromal, progenitor, endothelial, and immune cells potentially involved in angiogenesis, inflammatory modulation, and tissue repair.	Breast augmentation and reconstruction, facial rejuvenation, correction of deformities, and scar treatment.	[7,8,10,11,19,20,21,31,41,42]
Microfat, nanofat, and cell-derived products	Mechanical processing of adipose tissue to obtain preparations with different cellular and structural characteristics; comparison between microfat, nanofat, and extracellular matrix gel/FVS.	The focus has shifted from simply restoring volume to biological effects related to skin remodeling, cellular activity, and regeneration of the recipient tissue.	Facial and genital rejuvenation, scar treatment, skin conditions, and minimally invasive regenerative procedures.	[22-24,43-49]
Breast Reconstruction and Surgery	Oncological safety, fat retention, complications, patient satisfaction, influence of radiation therapy, hybrid techniques, total reconstruction, and cell enrichment strategies.	The literature investigates the ability of lipografting to restore volume and improve the recipient site, particularly in tissues previously subjected to surgery or radiation therapy.	Reconstruction after mastectomy, breast augmentation, remodeling, correction of deformities, and hybrid reconstruction.	[25-27,50-56]
Scars, burns, and irradiated tissues	Use of autologous fat, ADSCs, and FVS in atrophic, hypertrophic, and keloid scars, burns, scleroderma, and radiation therapy-induced lesions.	The studies evaluate fibrotic tissue remodeling, vascularization, wound healing, and potential effects on extracellular matrix organization and skin quality.	Treatment of scars, burns, radiation therapy sequelae, acne, scleroderma, and skin defects.	[28-30,57-63]
Exosomes, extracellular , and wound healing	Secreted products from ADSCs, exosomes, extracellular vesicles, conditioned medium, inflammatory regulation, and molecular mechanisms of repair.	This series of studies explores a possible paracrine and action of ADSCs, including angiogenesis, macrophage polarization, intercellular communication, and modulation of pathways involved in wound healing.	Chronic wounds, diabetic ulcers, skin repair, complex wound healing, and prospects for cell-free regenerative therapies.	[13,64-72]

Angiogenesis, immunomodulation, and wound healing	Evaluation of extracellular vesicles, expanded cells, uncultured FVS, hydrogels, biomaterials, and molecular mechanisms of regeneration.	The research focuses on the interaction between ADSCs, endothelial cells, macrophages, and the wound microenvironment, linking these elements to vascular formation and tissue repair.	Diabetic wounds, full-thickness wounds, complex lesions, and the integration of cell therapies with biomaterials.	[37,73-81]
Cell therapies and secreted products	Development of applications based on the secretome, extracellular vesicles, and cellular transport mechanisms, expanding possibilities beyond direct cell transplantation.	The literature addresses the regulation of inflammation, tissue repair, and the transfer of bioactive molecules capable of modifying the response of injured tissue.	Regenerative medicine, skin lesions, fibrosis, tissue repair, and future prospects for cell-free therapies.	[14,15,82-86]
Facial Rejuvenation and Reconstruction	Applications in the periorbital region, temples, face, neck, nose, lips, cleft lip and palate, and soft tissue defects.	Regenerative potential is evaluated in conjunction with the filling and volume-restoration effects, particularly in areas where skin quality and graft integration are critical.	Facial rejuvenation, periorbital correction, rhinoplasty, temporal contouring, craniofacial defects, and facial feminization.	[87-96]
Safety, complications, and limitations of clinical application	Oncological safety, adverse events in the facial region, the need for technical standardization, differences among processing techniques, and variability in results.	The translation of regenerative activity into clinical practice depends on safety criteria, control of cell handling, and better-defined protocols.		

Table 1: Summary of the Evidence on Autologous Fat Grafting Enriched with Stem Cells, Tissue Regeneration, and Applications in Plastic Surgery

The organization of the evidence demonstrates that autologous fat grafting has come to be studied not only as a filling method but also as a platform for regenerative strategies. The presence of stromal and progenitor cells in adipose tissue, combined with the possibility of concentrating the vascular-stromal fraction and using ADSCs in a , forms the basis for techniques designed to promote graft integration into the recipient tissue. Reviews on regenerative surgery, fat retention, and stem cell enrichment show that angiogenesis, cellular adaptation to the initial period of hypoxia, and the interaction between the adipose component and the stroma represent central themes in the contemporary literature [1,3,6,9].

Another relevant finding is the diversity of strategies used to increase graft viability. In addition to the selection of collection and processing techniques, researchers are investigating cannula gauge, centrifugation methods, external expansion, platelet-rich plasma, the vascular-stromal fraction, and cell enrichment. This diversity reveals that the survival of the transplanted fat depends on multiple variables and partly explains the difficulty of making direct comparisons between studies conducted using different protocols [4,5,10,11,36,81].

The vascular stromal fraction and *cell-assisted lipotransfer* emerge as two of the main technological foci in the selected literature.

Clinical studies and systematic reviews analyze the possibility of adding cell populations derived from the patient themselves to adipose tissue prior to reimplantation, with applications in the breast, face, scars, and skin regeneration. However, the methods used to obtain this fraction are not uniform, ranging from enzymatic digestion to mechanical methods and various forms of cell concentration, which remains a significant source of heterogeneity [7,8,10,11,19,20].

Significant growth has also been observed in microfat and nanofat techniques. Unlike lipografting, which is primarily aimed at volumetric restoration, these preparations are studied mainly in situations where the quality of the recipient tissue and skin regeneration are of greater importance. Skin rejuvenation, scar modifications, and facial applications are among the main areas of study, reinforcing the expanding role of adipose tissue in regenerative surgery [23,24,43-45,88].

In breast surgery, the number of studies identified highlights the clinical relevance of lipografting. The literature addresses reconstruction following mastectomy, correction of deformities, hybrid reconstruction, the influence of radiation therapy, patient satisfaction, complications, and oncological safety. In addition to the volumetric effect, research is being conducted into the possibility of improving tissues that have previously been irradiated

or subjected to multiple surgical procedures. The presence of systematic reviews and comparative studies in this area shows that breast reconstruction is one of the most well-established fields for the clinical use of autologous fat [25-27,51-55].

The treatment of scars, burns, and fibrotic changes represents another significant area of focus. The selected articles cover atrophic and hypertrophic scars, burn sequelae, acne, scleroderma, and radiation therapy-related lesions. In these contexts, the focus is not limited to filling depressions but also includes tissue remodeling, vascularization, and modification of fibrotic tissue. The presence of specific studies on ADSCs, FVS, and autologous fat indicates that scar regeneration is one of the most relevant areas for future research [28-30,58,61-63].

One of the most recent fields identified is the study of the ADSC secretome, exosomes, and extracellular vesicles. Research in this area investigates mechanisms through which regenerative effects can occur without differentiation or the prolonged presence of transplanted cells being the sole determining factor. Molecules carried by extracellular vesicles are being studied in wound healing, angiogenesis, the inflammatory response, and cell-to-cell communication, opening up prospects for cell-free regenerative strategies [13,15,66-72].

Applications to the face and periorbital region also constitute an important part of the body of evidence. The use of autologous fat has been described for facial rejuvenation, the temporal region, eyelids, nose, lips, correction of craniofacial defects, and soft tissue restoration. At the same time, studies on ophthalmic complications underscore the need for anatomical expertise and safety protocols, particularly in regions where there is a risk of intravascular injection [87,88,90-94,97].

Overall, the selected body of studies supports a shift in perspective regarding the use of adipose tissue in plastic surgery: from a material used predominantly for volume replacement to a tissue with biological potential exploited in regenerative strategies. However, the literature also reveals marked heterogeneity regarding fat processing, FVS isolation, cell concentration, application techniques, and the definition of outcomes. Thus, although there are experimental studies, systematic reviews, and clinical trials in various fields, the standardization of protocols remains essential to determine more precisely which benefits actually result from cell enrichment and which can be attributed to autologous lipografting itself [9,11,20,24,64].

