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REVIEW

AUTOLOGOUS FAT GRAFTING

S. Naasan Alhaj Ali, I. Lascar

Plastic and Reconstructive Microsurgery, Clinical Emergency Hospital, Bucharest, Romania

Summary

Autologous fat grafting for soft-tissue augmentation has become increasingly popular in recent years. The evolution and spread of liposuction techniques have led to the renewal of fat grafting and its applications. Fat grafting has become an effective, safe and reliable method for restoring volume and correcting the atrophy that accompanies senescence.
Key words: Fat graft, lipofilling, Liposuction

Résumé

La greffe du tissu adipeux autologue

La greffe autologue du tissu adipeux pour l'augmentation du tissu mou est devenue très populaire les années récéntes. L'évolution et l'expansion des techniques de la liposuccion ont conduit au renouvellement du greffage du tissu adipeaux et de ses applications. Le greffage du tissu adipeux est devenu une méthode efficace, sûre et fiable pour la restauration du volume et la correction de l'atrophie qui accompagne la sénescence.
Mots clés: greffe du tissu adipeaux, lipofilling, liposuccion

Introduction

Filler materials are an important tool in the armamentarium of plastic surgery. Autologous Fat has the potential to be the ideal soft-tissue filler because it is abundant, easily accessible, inexpensive, host compatible and because it can be harvested repeatedly. It also offers a similar long-term durability with a low-cost compared to dermal fillers. (1)

A large array of indications have been reported previously: Cosmetic enhancement and rejuvenation, body contour improvement and reconstruction of scarred sites, periocular rejuvenation, fat atrophy in human immunodeficiency virus positive patients, Parry-Romberg syndrome and radiation-damaged sites, among others.

Multiple contributions and discoveries have also been made in this field and tumescence anaesthesia is the pillar of all these fat graft surgeries.(2)

Use of platelet rich plasma for longer survival of grafts and the realization that fat contains stem cells are few of the new concepts that have gained importance nowadays. (3)

Even though, fat grafting has become widely used by plastic surgeons, most surgeons choose their method of fat grafting based almost entirely on their experience. This paper focuses on the evolution of autologous fat grafting and giving a rationalized approach to it in present times.

Historical perspective

Autologous fat grafting has been attempted for over a century with varying degrees of success.

Table 1 shows the historical contributions made in the field of Autologous fat grafting. In the early 2000s, appreciation of the potentials of adipose tissue and its related stromal elements, led to examination of the adipose-derived adult mesenchymal stem cell content. (2,4,5)

Evidence as clearly shown the key importance of the progenitor cells, stromal vascular fraction and extracellular matrix as integral contributors to the tissue maintenance and healing processes. (3)

Fat grafting technique

The most important principle in the surgical management is the atraumatic transfer of fat. Trauma to fat in the process of harvesting or placing fat affects the survival of the graft. While a nonviable graft initially may appear to have corrected the problem, eventual resorption of the tissue negates the result. Any blood that remains in the harvested fat also facilitates rapid degradation of the transplanted lipograft. The 3 parts of the surgery are harvesting the graft, transferring the graft, and placing the graft.

Preoperative details

First, carefully mark the recipient site(s) with the patient's

Correspondence address: *Shadi Naasan Alhaj Ali, MD. Bucharest, Romania* *e-mail: dr.sh.naasan@gmail.com*

Table 1 - Historical contributions to the field of autologous fat grafting

Year	Name of the contributor	Contribution
1893	Neuber	1st documented use of AFG. He transplanted multiple 1-cm fat grafts from the arm to fill soft-tissue depressions of the face caused by tuberculosis.
1909	Lexer	Grafted fat from the abdomen to treat a depression of the malar infraorbital area and to augment a receding chin.
1911	Tuffier	Studied the histopathology of transplanted fat and made note that large portions of fat were absorbed and replaced with fibrous tissue. Furthermore in that year, Brunings used fat for the correction of postrhinoplasty deformities.
1950	Peer	Determined that approximately 45% of the volume of transplanted fat was absorbed after 1 year.
1977	Illouz	Demonstrated that it was possible to extract fat by suction rather than by the previous rudimentary methods.
1982	Bricoll	The first formal presentation of lipo injection for facial recontouring was made.
1989	Fournier	Coined the term liposculpture to describe a procedure by which adipose tissue was removed with liposuction and selectively injected to areas with contour irregularities and also demonstrated that fat could be extracted using a13-gauge needle while using local anaesthesia.
1986	Ellenbogen	Used free "pearl" fat autographs of between 4 min and 6 mm in diameter for treatment of acne scarring,facial atrophy and rhytides.
1987	Klein	Introduction of the tumescent anaesthesia.
1993	William Coleman III	"Lipocytic dermal augmentation"-mechanically processed fat when injected intradermally stimulated newcollagen synthesis as a result of fibrosis at the recipient site.
1997	Sidney Coleman	He believed that by using large volumes of fat, he was able to achieve maximum aesthetic results.
2000	Carpeneda	Believed that there was improved survival and longevity of the transplanted fat when small volumes of fat, less than 3 mm in diameter, were implanted. As a result of technical difficulties and variable survival of the implanted fat, fat transplantation fell out of favour. It is of interest to note that during the early part of the 1900s, numerous medical specialties attempted to employ fat transplantation. However, Autologous fat grafting was rediscovered in the 1970s-1980s

