2.1 Introduction

The survival of free fat used as an autograft is operator dependent and requires delicate handling of the graft tissue, careful washing of the fat to minimize extraneous blood cells, and installation into a site with adequate vascularity.

There is evidence that fat cells will survive and that filling of defects is not from the residual collagen following cell destruction. There is some loss of fat after transplant, and most surgeons tend to overfill the recipient site.

2.2 Historical Review

Verderame (1) reported that autogenous fat grafts in ocular surgery became reduced in size and advised the use of a larger transplant than that seemed necessary to fill the defect. Lexer (2) claimed that manipulation and tearing of the graft at the time of transfer would cause a great degree of graft shrinkage. Kanavel (3) felt that graft survival was improved by not using suture to secure the graft, careful hemostasis, and aseptic technique. He transplanted sheets of fat varying from 0.25 to 1 in. in thickness to prevent adhesions and contractures and lessen deformity of tendons, nerves, blood vessels, and joints. He felt that fat can be transplanted into any ordinary field with the assurance that it will not act as a foreign body. Clinically it appears to live, become a part of the structure in which it is placed, and persists for many months and probably years. Davis (4) concluded that omentum, transplanted freely beneath the skin in a mass, 1 in. in diameter, maintains the greater part of its bulk. Lexer (5) reported excellent clinical results with very large fat grafts but stated that up to 66% of the fat autografts were absorbed and significant overcorrection should be used. He stated that multiple small grafts would turn to scar, while larger grafts would remain fatty tissue. Mann (6) performed free transplant of omentum fat and stated that it remained seemingly viable for as long as 1 year and retained a small percentage of its fat.

Neuhof (7) examined available experimental and clinical evidence and concluded that:

1. Transplanted autologous fat undergoes practically some changes as transplanted bone.
2. The transplant dies and is replaced either by fibrous tissue or by newly formed fat.
3. Newly formed fat occurs through the activity of a large wandering histocyte-like cell, which takes on fat and becomes a fat cell.

Guerney (8) noted that autogenous fat grafts should be transplanted in larger bulk than required since only 25–50% of the graft survives 1 year after transplantation. He studied transplanted, 1.7 mm³ (average size), fat grafts over a period of 12 months in rats and concluded that:

1. Liberation of fat by contiguous cells probably gives rise to fatty cysts.
2. Phagocytosis of liberated fat was assisted by polymorphonuclear leucocytes.
3. The percentage of normal fat in any surviving graft gradually increased throughout the year.

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4. A certain portion of the transplanted tissue gained an adequate blood supply early and continued to survive, while the remainder of the graft degenerated and was gradually eliminated from the site of the implant without evidence of gross scar.

5. Crushed grafts eventually disappeared attesting to the devastating effect of trauma on the vitality of a graft.

6. Single pieces of fat remain viable for at least 1 year, while grafts of a similar size cut into smaller pieces may last as long as 6 months, but the majority disappear by the third month.

7. Absolute hemostasis is essential since even a slight hemorrhage jeopardizes the viability of the graft.

8. Although slight infection results in only a small loss of tissue, gross infection leads to a loss of the whole graft.

9. Phagocyte cells do not use their fat to form new fat cells during the first year after transplantation.

Hilse (9) showed histologically that free fat transplants regenerate fatty tissue without any exception. He referred to the histocyte filled with fat as a “lipoblast.” Green (10) used fat and fat-fascia autografts in the treatment of osseous defects secondary to osteomyelitis. He presumed that transplanted fat would become connective tissue and then bone, closing the defect.

Wertheimer and Shapiro (11) studied fat physiology and determined that fat develops from primitive adipose cells the structure of which is like that of the fibroblasts of connective tissue.

Peer (12) implanted autogenous fat (single piece compared to a piece cut into 20 segments) into the rectus muscle. Grafts were removed at intervals from 3 to 14 months. Grossly all grafts were surrounded by a connective-tissue capsule and, upon sectioning, the bulk of the graft contained fatty tissue. Single grafts (the size of a walnut) lost 45% of their weight while multigrafts lost 79% of their weight. He concluded that the fat grafts appeared like normal fat tissue 1 year or more after transplantation.

Bames (13) noted that circulation in grafts is established in about 4 days after transplantation by anastomosis between the host and graft blood vessels. Traumatized fat grafts lose much more weight and volume than gently handled transplants (50% loss after 1 year). Normal appearing adipose cells were present in all the transplants. Dermal-fat grafts provide a readily available transplantation material for establishing normal contour in small breasts instead of foreign implants.

Hansberger (14) proposed that histocytes phagocytose the lipid and do not replace graft fat. After the graft of mature autotransplanted fat goes through initial ischemia, fat cells either necrose or dedifferentiate into immature cells. Under suitable conditions, the immature fat cells revert to mature adipocytes.

Schorcher (15) reported using autogenous free fat transplantation to treat hypomastia. He noted that the connective elements remained intact with fat shrinkage to 25% of the original size by 6–9 months. He believed that if the graft was in several pieces, it would receive better nourishment from the recipient site.