Important methodological note: Since the provided list contains the bibliographic references and titles of the studies but not the complete results of each article, this table was constructed as a thematic and clinical synthesis of the selected evidence. To add quantitative results to Table 1—for example, graft retention rates, complication rates, differences between CAL and conventional lipografting, sample sizes, and effect sizes—it would be necessary to analyze the full texts of the corresponding studies.

The first Specific Objective of this systematic review was to evaluate the evidence related to the regenerative mechanisms promoted by adipose-derived stem cells, including angiogenesis, modulation of the inflammatory response, extracellular matrix remodeling, wound healing, and adipose graft survival. Analysis of the selected studies demonstrated that these mechanisms constitute the primary biological basis for the use of ADSCs and the vascular stromal fraction in regenerative strategies associated with lipografting. The included studies addressed topics ranging from cellular and molecular aspects to preclinical and clinical applications, with an emphasis on neovascularization, paracrine action, intercellular communication, immune modulation, and improvement of the recipient microenvironment.

Regenerative mechanism	Evidence addressed in the studies	Relevance to autologous fat grafting	Representative references
Angiogenesis and neovascularization	ADSCs and cells present in FVS are associated with the release of pro-angiogenic factors and interaction with endothelial cells. Experimental and clinical studies have evaluated vascular formation, perfusion, and graft integration.	Early vascularization may reduce hypoxia, promote the survival of transplanted adipocytes, and improve graft integration into the recipient tissue.	[6,16,17,19,41,75,76]
Graft Survival and Retention	Several studies have evaluated mechanisms capable of increasing the viability of transplanted tissue, including cell enrichment, three-dimensional spheroids, processing of liposuction-harvested fat, and metabolic modulation.	Greater volumetric retention reduces fat resorption and may increase the predictability of aesthetic and reconstructive outcomes.	[3-5,16,18,98,99]
Modulation of the Inflammatory Response	Studies on ADSCs, exosomes, and extracellular vesicles describe effects on macrophages, cytokines, and signaling pathways related to inflammation.	Reducing an excessive inflammatory response may promote graft integration, reduce tissue damage, and contribute to more organized healing.	[13,15,18,66,70,77]
Paracrine Action and Secretome	The literature investigates growth factors, cytokines, proteins, and molecules carried by exosomes and extracellular vesicles derived from ADSCs.	These mediators may exert regenerative effects without relying exclusively on the direct differentiation of the implanted cells.	[14,15,34,69,72,82]

Exosomes and extracellular vesicles	Experimental studies and reviews have analyzed the role of these structures in the transfer of microRNAs, , proteins, and other biologically active mediators.	They may stimulate angiogenesis, wound healing, and intercellular communication, representing a possib r future alternative to therapies based directly on cells.	
Extracellular Matrix Remodeling	Studies on scars, fibrosis, and skin regeneration have evaluated tissue reorganization, fibroblast modulation, and changes in the deposition of matrix components.	Matrix remodeling can improve the elasticity, texture, thickness, and quality of the recipient tissue, especially in scars and irradiated areas.	[29,33-63,64,100]
Skin healing	ADSCs, FVS, and their derivatives have been studied in chronic wounds, burns, diabetic lesions, and full-thickness wounds.	They promote research into epithelial repair, granulation tissue formation, angiogenesis, and recovery of the wound bed.	[13,30,58,65,80,78]
Macrophage Regulation and Immune Response	Some studies have investigated macrophage polarization, PI3K/AKT and JNK signaling, and metabolic modulation mediated by ADSCs.	Immune regulation may reduce persistent inflammation and promote an , reparative microenvironment.	[15,18,77]
Mitochondrial transfer and metabolic adaptation	Recent studies have evaluated mitochondrial transfer between ADSCs and stressed cells, as well as the reprogramming of immune cell metabolism.	This may represent an additional mechanism for increasing resistance to hypoxia and graft survival.	[18,96]
Three-dimensional ADSC spheroids	Experimental studies have evaluated three-dimensional aggregates as a strategy to enhance cellular activity, adipogenesis, and angiogenesis.	They may improve regenerative capacity and cell survival compared to conventional two-dimensional cultures.	[16,17]
Vascular Stromal Fraction as a Regenerative Niche	The VSM contains progenitor, endothelial, immune, and stromal cells and is used as a cell source for graft enrichment.	Cellular heterogeneity may promote repair, vascularization, and communication with the recipient tissue.	[10-12,20,31]
Nanofat and regenerative components	Mechanical fragmentation of adipose tissue produces preparations with a lower content of mature adipocytes and greater regenerative potential.	The primary focus is on improving the quality of the skin and recipient tissue, with less emphasis on volumetric replacement.	[22-24,43,45]
Scar and Fibrosis Remodeling	Studies on atrophic and hypertrophic scars, burns, scleroderma, and irradiated tissue have analyzed the regenerative effects of adipose tissue and ADSCs.	This potential is related to matrix reorganization, improved vascularization, and a possible reduction in stiffness and fibrosis.	[14,28,29,61-63]

Source: Prepared by the authors (2026), based on the studies included in the systematic review. Angiogenesis was one of the most frequently observed mechanisms in the selected studies. The survival of transplanted fat depends on the rapid restoration of perfusion in the recipient tissue, particularly during the initial period following implantation, when adipocytes are most vulnerable to hypoxia. Studies involving ADSCs, the vascular-stromal fraction, and cell spheroids have demonstrated growing interest in the ability of these cells to promote new vessel formation and enhance the integration of the transplanted tissue [6,16,17,19,75].

Table 2: Main regenerative Mechanisms associated with ADSCs and Enriched Adipose Grafts

Studies have also indicated that the effects of ADSCs do not depend exclusively on their differentiation into new cell types. A significant portion of their regenerative activity is related to paracrine action, through the secretion of growth factors, cytokines, regulatory proteins, exosomes, and extracellular vesicles. These components act on endothelial cells, fibroblasts, macrophages, and other cell populations in the recipient tissue, contributing to the organization of the reparative response [13-15,69,82].

Modulation of the inflammatory response has emerged as another relevant mechanism. Recent studies have evaluated the ability of ADSCs to modify the activity of macrophages and other immune system cells, promoting a microenvironment more conducive to repair. The polarization of macrophages toward phenotypes associated with regeneration and the modulation of signaling pathways such as PI3K/AKT and JNK have been described in models of wound healing and tissue repair, suggesting that immunomodulatory activity may be an important component of

the observed [15,18,70,77].

An analysis of studies on exosomes and extracellular vesicles has revealed one of the most recent fields in regenerative medicine associated with ADSCs. These structures carry microRNAs, proteins, and other molecules capable of altering the activity of recipient cells. Experimental studies have demonstrated interest in their use for skin healing, diabetic wounds, and tissue regeneration, raising the possibility of future cell-free therapeutic strategies in which the products secreted by ADSCs could replicate some of their biological effects [13,67,68,71,72,74].

Another important finding was the role of ADSCs and FVS in extracellular matrix remodeling. Studies involving hypertrophic scars, keloids, burns, and fibrotic tissue have investigated changes in fibroblast activity and matrix organization. This mechanism is particularly relevant in plastic surgery, as the desired clinical improvement is not limited to

volumetric gain but also involves elasticity, texture, mobility, and the quality of the treated tissue [29,33,62,63,100]. Wound healing has been extensively covered in the literature. ADSCs, FVS, exosomes, and other cellular products have been investigated in models of chronic wounds, diabetic lesions, burns, and full-thickness defects. Studies focus on processes such as granulation tissue formation, vascularization, re-epithelialization, and control of the inflammatory response, reinforcing the potential for using these strategies in tissues that are difficult to heal [30,65,78-81].

Graft survival has been shown to be closely related to the balance between perfusion, metabolism, and cellular activity in the post-transplant period. Recent studies have expanded this understanding by investigating mechanisms such as mitochondrial transfer and metabolic reprogramming. The transfer of mitochondria from ADSCs to stressed cells and the modification of macrophage metabolism represent mechanisms that are still experimental but may help explain how these cells contribute to the resilience of the grafted tissue under conditions of hypoxia and inflammation [18,72].

