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Review Article

A study of autologous free fat transplantation for augmentation of contour deformities of face: a study of 10 cases with review of literature

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ABSTRACT

Increased understanding, improving technology and the latest advances along with growing emphasis on the operative details over a period of last 100 years are the important factors due to which, 'free fat transplant' is now becoming a method of choice for reconstruction of soft tissue deformity of face. Although it requires initial overfilling of the fat and also considering the possibility of uncontrolled, unpredicted absorption of the injected fat, transplant of the free fat itself being a simple and cost effective procedure has emerged out to be a treatment of choice for contour deformities of face and is preferred over other methods of soft tissue reconstruction for the face. It gives natural look and feel to the tissue and also has less post-operative consequences comparatively. Here we present our experience of free fat auto-transplant for soft tissue reconstruction of face by taking into account ten cases in whom, we performed the procedure and kept a follow-up to obtain the exact status of results, benefits and complications. Also we are comparing our result with that mentioned in the literature and presenting it with a review.

Keywords: Autologous, Free fat transplant, Face deformities

INTRODUCTION

Autologous fat transplantation is the oldest method for tissue augmentation dating back 100 years. Gersuny first reported that he had injected the scrotum of a young man with paraffin to replace testicles. He later reported the use of paraffin to correct facial contour defects. Miller described numerous uses of paraffin for the correction of imperfection of the face.[1,2] Aesthetic surgeons continued to use injection techniques to inject other substances. Rubber and purified latex (i.e gutta percha) became popular in the 1920's.[3,4] When liquid injectable silicone was first introduced in 1965, many plastic surgeons felt that this would be the implant material of the future, because there would be no absorption or reaction.[5,6] Thick dermal fat grafts, pedicle tissue transfer, bone and cartilage grafts were all reported and used in the 1970's.[7,8] Eventually, with rise of microsurgery, free dermal fat flaps were reported. Although the corrections obtained by these operations do jot resorb, there is tremendous morbidity associated with them.[9] Also, they are impractical for those who need minor contour correction. The clinical need for injectable substances for soft tissue augmentation remains undisputed. A variety of problems ranging in severity from hemi facial atrophy to early visibility of dynamic expression lines in photo aging, suggests the need for safe, elegant, reproducible and widely applicable injectable. Compounds like collagen both human and animal, hyaluronic acid, water molecules and various other injectable have been used. However there were several limitations ranging from antigenicity and cost to effectiveness and long term

benefits. Lack of satisfaction with these materials for a variety of reasons has turned physician's attention to autologous fat as a potential source for augmentation. Autologous fat transplantation is the oldest method for tissue augmentation dating back 100 years. In the 1980's with the advent of liposuction, a dramatic change occurred. Many investigators felt it was possible to return visible fat to the body. Nevertheless, the best mode of fat removal and the best mode of fat implantation may still elude us. Whether the size of the lipocyte, the metabolic rate, the site of removal or washing and stabilizing agents are important in the application of fat transplantation remains unclear. Similarly, no one has yet defined the most amenable sites for transplantation. Controversy regarding longevity still exists, as well as controversy regarding the practice of freezing fat for subsequent use. The viability of fat cells that have been frozen and thawed has been questioned.[10] Fat is biocompatible and safe, non-detectable as a separate entity (natural appearance), predictably stable, convenient and these are the factors, which makes fat as an ideal soft tissue substitute. Ellenbogen states that, "with all the fat tissue being discarded in present day surgical procedure and all the aesthetic defects secondary to subcutaneous tissue loss, free fat should be considered as a replacement".[11,12]

The objective of this study was to study the role of fat transplantation (injection) for localized deformities in the face and to determine the short and intermediate term survival and efficacy of transplanted fat and based on the incidence of complications and sequelae, to determine whether this technique is a reasonable method for soft tissue augmentation.