agreement while he or she is in the upright position. Sterilely prepare and drape both the harvest site and the recipient site.

Intraoperative details

Harvest

Common donor sites include periumbilical, lumbar, and trochanteric areas; the thigh; and medial sites of the knee and arm.

Use local anesthesia to anesthetize the site for a small access incision. Through this incision, use a long syringe to introduce tumescent fluid for anesthesia of the region. The same site serves as the access for harvesting.

The choice of tumescent fluid varies. A standard solution consists of 1 mg of epinephrine, 200 mg of lidocaine, and 5 mEq of sodium bicarbonate in 1 L of normal saline. Dosages of lidocaine up to 35 mg/kg can be used for the tumescent technique, although substantially less is required for simple fat harvesting.

Following infiltration of the region to be harvested, use an aspiration cannula (eg, Mercedes) connected to a syringe. Suction by hand or with a mechanical vacuum. Use a gentle passing motion for aspiration. Small syringes are recommended to avoid creation of negative pressures greater than 1 atm. Increasing the power suction from -0.5 atm to -0.95 atm has been experimentally demonstrated to result in the breakage and vaporization of fat cells, destroying their ability to be successfully transplanted. (6) (fig. 1)

Transfer and purification

Once harvesting is complete, the aspirate then is trans-

Figure 1

ferred sterilely through multiple syringes to 1-mL tuberculin syringes. The liquid fraction of the graft is gently washed free of oil, lidocaine, and blood with this transfer.

An alternative to gentle hand tipping is use of the centrifuge. Although Chajchir found that use of the centrifuge machine at high or low speed completely destroyed the adipose cells, (7,8) other groups have reported good results with use of the centrifuge. The aspirate divides into 3 layers. The top layer is free oil from ruptured fat cells. This layer is decanted or blotted gently. The bottom layer contains variable amounts of tumescent fluid and blood and is drained. The middle layer consists of fat cells for grafting. More vigorous washing or straining may damage the fragile cells and decrease the viability of the graft.

The choice of fluid for fat suspension is controversial. Most commonly, normal saline or lactated Ringer solution is used. Serum free culture medium is also available, although it is more expensive. Some groups advocate additives such as heparin, insulin, vitamin E, and nonsteroidal anabolic hormones. The contribution of lidocaine is also debatable.

In anticipation of future lipografts, adipocytes may be frozen to -30°C and reused. A high number of viable cells exist even after defrosting. Slow freezing and thawing is the method of choice to retain the maximal number of live cells. (Fig. 2)

Placement

Regional nerve blocks are the most useful because adequate anesthesia can be provided without obscuring the defect to be treated.

The goal with any grafting procedure is to gently apply the graft to a well-vascularized bed to maximize graft take. Every part of the graft should be within 1.5 mm of living, vascularized tissue. If a large area is grafted, the central area, which is most removed from the blood supply, may not survive. Still, some clinical evidence shows good lipografting survival in some tissues that are not well-vascularized (ie, hemifacial hemiatrophy and posttraumatic scars).

Creating small tracks for the grafts helps keep the grafted fat adherent to the recipient site.

Insert the cannula either over a bevel-tipped needle or through a 1-2–mm access incision made by a No. 11 blade scalpel. Guide the needle or cannula and inject fat in a controlled method gently upon withdrawal. Slight overcorrection is important because some absorption of the liquid carrier occurs. Some groups recommend a 30% overcorrection.

The level of fat grafting varies with the structure being augmented. Fat is grafted from the deep layer to the superficial layer.