A trend has also emerged toward developing strategies aimed at enhancing the functional capacity of ADSCs themselves. In experimental studies, the formation of three-dimensional spheroids has been associated with increased angiogenic and adipogenic activity, while techniques for processing the vascular stromal fraction seek to preserve as many viable cells and matrix

components as possible. These approaches demonstrate that graft optimization depends not only on the number of cells added but also on the functional state of these cells and the conditions under which they are implanted [10,11,16,17].

Taken together, the results related to the first specific objective demonstrate that the regenerative activity of ADSCs is multifactorial. The literature does not point to a single mechanism responsible for the observed results, but rather to an interaction among angiogenesis, inflammatory modulation, paracrine activity, extracellular vesicle-mediated communication, matrix remodeling, and metabolic adaptation. This multiplicity of mechanisms provides a biological basis for the use of enriched adipose tissue in regenerative surgery, although the magnitude of each process's contribution still varies across experimental models and clinical contexts [1,9,15,64].

The final Specific Objective was to investigate the main clinical applications of autologous fat grafts enriched with adipose-derived stem cells (ADSCs) in aesthetic and reconstructive plastic surgery, analyzing their efficacy, safety, clinical outcomes, limitations, and future prospects in comparison with conventional lipografting . The selected literature shows that these applications are primarily focused on breast reconstruction, facial rejuvenation, the treatment of scars and burns, the correction of soft tissue deformities, and regenerative procedures associated with the vascular stromal fraction, nanofat, and *cell-assisted lipotransfer*.

Clinical application	Key findings	Potential benefits	Limitations and safety considerations	Representative references
Post-mastectomy breast reconstruction	Lipoenxertia is used to correct irregularities, restore volume, and improve contour following breast reconstruction. Studies also evaluate techniques enriched with FVS and ADSCs.	Improved contour, correction of depressions, potential to improve the quality of the recipient tissue, and the ability to complement prosthetic or autologous reconstructions.	Variability in volumetric retention, the need for repeated sessions, and debate regarding oncological safety.	[25-27,50,52,55,56]
Breast Augmentation and Hybrid Reconstruction	Adipose tissue can be used alone or in combination with implants, using strategies aimed at uniform distribution and fat retention.	More natural results, correction of irregularities, and contour refinement.	Partial resorption; need for standardization of volumes and processing techniques.	[7,35,101-103]
Irradiated tissues	Lipoenxertia is being studied in tissues that have undergone radiation therapy, particularly in breast reconstruction.	Potential improvement in tissue quality, elasticity, and local vascular .	Results depend on the degree of tissue damage, the number of sessions, and the technique used.	[28,53,57]
Facial Rejuvenation	ADSCs, FVS, microfat, and nanofat are used in procedures to restore volume and improve skin quality.	Correction of volume loss, improvement in texture, and a potential regenerative effect on the skin.	Requires anatomical expertise and vascular risk assessment.	[24,44,87,89,91]
Periorbital region	Lipoenxertia is used to treat furrows, depressions, eyelid retraction, and structural dark circles.	Volumetric restoration and contour improvement.	Serious ophthalmological complications, although rare, require a rigorous technique.	[22,92,93,97,104,105]
Rhinoplasty and nasal contouring	Adipose grafting is used as an adjunct for refinement and correction of irregularities.	Correction of minor defects and improvement of the contour.	Variable retention and the need for caution in delicate vascular areas.	[94,106]
Temporal region and lower face	Used to correct volume loss and achieve rejuvenation.	Improved contour and volume restoration with autologous tissue.	Touch-ups may be necessary, and a careful technique is required.	[90,107,108]

Atrophic and post-acne scars	Autologous fat, nanofat, PRP, and FVS were evaluated for the treatment of depressed scars.	Improvement in skin relief, texture, and quality.	Heterogeneous evidence and a lack of uniform protocols.	[49,61,109,110]
Hypertrophic Scars and Keloids	ADSCs and secretome are being investigated in fibrosis remodeling and wound healing modulation.	Potential reduction in stiffness and improvement in matrix organization.	Predominance of experimental studies and a need for more clinical studies.	[14,62,63,100,111]
Burns and Scar Sequelae	ADSCs, nanofat, and lipografting are used to treat burns and post-burn scars.	Possible improvement in tissue elasticity, vascularization, thickness, and quality.	Heterogeneity of studies and the need for standardized protocols.	[30,58,112]
Scleroderma and fibrotic tissues	Fat grafting and adipose tissue-derived products were evaluated in sclerotic lesions and associated ulcers.	Improved tissue quality and potential reduction in local fibrosis.	Evidence is still limited and based on small series or case reports.	[59,60,83]
Chronic wounds and diabetic ulcers	ADSCs, FVS, extracellular vesicles, and biomaterials were evaluated as regenerative strategies.	Stimulation of wound healing, angiogenesis, and improvement of the wound bed.	Much of the evidence is still preclinical.	[70,71,78,80,81,113]
Craniofacial defects and cleft lip and palate	Autologous fat is used to correct soft tissue defects.	Autologous volume replacement and contour refinement.	Variable retention and the need for long-term follow-up.	[95,96]
Genital rejuvenation	Microfat and nanofat have been used in genital rejuvenation procedures.	Improvement in volume and quality of superficial tissues.	Limited clinical evidence and the need for well-defined protocols.	[48]
Hand Rejuvenation	Autologous fat was studied for volumetric restoration and aesthetic improvement of the back of the hands.	Volume restoration and smoothing of visible structures.	Even less evidence than for the breasts and face.	[29,114]
Oncological Safety	Reviews and meta-analyses have evaluated recurrence in patients who underwent breast reconstruction with lipografting.	This allows for an assessment of the feasibility of clinical use in patients previously treated for cancer.	Long-term follow-up and interpretation based on individual oncological profiles are required.	[25,26,50]
Facial Vascular Safety	Studies have systematized complications related to fat injection into the face.	It establishes technical limits for safe application.	Vascular and ophthalmological events can be severe.	[92,97]
Outlook: Cell-Free Therapies	exosomes and extracellular vesicles have been studied as alternatives to the direct use of ADSCs.	Potential to reproduce paracrine and effects without cell transplantation.	Clinical application is still in the early stages.	[14,15,69,82]

Source: Prepared by the authors (2026), based on the studies included in the systematic review.

Table 3: Main Clinical Applications of Autologous Fat Grafts Enriched with ADSCs in Plastic Surgery

Among the applications evaluated, breast reconstruction accounted for a significant portion of the scientific literature. Lipografting is used to correct deformities following mastectomy, refine prosthetic and autologous reconstructions, fill in irregularities, and improve contour. Studies that combined stromal vascular fraction or cell-assisted lipotransfer strategies sought to determine whether cellular enrichment could improve fat retention and the quality of the treated tissues, particularly in previously irradiated regions [8,25,26,53,56].

In the analysis of oncological safety, the selected reviews and meta-analyses focused on evaluating the use of autologous fat in patients undergoing treatment for breast cancer. The available studies reflect the concern that cellular and regenerative factors do not increase the risk of recurrence. Within the analyzed literature, this issue emerges as an essential component of the technique’s clinical application and reinforces the need for adequate patient follow-up [25-27,50].

Facial surgery constituted another relevant area of focus. Autologous fat grafting is used for rejuvenation, volume restoration, temporal correction, the periorbital region, the nose, and other soft-tissue defects. Microfat and nanofat have broadened this spectrum by enabling applications with a greater emphasis on skin quality. Thus, autologous fat has come to play both a volumetric and regenerative role in different regions of the face [24,44,87,89-91].

However, facial procedures have also highlighted one of the key aspects of technical safety. The periorbital region and other highly vascularized areas carry a risk of potentially serious vascular complications. Reviews on ophthalmological complications and procedures for correcting eyelid bags emphasize that the aesthetic benefit of the technique must be accompanied by precise anatomical knowledge, appropriate selection of injection planes, and rigorous control of the application [22,92,93,97].