History and review of literature

The Meulene V described the use of fat in human auto transplantation for the first time. The first use of free fat auto grafts in human was by Neuber. Neuber only used sufficient to fill the defect and reported excellent aesthetic results. He had less success when he tried to use larger grafts, saying that, "grafts larger than an almond would not give good results.[13,14]

Use of free fat auto grafts to the face

- Lexer reported in the first use of fat plasty applied for support.
- Ellenbogen reported preliminary results in the use of free pearl fat auto grafts to correct pitting acne, post traumatic defects, nasolabial folds, 'marionette mouth', facial atrophy, facial wrinkles, depressed scars and eyelid depressions, as well as in chin augmentation. These auto grafts or 'pearls' were 4 to 6 mm in diameter.[13]

Use of free fat auto grafts in repair of breast defects and micromastia

- First reported use of fat in breast reconstruction was a celebrated case by Czerny.
- Free fat auto-transplantation, for the treatment of micromastia was reported by Schrocher.[13]

Other uses of free fat auto transplantation

- Orthopedic surgeons have used auto grafts of free fat to fill bony defects that were both osteomyelitis and aseptic in nature in the treatment of joint ankylosis.
- Neurosurgeons have used free fat auto grafts in the treatment of defects of the skull, dura and brain. Auto grafts also have been used to surround nerves and neurolysis.
- Thoracic surgeons have used free fat auto grafts in the treatment of chest wall defects, pleural defects, and pulmonary conditions.
- ENT surgeons have used fat auto-transplants in the treatment of eye enucleation, chronic frontal sinusitis, defects after mastoid surgery, cosmetic defects of the ear and deafness.
- General, genitourinary and pelvic surgeons have used fat grafts for intra-abdominal parenchymal hemorrhage, peritoneal adhesions, abdominal wall defects and genitourinary tract defects.
- Other uses have included free fat grafts after tenolysis, perinovaginal wounds, post prostatectomy defects, cleft palate, a depressed scar, oronasal and oroantral communications and sub dermal augmentation.

Evolution of behavior of autogenously free fat transplants

The transplantation technique underwent development from transplanting fatty tissue en bloc, to manually excised and prepared 4 to 6 mm large 'pearls' of fat, and finally to be tissue suspension obtained by manual power of vacuum machine assisted suction. The hypothesis is that aspiration with lower negative pressure causes lesser trauma to the fat cells and therefore should be used for fat harvesting.[13]

Lexer believed that manipulation and tearing of the graft at the time of transfer would cause a greater degree of graft shrinkage. He believed that careful preparation of the implantation bed and immediate careful transfer would give optimal results. Kanavel felt that graft survival was enhanced by not using sutures to secure the graft, careful hemostasis and asepsis at the implantation bed. Lexer in his inclusive review in concluded that adipose tissue grafts and fascia fat grafts could be useful in a wide variety of reconstructions. He condemned the use of multiple small grafts over large grafts because he felt that small grafts would turn to scar while larger grafts would remain fatty tissue.

Neuh of believed that fat transplants acted generally like bone grafts in which the autogenous adipocytes of the graft would die and be totally replaced by either newly formed host adipocytes or host fibrous tissue. Green reported the use of fat and fascia-fat auto grafts in the treatment of osseous defects secondary to osteomyelitis.

He thought that transplanted fat would 'turn to' connective tissue and then to bone, closing the defect.

In a landmark article, Wetheimer and Shapiro reported that fat develops from very primitive adipose cells and the structure of the cells and tissue is much like that of the fibroblasts of the connective tissue. This concept was revolutionary and discredited the older viewpoint that fat tissue was simply connective tissue in which fat is deposited. Peer stressed that survival was dependent on early neo vascular anastomosis and he felt attached dermis might facilitate this vascular nutrition. He stated that, "an average of 50 % of the adipose cells in free fat auto genous grafts survives."

Fournier focused attention on the reductionist model of autologous fat grafting utilizing common hand-held syringes to both harvest and reject fat. Illouz, who fathered the technique, believes that the fascial area offers the best chance of success for free fat injection.

Current cosmetic surgical interest in the phenomenon of autologous fat grafting is closely related to the development of liposuction surgery.[14]

Indications for autologous fat transplantation

Indications have been excellently reviewed and put down on paper by Skouge and Berdeguer.

Table 1: Skouge indications for fat transplant.[15]

Facial	Cosmetic	Scars	Nonfacial
Aging changes	Lip augmentation	Traumatic	Rejuvenation of hands
Melolabial grooves	Chin augmentation	Lipoatrophic acne	Body contour defects
Central cheek depression	Malen augmentation	Idiopathic lipodystrophy	Depression
Subcommisural depression		Facial hemiatrophy	Liposuction induced
Flattened upper lip			Breast enlargement
Glabella			Traumatic scars
Diffuse age related lipoatrophy			

Table 2: Berdeguer indications for fat transplant.[16]

Depressed scars	Aging skin with loss of supportive tissue	Aesthetic enhancement	Congenital defects
Face and body	Glabellar furrows	Cheek augmentation	Hemifacial atrophy
Post-surgical	Upper lip	Chin augmentation	Soft tissue defect
Post-traumatic	Melolabial folds	Leg contour surgery	
	Hollow cheeks		
	Dorsal hands		

Best candidates for fat injections are the individuals with scarring, sagging, or wrinkling on the face. Candidates, who are missing some of the youthful plumpness or high contours on the face, can also be subjected to fat injections. Similarly, subjects in good physical health, psychologically stable and wanting to improve their appearance are eligible for this procedure. Also the candidates, who are realistic in their expectations as well as those who are aware of their options can be subjected to fat transplants.