Serial injection may be performed at 3-month intervals. Generally, 3 procedures should be anticipated. Even distribution of the injection is crucial. Excess bulk in a particular area may isolate the fat in the central region from the new blood supply. (Fig. 3)

Postoperative details

Discourage massage immediately following fat grafting.

Compression dressings to prevent migration have been described; however, they are often difficult to maintain and probably add little to the final result. If the fat has been placed in an appropriate tunnel, minimal concern about migration should exist.

Follow-up

Patients should be seen in the first week postoperatively to check the donor and recipient sites. Some edema and a minimal amount of bruising may be apparent; reassure patients.

An additional follow-up appointment should be made for approximately 6-8 weeks. At this point, most of the edema has subsided, and early results can be assessed.

If a repeat procedure is to be performed, a waiting period of 3 months is prudent to allow the first graft to revascularize and to allow any edema to resolve.

Complications

The major complications of fat grafting are undercorrection and overcorrection. Undercorrection can be the

Figure 2

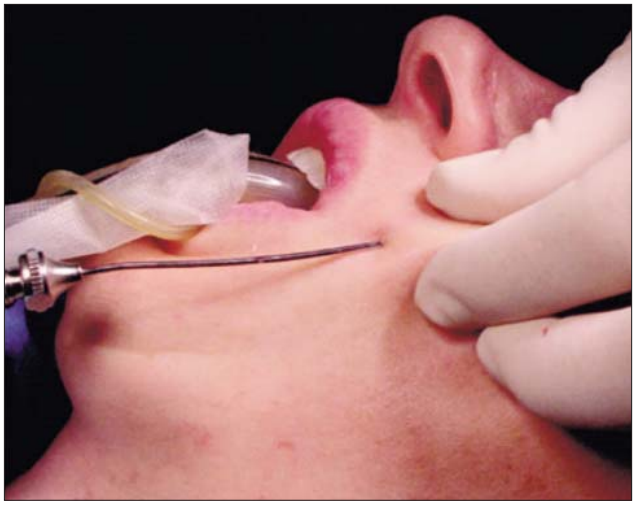

Figure 3

result of the placement of less than the required amount of fat or from the resorption of some of the graft.

Although placing too little fat obviously fails to correct the defect, increasing the amount of injected fat does not always prevent problems. Placing too much fat in a particular area can contribute to failure of revascularization of the graft. Graft necrosis may cause palpable irregularities and eventual disappearance of the grafted material. Graft migration is usually caused by infiltrating too much fat into a particular site. The graft either is forced into an undesirable area or succumbs to pressure and lack of blood supply.

When grafting scarred areas, the graft tends to move to the areas of least tension.

Undercorrection is generally easier to treat than overcorrection. Additional fat may be grafted at a separate sitting to complete the correction. Removing excess graft is more difficult as the host tissue infiltrates into the graft.

Damage to underlying structures, particularly around the eye, is possible and generally is prevented using the blunt needle for infiltration. Coleman reported a case of parotid injury when grafting a scar adherent to the parotid. Sharp needles were used. Niechajev and Sevcuk reviewed complications and discovered 4 cases of unilateral blindness and 1 case of severe damage to the CNS.(6) All of these cases involved treating glabellar frown lines with probable resultant fat embolism. Careful control of the injection to keep the fat in superficial areas as well as use of the blunt cannula should prevent these complications.

Edema usually is evident for 2 weeks after the procedure; however, as with any procedure, prolonged edema is possible and troubling to the patient.

Bleeding complications usually are limited to transient mild ecchymosis and are associated with the use of sharp needles for fat injection. Superficial ecchymosis tends to resorb rapidly. Small hematomas are more unusual and are associated with the use of sharp needles for graft placement.

Although rare, infections can occur wherever the skin envelope is violated. The most common source of infection is the oral mucosa.

Additionally, donor site scarring is a potential concern. Contour irregularities can result from overly aggressive harvesting in a small area.

Outcomes and prognosis

The major questions regarding fat grafting are how much of the graft survives and for how long. Many groups have reported on the fate of grafted fat; however, solid quantitative results have been difficult to establish. In addition to the variations in technique of fat grafting, quantifying the results objectively has been nearly impossible. Biopsy of the areas has been performed but is not a palatable option in the cosmetic patient. Further, while histology may demonstrate the integration of the graft, the relative volume retained remains unknown.(9)

Imaging studies, such as MRI, may yield information in a noninvasive manner; however, such studies are quite expensive and inconvenient for the patient. Also, many of these patients undergo additional procedures either simultaneously or at a later date, which may confound the results. Individual variation in aging is another uncontrollable factor, although many studies reporting poor long-term results have been published. Surgeons who routinely perform fat grafting counter that failure to maintain meticulous technique accounts for the shortcomings.