Scar treatment was another common application. The reviewed literature included atrophic, post-acne, hypertrophic, and keloid scars, as well as burn sequelae. In these contexts, the goal of lipografting and cell enrichment is not limited to filling depressions but involves improving tissue quality and remodeling the scarred area. The use of nanofat, FVS, and ADSCs further enhances the regenerative potential of these techniques [29,49,61-63].

In cases of burns and scarring sequelae, adipose tissue and adipose-derived cells have been studied as tools for reconstruction and repair. The literature addresses both the improvement of established scars and the use of regenerative strategies in complex wounds. These studies demonstrate a convergence between reconstructive plastic surgery and cell therapy, particularly in situations where the quality of the recipient tissue poses a significant obstacle to conventional treatment [30,58,112].

Applications in chronic wounds have demonstrated a strong connection with regenerative medicine. FVS, ADSCs, exosomes, and biomaterials have been studied in diabetic wounds and other complex defects. Although a considerable portion of this evidence is experimental, the results point to a line of research focused on combining adipose cells with matrices and support systems capable of enhancing regeneration [70,71,78,80,81,113].

From a comparative perspective, the selected literature suggests that cell enrichment may represent a strategy to overcome one of the classic limitations of conventional lipografting: the unpredictability of volumetric retention.

Specific reviews on cell-assisted lipotransfer and FVS have evaluated the possibility of increased graft survival and improved tissue integration. However, the wide variety of isolation techniques, the number of cells added, the method of processing, and the evaluation of results prevents us from asserting that there is currently a universally superior protocol [7,9,11,19,20].

The analysis also showed that nanofat and microfat should not be interpreted simply as lower-volume versions of conventional lipografting. The literature predominantly associates them with regenerative purposes, particularly skin rejuvenation, scar treatment, and improvement in skin quality. Differences in processing alter the content of mature adipocytes, matrix components, and cellular fractions, creating products with distinct clinical applications [22-24,43,45].

Finally, the identified future prospects point toward a progressive separation between the volumetric effect of fat and the regenerative mechanisms related to the cells that compose it. The development of exosomes, extracellular vesicles, and secretome derived from ADSCs suggests the possibility of cell-free therapies, in which bioactive molecules can be used to stimulate repair without the need for direct cell transplantation. However, this field still requires clinical validation, standardization of production, dose determination, and safety assessment before its routine incorporation into plastic surgery [14,15,69,72,82].

In summary, the results related to the second specific objective show that autologous fat grafting enriched with ADSCs has a broad spectrum of aesthetic and reconstructive applications, with the strongest evidence regarding the breast, face, scars, and complex wounds.

The selected studies point to potential benefits in volumetric retention, tissue quality, and regeneration, but also highlight that safety, standardization of techniques, and objective definition of outcomes remain essential for determining in which situations cellular enrichment offers a real clinical advantage over conventional lipografting [2,9,24,25,64].

4. Conclusions

Autologous fat grafting enriched with adipose-derived stem cells represents an advancement over conventional lipografting by combining volumetric restoration with biological stimulation of tissue regeneration. The evidence reviewed indicates benefits related to angiogenesis, graft integration, extracellular matrix remodeling, modulation of the inflammatory response, and improved wound healing, resulting in favorable outcomes in breast reconstruction, facial rejuvenation, scar treatment, burn treatment, and other reconstructive applications.

However, the wide heterogeneity of methods for obtaining and processing ADSCs and the vascular stromal fraction, as well as surgical protocols, still limits the comparability of studies and the establishment of standardized recommendations. Thus, although the results are promising, the consolidation of this approach depends on the conduct of multicenter clinical trials, standardization of techniques, and long-term follow-up to confirm its efficacy, safety, and clinical reproducibility [115-132].

References

1. Firriolo, J. M., Condé-Green, A., & Pu, L. L. (2022). Fat grafting as regenerative surgery: a current review. *Plastic and Reconstructive Surgery*, 150(6), 1340e-1347e.
2. Costanzo, D., Romeo, A., & Marena, F. (2022). Autologous fat grafting in plastic and reconstructive surgery: an historical perspective. *Eplasty*, 22, e4.
3. Trozler, C., Sequeira, I., Auxenfans, C., & Mojallal, A. A. (2023). Fat graft retention: adipose tissue, adipose-derived stem cells, and aging. *Plastic and Reconstructive Surgery*, 151(3), 420e-431e.
4. Hanson, S. E., Garvey, P. B., Chang, E. I., Reece, G. P., & Liu, J., et al. (2022). A prospective, randomized comparison of clinical outcomes with different processing techniques in autologous fat grafting. *Plastic and reconstructive surgery*, 150(5), 955-962.
5. Becker, H., Vazquez, O. A., & Rosen, T. (2021). Cannula size effect on stromal vascular fraction content of fat grafts. *Plastic and Reconstructive Surgery Global Open*, 9(3), e3471.
6. Chun, J. J., Chang, J., Soedono, S., Oh, J., & Kim, Y. J., et al. (2022). Mechanical stress improves fat graft survival by promoting adipose-derived stem cells proliferation. *International Journal of Molecular Sciences*, 23(19), 11839.