Principles of autologous fat transplantation

Mccurdy analyzed fat cell survival and concluded that the technical factors to accomplish the goal of 40-50% transplanted adipocyte survival includes various factors including the low vascularity of donor site, high vascularity for recipient site. Similarly, low pressure technique of aspiration of fat along with filtering and washing harvested adipocytes also constitute the principles of autologous fat transplantation. Use of >2mm cannula for injection to minimize adipocyte injury, multilayered deposition of fat and over-correction of recipient site are also the important principles.[17] Because of the problem of resorption of fat with fat transplantation 30-50% over injection is ordinarily used. Assadi determined that sub dermal injection is important for long-term results.[18-23]

Case series

Ten patients were subjects for autologous free fat transplant for various indications. Similar a complete follow-up was kept and the complications and the results were noted. Also the record of the operative details including the amount of fat injected and the site of fat injection, which is the recipient site along with the donor site were all noted. Also the satisfaction of the surgeon and the patients were also recorded.

Table 3: Indications for Autologous free fat transplant in our series.

Case no.	Indications			
	Congenital	Post traumatic	Disease related	Age related atrophy
1	-	-	Right cheek Morphia	-
2	Treacher Collin's Syndrome	-	-	-
3	Right hemifacial Microsomia	-	-	-
4	Treacher Collin's Syndrome	-	-	-
5	-	-	-	Age related Atrophy
6	-	Facio-maxillo injury	-	-
7	-	Facio-maxillo injury	-	-
8	-	-	Romberg's disease	-
9	-	Facio-maxillo injury	-	-
10	-	Facio-maxillo injury	-	-

Table 4: Master Chart showing the cases, location of fat transplant, complications and results.

Case no.	Age	Sex	Location of defect on face	Volume of injected fat (cc)	Donor site	Maximum follow up months	Complications		Results		
							Recipient site	Donor site	Patient satisfaction	Surgeon satisfaction	Rough % fat
1	18	F	Right cheek	12	Abdomen	1	Oedema	-	Good	Satisfied	20
2	28	F	Left cheek +Right infraorbitl	15	Abdomen	25	Overcor-rection+Oedema	-	Excellent	Satisfied	Minimal
3	19	F	Right hemiface	15	Abdomen	21	Bruisin+Oedema	Tenderness	Good	Satisfied	40
4	20	F	Bilateral cheek + Zygomatic	70	Abdomen	14	Oedema	-	Poor	Unsatisfied	70-80
				50	Upperlateral thigh		Oedema	-	Fair	Unsatisfied	50-60
				45	Gluteal		Oedema	-	Good	Satisfied	30
5	38	F	Right cheek	5	Abdomen	12	Oedema	Tenderness		Satisfied	20
6	25	M	Left cheek + Zygomatic	10	Abdomen	1	Oedema	-	Good	Satisfied	20
7	24	M	Left cheek + Zygomatic	10	Abdomen + Gluteal	9	Oedema	-	Good	Satisfied	20
8	21	M	Left cheek	38	Upperlateral thigh	1	Oedema	-	Good	Satisfied	40
9	27	M	Right side forehead + Zygomatic +Infraorbital+ Upper eyelid+ Glabellar	42	Abdomen	1	Fat graft pouting from injection puncture site+Oedema	Contour irregularity + pain	Good	Satisfied	30
10	26	M	Right forehead + Chin	18	Upperlateral thigh+Gluteal	1	Oedema	-	Good	Satisfied	30

A and B; post trauma-malar deformity correction (pre-operative and post-operative), C and D; hemifacial microsomia (pre-operative and post-operative), E and F; free fat graft (pre-operative and post-operative), G and H; post trauma-forehead and malar deformity (pre-operative and post-operative), I and J; romberg's disease (pre-operative and post-operative), K and L; treacher collins syndrome (pre-operative and post-operative).

