Autologous Fat Transfer for Maxillofacial Reconstruction

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KEYWORDS

• Fat grafting • Reconstruction • Facial • Trauma • Postablative • Maxillofacial

KEY POINTS

- Fat transfer (grafting) is an essential part of today's maxillofacial reconstructive treatment algorithm. Autologous fat is a versatile graft essential for soft tissue reconstruction.
- The indications for fat transfer are an ever-expanding and developing treatment modality that may be incorporated for the treatment of congenital, acquired, and posttraumatic defects.
- Although fat has shown much promise in maxillofacial reconstruction, other options are available for restoration of depleted volume. Understanding the limitations and indications for fat are crucial in its application.

Fat transfer or fat grafting for facial cosmetic indications has solidified its place in contemporary cosmetic surgery over the past 2 decades. The transfer of autologous fat to the periorbital, perioral, temporal, and malar regions is useful to restore much needed volume, which is a sign of health, beauty, and youth. As the understanding of the aging process expands, the use of transferred fat to treat the nasolabial region, lips, jowls, forehead, and mandibular border has proven to provide a reliable and safe technique to efface deep rhytids and correct contour deformities with little morbidity.

Autologous fat transfer has historically been an instrument utilized in maxillofacial reconstruction for the correction of acquired and congenital deformities. It was first described as a treatment modality for tuberculosis-induced facial contour deformities by Neuber[1] in 1893. For the oral and maxillofacial surgeon, fat transfer is most often recognized as a modality in preventing heterotopic bone formation in temporomandibular joint (TMJ) reconstruction and for obliteration of the nasofrontal ducts or frontal sinus after trauma.[2]

As described by Sidney Coleman,[3] autogenous fat has many of the characteristics of an ideal filler and has numerous applications. An ideal filler is autologous, completely biocompatible, readily available in sufficient quantities, naturally integrated into the host tissues, and is removable if necessary. Observations of transplanted fat show changes not only in size with proportion to a patient's weight gain and loss but also improvement to the surrounding tissues.[3,4] For many years it was assumed that adipose tissue was primarily and simply a dormant reservoir of energy for storage and production. It is now known that it is intimately involved in homeostasis, energy metabolism, neuroendocrine function, immune regulation, structural support, and protection of vital organs.[5] Adipocytes make up approximately 35% to 70% of adipose tissue mass in adults and account for approximately 25% of the total cell population of the human body.[1] In addition to adipocytes, adipose tissue contains preadipocytes, adipokines, fibroblast, endothelial cells, and immune cells, as well as, more importantly, adipose-derived stem cells (ASCs).[6]

By understanding the components of adipose tissue and, more specifically, liposuction aspirate, surgeons are able to better predict the role of each component and modify techniques to improve the yield of targeted cell types to improve patient outcomes. Of particular importance are the preadipocytes, adipokines, and ASCs. Due to their smaller size, preadipocytes are more resistant to liposuction trauma when compared with mature adipocytes.[6] In addition, preadipocytes are able to survive without nutrition longer and have a lower oxygen consumption rate than mature adipocytes.[7–9] Thus, the inherent advantages of preadipocytes allow them to be one of the few tissues that can survive transplantation to distant anatomic sites with acceptable short-term and long-term viability.

Adipocytes secrete more than 100 proteins, or adipokines.[10] Adipokines may stimulate neovascularization from existing endothelial cells or through the recruitment of circulating endothelial progenitor cells.[11] They may contribute to the production of new blood vessels through the production of vascular endothelial growth factor (VEGF), fibroblast growth factor (FGF), insulin-like growth factor, adiponectin, stromal-derived factor 1, tumor necrosis factor, and leptin.[12] VEGF,

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FGF-2, and platelet-derived growth factor are tyrosine kinase receptor-mediated growth factors that, in animal studies, have been shown to improve fat graft transplantation results.[13] Rehman and colleagues[14] reported that the regenerative potential of autologous adipose tissue was related to the observed presence of multipotent mesenchymal stem cells. These cells secrete multiple potentially synergistic proangiogenic growth factors: the adipokines. Further understanding and the ability to influence production of adipokines may lead to increased graft survival in hypovascular areas. By establishing a vascular supply to a previously avascular region may promote further graft acceptance. This classic idea was described by Rigotti and colleagues[15] when they discussed the therapeutic potential of mesenchymal stem cells for ischemic tissue revascularization and restoration of function. Adjunctive supplementation with platelet-rich plasma (PRP) may further aid in neo-revascularization to promote graft stability. Many of the same growth factors that are stimulated by the adipokines are contained within PRP.