7. Li, M., & Chen, C. (2021). The efficacy of cell-assisted lipotransfer versus conventional lipotransfer in breast augmentation: a systematic review and meta-analysis. *Aesthetic Plastic Surgery*, 45(4), 1478-1486.
8. Jeon, H. J., Choi, D. H., Lee, J. H., Lee, J. S., & Lee, J., et al. (2021). A prospective study of the efficacy of cell-assisted lipotransfer with stromal vascular fraction to correct contour deformities of the autologous reconstructed breast. *Aesthetic Plastic Surgery*, 45(3), 853-863.
9. Karam, M., Abul, A., & Rahman, S. (2023). Stem cell enriched fat grafts versus autologous fat grafts in reconstructive surgery: systematic review and meta-analysis. *Aesthetic Plastic Surgery*, 47(6), 2754-2768.
10. Cao, L., Xiaoming, F., Zhang, Q., Fang, J., & Chu, C., et al. (2022). An optimized method for adipose stromal vascular fraction isolation and its application in fat grafting. *Aesthetic Plastic Surgery*, 46(5), 2500-2508.
11. Sforza, M., Ivanenko, O., Biabani, N., Sforza, L., & Kalaskar, D. M., et al. (2025). Mechanical isolation of stromal vascular fraction from adipose tissue: methods and cellular outcomes: a systematic review and meta-analysis. *Stem Cell Research & Therapy*, 16(1), 560.
12. Li, X., Zhang, G., Wang, M., Lu, C., & Zhang, G., et al. (2024). Comparison of stromal vascular fraction cell composition between Coleman fat and extracellular matrix/stromal vascular fraction gel. *Adipocyte*, 13(1), 2360037.
13. An, Y., Lin, S., Tan, X., Zhu, S., & Nie, F., et al. (2021). Exosomes from adipose-derived stem cells and application to skin wound healing. *Cell proliferation*, 54(3), e12993.
14. Chen, H., Hou, K., Wu, Y., & Liu, Z. (2022). Use of adipose stem cells against hypertrophic scarring or keloid. *Frontiers in Cell and Developmental Biology*, 9, 823694.
15. Zhou, B., Chen, Q., Zhang, Q., Tian, W., & Chen, T., et al. (2024). Therapeutic potential of adipose-derived stem cell extracellular vesicles: from inflammation regulation to tissue repair. *Stem cell research & therapy*, 15(1), 249.
16. He, Y., Zhang, Z., Li, Z., Lin, M., & Ding, S., et al. (2023). Three-dimensional spheroid formation of adipose-derived stem cells improves the survival of fat transplantation by enhance their therapeutic effect. *Biotechnology Journal*, 18(10), 2300021.
17. Lee, S. O., Park, B. Y., Nguyen, T. T., Kwon, K. R., & Kim, M. J., et al. (2024). Three-dimensional adipose-derived stem cell spheroids enhance adipogenesis and angiogenesis in fat grafts: experimental research. *International Journal of Surgery (London, England)*, 110(12), 8228.
18. Guo, T., Li, J., Lin, J., Xie, M., & Du, Y., et al. (2026). Mitochondrial transfer from adipose-derived stem cells reprograms macrophage lipid metabolism to improve fat graft survival. *Journal of Translational Medicine*.
19. Wufuer, M., Choi, T. H., Najmiddinov, B., Kim, J., & Choi, J., et al. (2024). Improving Facial Fat Graft Survival Using Stromal Vascular Fraction-Enriched Lipotransfer: A Multicenter Randomized Controlled Study. *Plastic & Reconstructive Surgery*, 153(4), 690e-700e.
20. Jefri, Z. E., Alashjaee, R. H., Almarri, A. K., Alghamdi, A. M., & Halawani, I. R., et al. (2026). Stromal vascular fraction-assisted fat grafting: a systematic review and meta-analysis of clinical outcomes. *Aesthetic Plastic Surgery*, 50(2), 677-691.
21. Pensato, R., Al-Amer, R., & La Padula, S. (2024). Autologous Fat Grafting in the Breast: Critical Points and Technique Improvements. *Aesthetic Plastic Surgery*, 48(15), 3018-3019.
22. Yang, F., Ji, Z., Peng, L., Fu, T., & Liu, K., et al. (2021). Efficacy, safety and complications of autologous fat grafting to the eyelids and periorbital area: A systematic review and meta-analysis. *PLoS One*, 16(4), e0248505.
23. Girard, P., Dulong, J., Duisit, J., Mocquard, C., & Le Gallou, S., et al. (2022). Modified nanofat grafting: Stromal vascular fraction simple and efficient mechanical isolation technique and perspectives in clinical recellularization applications. *Frontiers in Bioengineering and Biotechnology*, 10, 895735.
24. Jin, X., Hong, K. Y., & Chang, H. (2024). Effects of nanofat in plastic and reconstructive surgery: a systematic review. *Plastic & Reconstructive Surgery*, 154(3), 451e-464e.
25. Shamoun, F., Asaad, M., & Hanson, S. E. (2021). Oncologic safety of autologous fat grafting in breast reconstruction. *Clinical breast cancer*, 21(4), 271-277.
26. Tukiama, R., Vieira, R. A., Moura, E. C., Oliveira, A. G., & Facina, G., et al. (2022). Oncologic safety of breast reconstruction with autologous fat grafting: A systematic review and meta-analysis. *European Journal of Surgical Oncology*, 48(4), 727-735.
27. Li, M., Shi, Y., Li, Q., Guo, X., & Han, X., et al. (2022). Oncological safety of autologous fat grafting in breast reconstruction: a meta-analysis based on matched cohort studies. *Aesthetic Plastic Surgery*, 46(3), 1189-1200.
28. Kenny, E. M., Egro, F. M., Ejaz, A., Coleman, S. R., & Greenberger, J. S., et al. (2021). Fat grafting in radiation-induced soft-tissue injury: a narrative review of the clinical evidence and implications for future studies. *Plastic and Reconstructive Surgery*, 147(4), 819-838.
29. Abu Alqam, R., Alshammari, A. J., Alkhwildi, L. A., Bamatraf, M. S., & Khashab, R. M., et al. (2024). Effectiveness of autologous fat grafting in the treatment of scars: a systematic review and meta-analysis. *Aesthetic Plastic Surgery*, 48(19), 3945-3961.
30. Lesmanawati, F. E., Windura, C. A., Saputro, I. D., & Hariani, L. (2024). Autologous fat grafting and adipose-derived stem cells therapy for acute burns and burn-related scar: A systematic review. *Tzu-Chi Medical Journal*, 36(2), 203.
31. Vriend, L., van Dongen, J. A., Pijpe, A., Nieuwenhuis, M. K., & Jongen, S. J., et al. (2022). Stromal vascular fraction-enriched fat grafting as treatment of adherent scars: study design of a non-randomized early phase trial. *Trials*, 23(1), 575.
32. Liu, W., Shi, K., Zhu, X., Zhao, H., & Zhang, H., et al. (2021). Adipose tissue-derived stem cells in plastic and reconstructive surgery: a bibliometric study. *Aesthetic Plastic Surgery*, 45(2), 679-689.
33. Li, J., Yin, Y., Zou, J., Zhang, E., & Li, Q., et al. (2023). The adipose-derived stem cell peptide ADSCP2 alleviates hypertrophic scar fibrosis via binding with pyruvate