DISCUSSION

Autogenous fat transplantation is defined as the heterotopic transfer of fat cells along with their stromal tissues either by free adipose tissue transplantation, dermis fat graft-(transplantation of adipose tissue with dermal tissue as a carrier) or transplantation of adipose tissue with micro vascular free tissue transfer technique.

Figure 1: Photographs of the patients (pre-operative), (intra-operative) and (post-operative).

Fate of free fat

Microscopic behavior of Free Fat Auto transplants

In the first 4 days after transplantation there is an extensive host cellular infiltration of the graft involving polymorph nuclear cells, plasma cells, lymphocytes and eosinophil's. Within the vessels of the graft, red blood cells are clumped together and white blood cells are in the process of diapedesis. The endothelial cells, the fibroblasts of the stroma and the adipose cells of the graft show little or no signs of degeneration.[13]

On the fourth day, although the larger vessels are still collapsed, there is an engorgement and dilatation of smaller stromal vessels with abundant red blood cells, while white blood cells continue to be diapeditic. This signifies that anastomoses have occurred between smaller graft vessels and the red blood supply. The cellular infiltrate now shows an increased number of eosinophil's and often, foreign body type giant cells.

Marchand believed that two types of cells participated in this proliferation. The first being the proliferating adipose cells of the graft and secondly the host round 'histiocyte like' cells that took up lipid and enlarged. He believed that in transition these two types of cells could not be distinguished.

From fourteenth to twentieth day the same general processes occurs. There is further adipose cells breakdown and increasing numbers of large host histiocytes appear to be picking up lipid with formation of droplets within their cytoplasm.[24]

Neuhof transplanted iliac crest subcutaneous fat into a bronchopulmonary defect and looked at the graft after 22 days; he found the graft healing well with no signs of necrosis. He states, "One may have to change one's viewpoint as to degeneration and disappearance of the graft."[25]

Between 30 and 60 days, the number of large histiocytes increased and reached a peak at 2 months. These cells had scavenged lipid and coalescing fat globules in their cytoplasm.

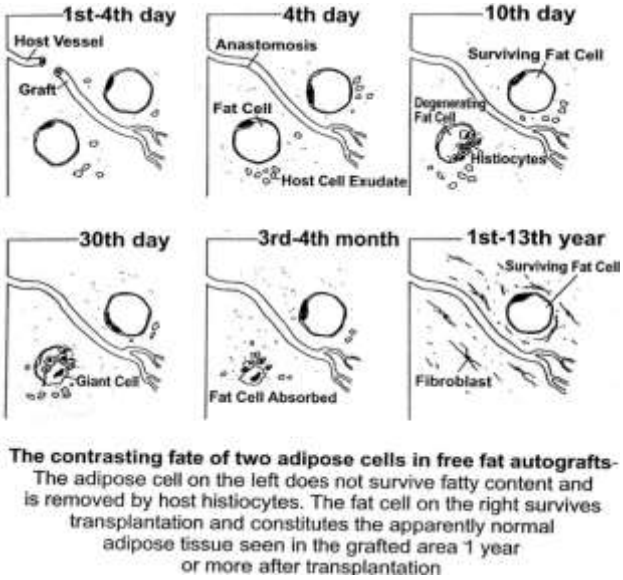

Figure 2: Fate of adipose cells in fat transplants.

Fat Survival Theories

Fat survival theories, basically comprises of two schools of thoughts-'the host replacement theory' and 'the cell survival theory'. 'The host replacement theory' proposed that the histiocyte would take on lipid material and eventually replace all adipose tissue of the graft, which had disappeared. 'The cell survival theory' proposed that the histiocyte act only as scavengers of lipid and do not replace the graft adipose tissue. It is latter cell survival theory that in recent years has been more popular hypothesis. The key points of the theory of fat survival are (a) fat is a dynamic tissue and (b) 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. Hausberger presented the theory that is the 'preadipocytes', or mesenchymal adipose cell precursors, that are destined to become mature adipose cells. Clark and Clark reported that fat storage was dynamic and was a cyclic deposition and removal of lipid from the large fat droplets within adipocytes. It was believed that the amount of dietary fat stored was directly dependent on the amount of fat in the diet. [13]

In our series of 10 cases, male to female ratio was 1:1, with the commonest indication of fat injection in male patients being post-traumatic facial soft tissue and

skeletal deformity (comprising of 40% of the cases). The majority of female patients were willing for fat injection due to congenital facial deformity (30%), which included 2 cases of treacher collins syndrome and 1 case of right hemi facial macrosmia. We had 2 case disease related facial soft tissue deformity involving right cheek morphia and age related atrophy. The least common indication was age related atrophy (10%).