Two major theories describe the survival of grafted fat. Peer proposed the host cell replacement theory. (10) Histiocytes phagocytize free fat and become adipocytes. This idea largely has been replaced by the cell survival theory. Circulation is restored to the grafted fat cells in a manner similar to the revascularization of a skin graft. In the first 4 days, host cells, such as polymorphonuclear leukocytes (PMNs), plasma cells, lymphocytes, and eosinophils, infiltrate the graft. Within the vessels of the graft, red and white blood cells are clumped. On or about the fourth day, neovascularization is evident. Histiocytes act only to remove fat from broken down, nonsurviving, or disrupted cells.

The key points of the theory of fat survival are (1) fat is a dynamic tissue and (2) cells that suffer trauma lose more volume. Therefore, careful handling of the graft is critical. Scarring and the added bulk of reactive tissue may contribute to the anticipated result.

Moore et al reported on the effects of mechanical damage to fat cells harvested with syringe suction lipectomy versus excision with local anesthetics.(11) The mechanical damage to tissue aspirated versus tissue that was excised was unchanged. Lidocaine inhibited the glucose metabolism and lipolysis of adipocytes in culture. The effect was maintained only for as long as the lidocaine was present.

Also, as Smahel reported, fat grafts, like other grafts, must be small enough to be revascularized but large enough to maintain structural integrity and some native blood vessels. (12) When part of the graft is not revascularized, the fat becomes necrotic and is not simply resorbed but is broken up and removed by the cellular elements.

Niechajev and Sevcuk reported long-term results of fat transplantation clinically and histologically. (6) Fat harvested by low-power aspiration was used. Patients were overcorrected by approximately 50% at the time of the initial procedure. Only partial resorption had occurred 1.5-4.5 years postoperatively. The clinical impression was that 40-50% of the result was maintained long-term. Histologic sampling at 7-36 months revealed fat cells in an organized structure. Longer-lived specimens demonstrated more pronounced fibrosis and organized connective tissue. The size of the graft was demonstrated to increase with overall weight gain by the patient.

Coleman reported long-term success when the treated rhytid was compared with a control rhytid.(13) Patients were monitored clinically with careful photographic controls for 6.5 years. However, ongoing aging and choice of control rhytid can affect the interpretation of results.

Koh et al showed that patients who received adipose-derived stem cells and fat grafts had less fat absorption than

those who received fat grafts alone. They measured fat absorption and volumetric differences using a 3-dimensional camera and 3-dimensional computed tomography.(14)

Clearly, the results depend on the technique used for the procedure and on the method of measuring results. Advances in digital photography aid in long-term follow-up care and documentation. Presently, clinical impressions and patient satisfaction support the use of fat grafting in many different situations.(15)

Future and controversies

Fat grafting has become a popular procedure in plastic surgery. The long-term results remain debatable. Standardized digital photography may allow more precise quantification of long-term results in a noninvasive manner.

Preliminary studies have suggested that fat injections may even be clinically effective in patients who experience the adverse effects of radiation and in patients with severe burns.(16,17,18)

The results are not only aesthetically pleasing but also appear to mimic the texture of skin better. Histologically, biopsy tissue shows neovascularization, increased collagen deposition, and dermal hyperplasia.[29] These effects are thought to be influenced by a population of stem cells, residing in the stromal vascular fraction of lipoaspirate tissue, that are capable of differentiating into multiple tissue types.(19,20,21)

Investigations regarding pharmacologic manipulation of the graft are underway. Some groups have tested agents such as insulin-like growth factor, basic fibroblast growth factor, and a selective B1 blocker to enhance the survival of lipograft in rats.

In addition, techniques for simplification of harvesting are being developed. The ability to grow cells in culture may allow for multiple grafting procedures with a single harvest. The results seem promising and may one day be used in human fat grafting.

Conclusion

This paper gives a brief review on autologous fat grafting, from evolution to current times. The often abundant supply of this autologous material in our patients requiring aesthetic correction following disease or intrinsic aging behoves us to refine our knowledge of this valuable technique. Furthermore with the new discovery of adipose-derived mesenchymal stem cells, there is added scientific interest now in this procedure

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