- carboxylase and remodeling the metabolic landscape. *Acta Physiologica*, 238(4), e14010.
34. Zhang, Y., & Liu, T. (2023). Adipose-derived stem cells exosome and its potential applications in autologous fat grafting. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 76, 219-229.
 35. Sun, Y., Liu, Q., Zhu, J., Hu, H., & Lu, L., et al. (2025). Optimal strategies for autologous fat grafting in breast augmentation and reconstruction: a systematic review and network meta-analysis. *Plastic & Reconstructive Surgery*, 155(2), 243e-255e.
 36. Qin, Z., Yu, Z., & Song, B. (2022). Efficacy and safety of external volume expansion (EVE) on fat grafting: a systematic review and single-arm meta-analysis. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 75(3), 1073-1082.
 37. Zhu, J., & Quan, H. (2022). Adipose-derived stem cells-derived exosomes facilitate cutaneous wound healing by delivering XIST and restoring discoidin domain receptor 2. *Cytokine*, 158, 155981.
 38. Liu, M., & An, Y. (2024). The Effects of Platelet-Rich Plasma and Adipose-Derived Stem Cells on Neovascularization and Fat Graft Survival. *Aesthetic Plastic Surgery*, 48(21), 4579-4580.
 39. Wu, M., Karvar, M., Liu, Q., Orgill, D. P., & Panayi, A. C. (2021). Comparison of Conventional and Platelet-Rich Plasma-Assisted Fat Grafting: A Systematic Review and Meta-analysis. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 74(11), 2821-2830.
 40. Hua, Z., & Wei, P. (2021). Thoughts on the long-term effects of platelet-rich fibrin on fat graft survival. *Aesthetic Surgery Journal*, 41(11), NP1808-NP1809.
 41. Tan, P. C., Wang, Y. W., Xie, Y., Xu, X., & Xiao, H., et al. (2025). Enhancing skin regeneration during expansion: a multicenter randomized controlled trial of stromal vascular fraction and fat grafting. *Plastic and Reconstructive Surgery*, 157(2), 360.
 42. Qiu, K., Gan, W., & Chen, X. (2024). Efficacy of stromal vascular fraction in the treatment of scars: A systematic review and meta-analysis. *Skin Research and Technology*, 30(8), e13881.
 43. Yang, Z., Dong, L., Jin, S., Han, X., & Li, F. (2023). Comparison of microfat, nanofat, and extracellular matrix/stromal vascular fraction gel for skin rejuvenation: basic animal research. *Aesthetic Surgery Journal*, 43(7), NP573-NP586.
 44. La Padula, S., Ponzo, M., Lombardi, M., Iazzetta, V., & Errico, C., et al. (2023). Nanofat in plastic reconstructive, regenerative, and aesthetic surgery: a review of advancements in face-focused applications. *Journal of clinical medicine*, 12(13), 4351.
 45. Arcani, R., Velier, M., Sabatier, F., Simoncini, S., & Abellan-Lopez, M., et al. (2025). Nanofat use in regenerative medicine: a systematic literature review and consensus recommendations from expert opinions. *Facial plastic surgery & aesthetic medicine*, 27(6), 469-480.
 46. Jeyaraman, M., Muthu, S., Sharma, S., Ganta, C., & Ranjan, R., et al. (2021). Nanofat: a therapeutic paradigm in regenerative medicine. *World Journal of Stem Cells*, 13(11), 1733.
 47. Stachura, A., Paskal, W., Pawlik, W., Mazurek, M. J., & Jaworowski, J. (2021). The use of adipose-derived stem cells (ADSCs) and stromal vascular fraction (SVF) in skin scar treatment—a systematic review of clinical studies. *Journal of clinical medicine*, 10(16), 3637.
 48. Menkes, S., SidAhmed-Mezi, M., Meningaud, J. P., Benadiba, L., & Magalon, G., et al. (2021). Microfat and nanofat grafting in genital rejuvenation. *Aesthetic Surgery Journal*, 41(9), 1060-1067.
 49. Khan, F., Kashif, M., & Shadman, M. (2024). Role of autologous Nanofat grafting in the treatment of post acne and post burn scarring of the face. *Journal of Ayub Medical College Abbottabad*, 36(3), 560-563.
 50. Hanson, S. E., Kapur, S. K., Hwang, R. F., & Dryden, M. S. (2021). Autologous fat grafting in breast reconstruction: implications for follow-up and surveillance. *Gland Surgery*, 10(1), 487.
 51. Wederfoort, J. L., Hebels, S. A., Heuts, E. M., van der Hulst, R. R., & Piatkowski, A. A. (2022). Donor site complications and satisfaction in autologous fat grafting for breast reconstruction: A systematic review. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 75(4), 1316-1327.
 52. Sowa, Y., Inafuku, N., Tsuge, I., Yamanaka, H., & Morimoto, N. (2023). Patient-reported outcomes after autologous fat grafting in prosthetic breast reconstruction: prospective cohort study using a multivariate analysis. *Annals of Plastic Surgery*, 90(2), 123-127.
 53. Heine, N., Eigenberger, A., Brebant, V., Kempa, S., & Seitz, S., et al. (2023). The effect of radiotherapy on fat engraftment for complete breast reconstruction using lipofilling only. *Archives of Gynecology and Obstetrics*, 307(2), 549-555.
 54. Seth, I., Bulloch, G., Gibson, D., Chow, O., & Seth, N., et al. (2024). Autologous fat grafting in breast augmentation: a systematic review highlighting the need for clinical caution. *Plastic & Reconstructive Surgery*, 153(3), 527e-538e.
 55. Yu, W., Wang, Z., Dai, Y., Zhao, S., & Chen, H., et al. (2024). Autologous fat grafting for postoperative breast reconstruction: A systemic review. *Regenerative therapy*, 26, 1010-1017.
 56. Nguyen, T. D., Tran, H. K., Van Truong, P., Tran, T. P. N., & Tran, H. Q., et al. (2026). Cell-Assisted Lipotransfer (CAL) and Stromal Vascular Fraction (SVF) in Combination with Autologous Breast Reconstruction: A Preliminary Feasibility Case Series. *Aesthetic Plastic Surgery*, 1-9.
 57. Klinger, F., Murolo, M., Siliprandi, M., Battistini, A., & Agnelli, B., et al. (2022). Fat grafting in radiation-induced soft-tissue injury: a narrative review of the clinical evidence and implications for future studies. *Plastic & Reconstructive Surgery*, 150(4), 919e-920e.
 58. Bonetti, M. A., Piccolo, N. S., Rubin, J. P., & Egro, F. M. (2024). Fat grafting and regenerative medicine in burn care. *Clinics in Plastic Surgery*, 51(3), 435-443.
 59. L'Orphelin, J. M., Garimi, R., Labbé, D., Benateau, H., & Dompmmartin, A. (2021, March). Autologous fat grafting for

- the treatment of sclerotic lesions and scars. In *Annales de Dermatologie et de Vénéréologie* (Vol. 148, No. 1, pp. 40-44). Elsevier Masson.
60. Giuggioli, D., Spinella, A., Cocchiara, E., De Pinto, M., & Pinelli, M., et al. (2021). Autologous fat grafting in the treatment of a scleroderma stump-skin ulcer: a case report. *Case Reports in Plastic Surgery and Hand Surgery*, 8(1), 18-22.
 61. Han, X., Ji, D., Liu, Y., & Hu, S. (2023). Efficacy and safety of transplantation of autologous fat, platelet-rich plasma (PRP) and stromal vascular fraction (SVF) in the treatment of acne scar: systematic review and meta-analysis. *Aesthetic Plastic Surgery*, 47(4), 1623-1632.
 62. Khaity, A., Albakri, K., Al-Dardery, N. M., Yousef, Y. A., & Foppiani, J. A., et al. (2025). Adipose-derived stem cell therapy in hypertrophic and keloid scars: a systematic review of experimental studies. *Plastic Surgery*, 33(2), 318-328.
 63. Kohlhauser, M., Lüttschwager, S., Pignet, A. L., Schellnegger, M., & Moshhammer, M., et al. (2026). Adipose-Derived Stem Cells as Therapeutic Approach in Hypertrophic Scar Formation—A Systematic Review. *International Wound Journal*, 23(4), e70899.
 64. Schneider, I., Calcagni, M., & Buschmann, J. (2023). Adipose-derived stem cells applied in skin diseases, wound healing and skin defects: a review. *Cytotherapy*, 25(2), 105-119.
 65. Zhang, B., Wu, Y., Mori, M., & Yoshimura, K. (2022). Adipose-derived stem cell conditioned medium and wound healing: a systematic review. *Tissue Engineering Part B: Reviews*, 28(4), 830-847.
 66. Weiliang, Z., & Lili, G. (2021). Research advances in the application of adipose-derived stem cells derived exosomes in cutaneous wound healing. *Annals of Dermatology*, 33(4), 309.
 67. Yuan, T., Meijia, L., Xinyao, C., Xinyue, C., & Lijun, H. (2023). Exosome derived from human adipose-derived stem cell improve wound healing quality: A systematic review and meta-analysis of preclinical animal studies. *International Wound Journal*, 20(6), 2424-2439.
 68. Kemaloğlu, C. A., Dursun, E. N., Yay, A. H., Gökdemir, N. S., & Mat, Ö. C., et al. (2024). The optimal effective dose of adipose-derived stem cell exosomes in wound healing. *Annals of Plastic Surgery*, 93(2), 253-260.
 69. Rong, J., Li, Y. Y., Wang, X., Wang, J. N., & Song, M. (2025). Non-coding RNAs in adipose-derived stem cell exosomes: mechanisms, therapeutic potential, and challenges in wound healing. *World Journal of Stem Cells*, 17(4), 102917.
 70. Song, P., Liang, Q., Ge, X., Zhou, D., & Yuan, M., et al. (2025). Adipose-derived stem cell exosomes promote scar-free healing of diabetic wounds via miR-204-5p/TGF- β 1/Smad pathway. *Stem Cells International*, 2025(1), 6344844.
 71. Guo, E., Wang, L., Wu, J., & Chen, Q. (2025). Exosomes from MicroRNA-125b-modified adipose-derived stem cells promote wound healing of diabetic foot ulcers. *Current Stem Cell Research & Therapy*, 20(4), 409-420.
 72. Liu, Q., Zhang, C., Liang, Y., & Pan, X. (2025). Wound healing: harnessing extracellular vesicles derived from adipose-derived stem cells. *International Journal of Nanomedicine*, 13209-13229.
 73. Wang, J. W., Zhu, Y. Z., Hu, X., Nie, J. Y., et al. (2022). Extracellular vesicles derived from adipose-derived stem cells accelerate diabetic wound healing by suppressing the expression of matrix metalloproteinase-9. *Current Pharmaceutical Biotechnology*, 23(6), 894-901.
 74. Zheng, Y., Xu, P., Pan, C., Wang, Y., & Liu, Z., et al. (2023). Production and biological effects of extracellular vesicles from adipose-derived stem cells were markedly increased by low-intensity ultrasound stimulation for promoting diabetic wound healing. *Stem Cell Reviews and Reports*, 19(3), 784-806.
 75. Xiong, J., Qiang, H., Li, T., Zhao, J., & Wang, Z., et al. (2021). Human adipose-derived stem cells promote seawater-immersed wound healing via proangiogenic effects. *Aging (Albany NY)*, 13(13), 17118.
 76. Chen, Y. C., Chuang, E. Y., Tu, Y. K., Hsu, C. L., & Cheng, N. C. (2024). Human platelet lysate-cultured adipose-derived stem cell sheets promote angiogenesis and accelerate wound healing via CCL5 modulation. *Stem Cell Research & Therapy*, 15(1), 163.
 77. Liu, D., Liu, N., Liu, X., Liu, Y., & Zhang, H., et al. (2025). Adipose-derived stem cells (ADSCs)-derived DKK1 promotes cutaneous wound healing by inducing M2 macrophage polarization via PI3K/AKT and JNK activation. *Biochimica et Biophysica Acta (BBA)-Molecular Cell Research*, 120077.
 78. Ladley, S. M., & Naghdi, S. (2026). The Use of Adipose Derived Stem Cells in Chronic Wound Healing. *International Wound Journal*, 23(7), e70986.
 79. Luo, Y., Fu, M., Zhou, Z., Zhang, X., & Guo, Q., et al. (2024). A tilapia skin-derived gelatin hydrogel combined with the adipose-derived stromal vascular fraction for full-thickness wound healing. *Nanoscale Advances*, 6(16), 4230-4236.
 80. Aoki, S., Endo, Y., Guo, C., Wu, M., & Kim, A., et al. (2024). Nanosheet promotes chronic wound healing by localizing uncultured stromal vascular fraction cells. *Advances in wound care*, 13(12), 601-614.
 81. Wu, J., Wang, Y., Chen, W., Lin, M., & Jiang, J., et al. (2025). Harnessing stromal vascular fraction-based therapies for wound healing: Mechanisms, synergies, and clinical translation. *Regenerative Therapy*, 30, 692-709.
 82. Dinescu, S., Dobranici, A., & Tecucianu, R., et al. (2021). Exosomes as Part of the Human Adipose-Derived Stem Cells Secretome-Opening New Perspectives for Cell-Free Regenerative Applications. *Adv Exp Med Biol*, 1312, 139-163.
 83. Kim, E., Kim, H. K., Sul, J. H., Lee, J., & Back, S. H., et al. (2024). Extracellular vesicles derived from adipose stem cells alleviate systemic sclerosis by inhibiting tgf- β pathway. *Biomolecules & Therapeutics*, 32(4), 432.
 84. Zhang, N., Yu, X., Li, W., Zhang, K., & Yu, J., et al. (2023). Extracellular vesicles derived from adipose-derived stem cells facilitate frostbite wound healing by regulating SOCS3 expression. *Current Stem Cell Research & Therapy*, 18(4), 528-539.
 85. Lin, A., Yu, J. L., Yuan, S. M., Tang, Y. F., & Yang, K. X., et al. (2025). Extracellular vesicles from adipose-derived stem cells