We harvested fat commonly from the abdominal region in 70% cases and more than one site in 20% cases. The minimum amount of fact injected was 5 cc in age related atrophy case whereas maximum amount of fat (70 cc) was injected in case of treacher collins syndrome. In 40% cases we injected 11 to 20 cc of fat.

A resorption rate of approximately 50% can be expected within the first 6 months. Resorption rates between 30% and 60% have been reported in the literature.[15,26] In our study, we observed that 90% of our patients have 40-50% of fat resorption, which is consistent with the above studies. Some authors have reported success rate with needle transplantation of fat from 0% to 100%. Peer state that "an average of 50% of the adipose cells in the free fat autogenous graft survives".[27-30] Niechajev I et al had found that fat absorption slows down after approximately 2 years and (usually) after that, 40% to 50% of the original volume of fat is retained.

This fat is revascularized and is susceptible to the volume changes after general weight gain by the patient. This confirms the earlier observations of Peer that free autogenously fat grafts may usually increase in size if the patient takes on increase in adiposity that affects the particular system from which the graft was taken.[31-32] Similarly, in our study the longest follow up to the date is 25 months, and following the expected postoperative resorption, no further loss of injected fat has been observed. On palpation, the feel of the fat is normal, and facial expression is also good.

The complications have been relatively minor in our cases. We encountered postoperative edema of recipient site (100%) in all our patients, lasting for several days. Ice compression appears to help in its settling down. The fat in the recipient site can be temporarily uneven or lumpy. But this fades over the first few days as general edema subsides. There was very minimal fat resorption in one case Treacher Collins syndrome and the patient and now patient complaints of persistent fullness over the injected site. One of our patients (Treacher Collins syndrome) developed signs of hypocalcaemia on 5th postoperative day of her third sitting of fat injection. In the case of facio-maxillary injury there was pouting of fat graft with its partial loss through injection puncture site of injection at recipient site on right upper eyelid. There was no infection in any of our patients, which is consistent with findings of Glogau RG.[10]

Skouge felt that fat cells from an area of relatively poor vascularity will be hardier, have decreased metabolic needs and increase survival.[15] In our patients, we harvested fat most commonly from the abdomen (70%) and more than one site in 20% cases, which is in contradiction to the study done by Asken who stated that more fibrous areas, such as upper abdomen, are not ideal for donor sites.[33]

The major problem with fat transplantation and injection is its unpredictability. The variables affecting graft survival have not yet been identified, and may be as diverse as body type, gender, specific anatomic donor area, harvesting method (high versus low vacuum, cannula versus syringe, 'open versus 'closed' system, etc.), composition of anesthesia, morbidity of recipient site, dietary influence (weight gain/loss), and so forth.[10] Certainly when the graft takes, the results can be gratifying; long term studies debate the ultimate fate of the fat graft. While fresh fat can often produce dramatic results, aesthetically the appeal of the fat remains-it can provide broad contouring that is soft and natural, which is difficult to achieve by any other means at present.

CONCLUSION

Although, the autologous free fat injection is an age-old method of improving aesthetic of face, it has been a neglected subject in recent years. It provides cosmetically significant correction for many filling defects. It is relatively easy to perform and results in very few complications. It is a safe and effective procedure. The lack of predictability however remains a major problem for the acceptance of this surgery. Certainly, when the graft takes, the results can be gratifying; long term studies debate the ultimate fate of the fat remains-it can provide broad contouring that is soft and natural, which is difficult to achieve by any other means at present.

The ideal soft tissue replacement material has not yet been found as far as immunology and an unlimited supply of donor sites are concerned, autogenously adipose tissue is the most appropriate and natural replacement material and is the ideal material. Unfortunately with present techniques its use has been disappointing and longevity of results is varying significantly from patients to patients. More studies have to be done so that we better understand the metabolism of fat and how we can treat it so that it can last longer in all patients.

Results of free fat auto-transplantation were found to be quite unpredictable, with wide variations in the resulting bulk of the graft but still autologous free fat transplantation has many potential advantages over other methods of soft tissue and bony augmentation for small to moderate sized defect. Though the results of this study were fairly satisfactory both from the patient's and the surgeon's point of view, the number of cases is too small to draw any definite conclusions about its long term

usefulness. In addition, the period of follow-up was fairly limited, again limiting the detailed evaluation of the long term fate of free autologous fat transfer.

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