Human adipose tissue is now a recognized important source for stem cells.[16,17] Adipose tissue has the highest percentage of adult stem cells of any tissue in the body, with as many as 5000 ASCs per gram of fat compared with 100 to 1000 stem cells per milliliter of bone marrow.[18] Zuk and colleagues[12,19] were the first to demonstrate ASC's capacity to differentiate into fat, bone, cartilage, muscle, and nerve. The significant presence of stem cells in the adipose tissue, with multilineage capacity and therapeutic neovascularization potential, make autologous adipose tissue transplantation a recommended therapy for the treatment of radiation-induced injuries.[15] To further validate the study by Rigotti and colleagues,[15] Phulpin and colleagues[20] replicated it in a murine model, noting that the histologic data highlighted a decrease in irradiated morphologic patterns characterized by an absence of necrotic areas and a high vascular network density associated with a normal histologic structure after fat graft transfer to an irradiated tissue field. The ASC present in fat grafts makes the graft extremely versatile and resilient. Both are characteristics needed to for optimal graft survival.

The versatility of autogenous fat graft is exemplified by the vast number of its applications. Previously reported applications include burns, frontal sinus obliteration, TMJ ankylosis, human immunodeficiency virus (HIV)-associated facial lipodystrophy, congenital craniofacial anomalies, nonhealing wounds, calvarial defects, enophthalmos, facial aging, breast contour deformities, damaged vocal cords, scars (with and without release of adhesions), and many others. Autogenous fat grafting has also been demonstrated to improve skin quality and color, soften scars, and restore proper contour and function.

The work of Sultan and colleagues[21] proposed the molecular mechanisms leading to scar improvement following fat grafting to thermal burns in a murine model. Their research demonstrated that autogenous fat grafts in the setting of a thermal burn downregulated transforming growth factor (TGF)-B1 secondary to the graft's neovascular properties. The downregulation of TGF-B1 led to improved clinical appearance, attenuation of epidermal thickening, leading to decreased scar formation, downregulation of Smad3 fibrotic pathway, improved collagen organization, and a 27% lower scar index in fat-grafted animals when compared with saline graft group.

The restoration of form and function in wounded warriors with craniomaxillofacial injury is challenging. To address the challenges of these injuries, the use of proven cosmetic surgery techniques, such as autologous fat grafting, greatly improve the patient's final form and function. Additionally, the authors have adapted these techniques for use in the treatment of blast injury patients to not only clinically improve contour deformities but also to address scarring, soften texture, and adapt hue to the uninjured adjacent skin.

Just as autologous adipose tissue is beneficial for elective facial cosmetic surgery procedures, its utility as an adjunct in craniomaxillofacial reconstruction has found a recent resurgence. Due to its versatility, structural fat grafting is being used much more frequently. Fat transfer for maxillofacial reconstruction can be categorized by its utility to treat the following deformity types: congenital, acquired, and posttraumatic. With a thorough and fundamental knowledge of surgical technique and indications, fat will complement bony and soft tissue reconstruction to provide an optimal aesthetic outcome for the categories listed in Table 1. See later discussion and case examples presented following a discussion of surgical technique.

Congenital deformities

Craniofacial syndromes broadly encompass genetic mutations, resulting in cranial suture stenosis that not only involves the skull but also frequently the cranial base. There is generally significant involvement in the orbito-naso-zygomatic complex, midface, and maxillary-mandibular complex. Corrective procedures rely on osteotomies and bone grafting for multidimensional correction. This bony foundation provides the greatest improvement in facial appearance and symmetry, but patients often lack soft tissue volume. Composite osteomyofascial microvascular free-flaps have been used in the past but carry a significant degree of morbidity. Autologous fat transfer is an excellent adjunctive procedure to further correct facial contours by improving structural support. Mesenchymal stem cells, which are inevitably harvested with the fat, have been shown to stimulate new bone formation. In 2004, Lendeckel and colleagues[22] published the use of ASCs for cranial bone regeneration. Taylor[23] treated an adolescent patient with bilateral orbito-zygomatic defects secondary to Treacher Collins syndrome with bone that was engineered from bone allograft, ASCs, recombinant human bone morphogenetic protein-2 (rh-BMP-2), and periosteal grafts.

As previously mentioned, craniofacial syndromes are often accompanied by soft tissue volume deficits. Treacher Collins and Nager syndromes are characterized by orbital and midface deformities. Affected patients present with bilateral malar, infraorbital, mandibular hypoplasia, external ear deformities, and orbital-palpebral defects. The periocular defects are noted secondary to the lack of bony support and

Table 1 Indications for fat transfer

Congenital Deformities	Acquired Deformities	Traumatic Deformities
Pierre-Robins sequence	HIV-associated lipoatrophy	Lagophthalmos
Treacher Collins	Postablative soft tissue defects	Ectropion
Hemi-facial macrosomia	TMJ reconstruction	Dystopia or diplopia
Nager syndrome	Postorthognathic defects	Scar revision
Progressive hemifacial atrophy	Scar revision	Facial asymmetries after trauma
		Frontal sinus depression
		Recon bar dehiscence
		Burns