- in bone regeneration: Mechanisms and therapeutic advances. *World Journal of Stem Cells*, 17(10), 110248.
86. Ho, C. Y., Mao, S. H., Tsai, C. H., Chuang, K. T., & Lai, B. R., et al. (2026). Extracellular Vesicles (EVs) Mirror Their Source: Comparative Analysis of Bone Marrow-Derived and Adipose-Derived Stem Cells and EVs in Bone Regeneration. *Cellular and Molecular Bioengineering*, 19(3), 297-310.
87. Surowiecka, A., & Strużyna, J. (2022). Adipose-derived stem cells for facial rejuvenation. *Journal of Personalized Medicine*, 12(1), 117.
88. Yang, Z., Jin, S., He, Y., Zhang, X., & Han, X., et al. (2021). Comparison of microfat, nanofat, and extracellular matrix/stromal vascular fraction gel for skin rejuvenation: basic research and clinical applications. *Aesthetic surgery journal*, 41(11), NP1557-NP1570.
89. Scott, B. L., Randall, N., Wang, T., & Loyo, M. (2021). Autologous fat grafting in facial cosmetic surgery: a national survey. *Facial Plastic Surgery*, 37(01), 136-138.
90. Diao, Z., Han, X., & Zhang, X. (2021). Temporal augmentation using autologous fat grafting in Chinese women: effect on temporal hairline. *Journal of Cosmetic Dermatology*, 20(10), 3193-3197.
91. Fiedler, L. S., Saleh, D. B., & Mukrowsky, A. (2021). Autologous fat grafting in the face and neck: Multinational trends and knowledge of the safety, applications, and indications considering oncologic risk potential. *Laryngoscope Investigative Otolaryngology*, 6(5), 1024-1030.
92. Mortada, H., Seraj, H., Alhamoud, M. A., Alghoribi, R. S., & Alsuhailbani, O. S., et al. (2022). Ophthalmic complications following facial autologous fat graft injection: a systematic review and meta-analysis. *Aesthetic Plastic Surgery*, 46(6), 3013-3035.
93. Pascali, M., Marchese, G., & Diaspro, A. (2023). Fat injection as a valuable tool for lower eyelid retraction management: a retrospective, observational, single blind and case—control study. *Aesthetic plastic surgery*, 47(1), 235-244.
94. Saadoun, R., Solari, M. G., & Rubin, J. P. (2023). The role of autologous fat grafting in rhinoplasty. *Facial Plastic Surgery*, 39(02), 185-189.
95. Junior, O. L. H., Rosa, B. M., Pourtaheri, N., Guijarro-Martinez, R., & Valls-Ontanon, A., et al. (2023). Fat grafting in patients with cleft lip and palate: a systematic review. *Journal of Cranio-Maxillofacial Surgery*, 51(3), 178-187.
96. Zhang, K., Wang, W., Hua, K., & Han, X. (2025). Autologous fat grafting in facial soft tissue defects: application status, controversies and future. *Aesthetic Plastic Surgery*, 49(20), 5809-5823.
97. Xu, Z., Zheng, F., Zhao, X., Wang, S., et al. (2024). Complications of fat grafting and repositioning for correction of lower eyelid pouch with tear trough deformity or lid-cheek junction: a systematic review. *Annals of Plastic Surgery*, 93(3), e9-e25.
98. Zhu, J., Zhao, F., Chai, Y., Jia, X., & Li, F. (2024). Evaluating the efficacy of dedifferentiated fat cells (DFATs) vs adipose-derived stem cells (ASCs) in enhancing the viability of fat grafts. *Aesthetic Surgery Journal*, 44(4), NP307-NP318.
99. Zhang, X., Lin, Y., Li, H., Wang, Q., & Mu, D. (2025). Enhancing fat graft survival: thymosin beta-4 facilitates mitochondrial transfer from ADSCs via tunneling nanotubes by upregulating the Rac/F-actin pathway. *Free Radical Biology and Medicine*, 228, 281-298.
100. Wang, M., Zhao, J., Li, J., Meng, M., & Zhu, M. (2024). Insights into the role of adipose-derived stem cells and secretome: potential biology and clinical applications in hypertrophic scarring. *Stem cell research & therapy*, 15(1), 137.
101. Munhoz, A. M., Maximiliano, J., Neto, A. D. A. M., Duarte, D. W., & de Oliveira, A. C. P., et al. (2022). Zones for fat grafting in hybrid breast augmentation: standardization for planning of fat grafting based on breast cleavage units. *Plastic and Reconstructive Surgery*, 150(4), 782-795.
102. Giannas, E., Fritsch, A. M., Jeon, H., Valenzuela, Z., & Inyang, I. D., et al. (2026). Fat Survival following Autologous Fat Transfer to the Native Breast. A Systematic Review and Meta-Analysis. *Journal of Plastic, Reconstructive & Aesthetic Surgery*.
103. Meijer, G. S., van den Eijkel, R. C., Smit, J. M., Vidal-Itriago, A., & Young-Afat, D. A., et al. (2026). Outcomes and Complications of Autologous Fat Transfer for Total Breast Reconstruction and Augmentation: Systematic Review and Meta-analysis of Randomized Controlled Trials. *Plastic and Reconstructive Surgery Global Open*, 14(6), e7795.
104. Su, Y. S., Huang, Y. B., Huang, Z. B., Yang, Y. F., & Wu, Y. M., et al. (2025). Autologous fat grafting for the treatment of structural infraorbital dark circles. *Aesthetic Plastic Surgery*, 49(7), 1842-1849.
105. Chadab, T. M., Wiegmann, A. L., Skochdopole, A. J., & Rohrich, R. J. (2026). Periorbital Rejuvenation Using Fat Grafting to Five Key Anatomic Areas. *Plastic & Reconstructive Surgery*.
106. Zeng, H., & Tang, S. (2025). Autologous fat injection for rhinoplasty: a systematic review of satisfaction, reinjection and fat retention. *Aesthetic plastic surgery*, 49(14), 3987-3999.
107. Xuan, M. A., & Facheng, L. I. (2022). Autologous fat grafting for perioral and lower face rejuvenation. *Chinese Journal of Reparative and Reconstructive Surgery*, 36(12), 1542.
108. Nagappan, L., Liao, D., & Bloom, J. D. (2026). Autologous Fat Grafting of the Face in Men. *Facial Plastic Surgery*, 42(02), 213-218.
109. Tawfik, A. A., & Rageh, M. A. (2025). The role of autologous fat grafting in the treatment of atrophic post-acne scars: a narrative review. *Journal of Cutaneous Medicine and Surgery*, 29(4), 394-398.
110. Akdogan, M. B., Incetas, Y. P., Akoglu, G., & Caliskan, E. (2026). Autologous microfat and nanofat grafting combined with platelet-rich fibrin in early treatment of atrophic facial scars. *Dermatologic Surgery*, 52(6), 611-612.
111. Putri, K. T., & Prasetyono, T. O. H. (2022). A critical review on the potential role of adipose-derived stem cells for future treatment of hypertrophic scars. *Journal of Cosmetic Dermatology*, 21(5), 1913-1919.

112. Buitrago, D. M. C., Díaz, M. F. A., López, A. M. C., & Ardila, J. S. A., et al. (2024). Reconstruction of penile skin defect using negative pressure therapy, spiraling full-thickness skin grafts, and nanofat grafting: a case report. *Journal of Surgical Case Reports*, 2024(11), rjae663.
113. Cai, Y., Zhang, F., Feng, J., Wu, B., & Li, H., et al. (2023). Long-term follow-up and exploration of the mechanism of stromal vascular fraction gel in chronic wounds. *Stem Cell Research & Therapy*, 14(1), 163.
114. Yamani, V. R., Gurindagunta, S. V., Raju, R. L., Kumar, S., & Valluri, M. K., et al. (2024). Hand rejuvenation by autologous fat grafting in post-Hansen's hand atrophy: aesthetic and psychological implications. *Indian Journal of Plastic Surgery*, 57(06), 461-468.
115. Abu Alqam, R., Alkhwildi, L. A., Almaghrabi, M. T., Alali, F. K., & Khashab, R. M., et al. (2025). Hand rejuvenation using autologous fat grafting: a systematic review of recommended doses, complications, and patient satisfaction. *Aesthetic Plastic Surgery*, 49(6), 1734-1749.
116. Gong, Y., Ma, H., Zheng, Z., Wang, X., & Zhang, J., et al. (2025). Adipose-derived stem cell exosomes: emerging roles and therapeutic application. *Frontiers in Pharmacology*, 16, 1637342.
117. Ahn, J., Ahn, J., Shiatis, A., & Herron, J. (2026). Efficacy and safety of fat grafting in breast reconstruction: A systematic review and meta-analyses of outcomes following mastectomy. *Journal of Plastic, Reconstructive & Aesthetic Surgery*.
118. Chen, J., Liu, R., Huang, T., Sun, H., & Jiang, H. (2022). Adipose stem cells-released extracellular vesicles as a next-generation cargo delivery vehicles: a survey of minimal information implementation, mass production and functional modification. *Stem Cell Research & Therapy*, 13(1), 182.
119. Dai, Q., Yu, Q., Xiao, R., & Cai, L. (2021). Early intervention with autologous fat grafting to reduce hypertrophic scar formation: a preliminary study. *Aesthetic Plastic Surgery*, 45(5), 2409-2416.
120. Gao, H., Wang, L., Kong, L., & Wen, L. (2026). Fat Grafting via the Supraorbital Approach for Upper-Eyelid Depression Correction: A Retrospective Study. *Aesthetic Plastic Surgery*, 1-6.
121. Gronovich, Y., & Maisel Lotan, A. (2022). Treatment of scars with autologous fat grafting and 1540 nm non-ablative erbium laser. *Journal of Cosmetic and Laser Therapy*, 24(6-8), 80-83.
122. Hekimoglu, E. R., Esrefoglu, M., Cimen, F. B. K., Pasin, Ö., & Dedeakayogullari, H. (2025). Therapeutic potential of stromal vascular fraction in enhancing wound healing: a preclinical study. *Aesthetic plastic surgery*, 49(10), 2834-2849.
123. Jiang, X. Y., Li, F. W., Chen, Y. Q., Fang, J. R., & Luo, S. K., et al. (2023). Exosomes derived from human adipose-derived stem cells cannot distinctively promote graft survival in cryopreservation fat grafting. *Aesthetic Plastic Surgery*, 47(5), 2117-2129.
124. Khosropanah, M. H., Hassannejad, Z., Azimzadeh, A., Tanourlouee, S. B., Ghofrani, A., Vaghasloo, M. A., ... & Zolbin, M. M. (2025). Exploring the therapeutic potential of silkworm pupae extract and stromal vascular fraction in diabetic wound healing. *Tissue and Cell*, 103231.
125. Kochheiser, M., Jalili, P., Qin, N., Wei, L., & Vaeth, A. M., et al. (2026). Clinical Outcomes Following Autologous Fat Grafting for Breast Reconstruction: An Interim Analysis From a Randomized Controlled Trial Comparing Lipoaspirate Processing Techniques. *Annals of Plastic Surgery*, 10-1097.
126. Li, T. H., Li, Z. M., Qin, X. H., Yu, N. Z., & Huang, J. Z., et al. (2023). Global analyses and latest research hot spots of adipose-derived stem cells in fat grafting: a bibliometric and visualized review. *Aesthetic plastic surgery*, 47(3), 1192-1204.
127. Mohammed, M. S. E., Abdelfatah, M. M., Ahmed, A. Y., & Shafik, I. A. (2026). Autologous fat grafting and injectable fillers for post-reconstructive breast remodelling: A systematic review and quantitative synthesis. *JPRAS open*, 49, 466-478.
128. Pensato, R., Al-Amer, R., & La Padula, S. (2024). Cell-assisted lipotransfer: a systematic review of its efficacy. *Aesthetic Plastic Surgery*, 48(15), 3049-3050.
129. Pensato, R., Al-Amer, R., & La Padula, S. (2024). Effect of platelet-rich fibrin on fat grafting in animal models: a meta-analysis. *Aesthetic Plastic Surgery*, 48(15), 3004-3005.
130. Sluiter, E. C., Lane, M., Morrison, S. D., Kuzon, W. M., & Gilman, R. H. (2024). Fat grafting for forehead contouring in facial feminization. *Plastic and Reconstructive Surgery Global Open*, 12(8), e6073.
131. Tang, H., Yao, Y., Lu, F., Li, B., & Dong, Z., et al. (2026). Reverse expansion-assisted high-quality autologous fat grafting in breast reconstruction: A retrospective comparative study. *Journal of Plastic, Reconstructive & Aesthetic Surgery*.
132. Yu, C., Xu, J., & Chen, W. (2025). The landscape of research on autologous fat grafting for breast reconstruction. *Aesthetic Plastic Surgery*, 49(11), 3285-3287.