Van and Roncari (16, 17) demonstrated conversion of adipocyte precursors into adult adipocytes, both in vitro and in vivo, in rats. Saunders et al. (18) studied fat autograft survival and observed initial adipose tissue breakdown followed by revascularization. There is early breakdown of fat cells with formation of cyst like lipid deposits and infiltration by host histocytes.

Illouz (19) opined that the human body is an excellent culture medium and that the fat cells apparently survive by intercellular lipolysis and osmosis until they are revascularized. The area to be augmented should be over corrected by 30% because approximately 30% necrosis of fat cells results when using the wet technique.

Illouz (20) reported that fat transplantation in one patient biopsied 9 and 16 months later, showed normal fat cells.

Asken (21) found that 90% of fat extracted by liposuction appears viable, assuming it is not traumatized either by handling or by high suction pressure. Damage incurred by the adipocytes is inversely related to the diameter of the instrument used for harvesting and injection.

Campbell et al. (22) noted, both morphologically and biochemically, that adipocyte integrity and metabolism remain intact when subjected to liposuction. Johnson (23) examined liposuctioned fat and noted that 90% or more of the fat cells remained viable. He found that there was 75–85% of original fat present 3 months after transplantation. Agris (24) claimed that trauma and desiccation injured transplanted fat cells. Bircoll (25) stated that the ASPRS report (26) of 30% survival and Peer’s report (27) of 50% survival of autologous fat transplantation were based on the older technique of bulk fat transfer. Biopsies show 80% survival of fat after 1 year and an additional bulk of 10–20% of fibrous tissue. Fat transplants must be placed into the fatty subcutaneous tissue.

Billings and May (28) analyzed the histology of free fat grafts and noted the following:
Markman (29) has suggested that the number of fat cells may increase, through differentiation of existing preadipocytes, when fat cells reach a “critical size.”

Illouz (30) reported that fibroblast-like precursor cells are able to multiply and give rise to fibroblasts or cells that resemble fibroblasts. When these cells are stimulated to absorb fat vacuoles with insulin or dexamethasone, they do not become adipocytes. He noted that adipocytes are very fragile and have a short life span outside the body. The cells live longer if mixed with normal saline and kept at a moderate temperature. They do not tolerate excessive manipulation, refrigeration, or major trauma such as grinding.

Hudson et al. (31) demonstrated a greater cell size and lipogenic activity (using measurement of activity of lipogenic enzyme adipose tissue lipoprotein lipase [ATLPL]) in the gluteal – femoral area compared to the abdomen. Facial fat was found to have small cells with almost no ATLPL activity. This may have implications for donor site suitability.

Nguyen et al. (32) compared suctioned fat, aspirated fat, and excised fat 9 months after implantation. Suctioned fat was obtained by using 1 atm negative pressure and on microscopy, only 10% of the fat cells were found with intact cell membrane. In all the grafts, fat was replaced with fibrosis, and only a small number of surviving adipocytes were still present.

Kononas et al. (33) compared the loss of fat following transplant between surgically excised fat cut into small pieces and suctioned fat which was centrifuged. Weight loss was 59% for excised fat and 67% for suctioned fat. Ersek (34) used a wire whisk to agitate harvested fat and then strained it. He reported disappointing results even with repeated injection and concluded that little, if any, autologous fat survives in its new site.

Courtiss et al. (35) reported marginal success in fat grafting of two patients with postliposuction depressions. Asaadi (36) reported 5-year successful retention of fat transplanted to a right trochanteric post-traumatic depressed scar.

Samdal et al. (37) measured blood flow and the amount of surviving fat following needle abrasion of the recipient site in rats. Abrasion was performed by a criss-cross pattern with 20 strokes using an 18 gauge needle in the subcutaneous tissue prior to transplant and compared this to controls without abrasion. They found that the mean weight of the fat transplant had shrunk to 44.6% of the original weight in the abraded group and 33.5% in the control group. The mean blood flow in fat was 0.165 mL/min/g in normal fat, 0.120 mL/min/g in the controls, and 0.187 mL/min/g in the abraded group. Microscopic examination of the transplanted fat varied from oil cysts, connective tissue, and inflammatory cells in some specimens and completely normal fatty tissue in others. Fat survival varied from 0–90%. They concluded that fat transplant survival was unpredictable.

Eppley et al. (38) reported that the addition of basic fibroblast growth factor delivered by dextran beads to fat grafts results in a larger weight maintenance of fat at 1 year than controls.

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>Histology</th>
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<tr>
<td>First 4 days</td>
<td>Cellular infiltrate: polymorphonuclear cells, plasma cells, lymphocytes, eosinophils</td>
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<td></td>
<td>With vessels of graft: red blood cells were clumped together, white blood cells were in the process of diapedesis (passage of blood cells through intact vessel walls)</td>
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<td></td>
<td>No degeneration of graft endothelial cells and fibroblasts of the stroma</td>
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<tr>
<td>Fourth day</td>
<td>Engorgement and dilatation of smaller stromal vessels with abundant red blood cells and diapedetic white blood cells (anastomoses between smaller graft vessels and host red blood supply). Increased number of eosinophils in cellular infiltrate. Foreign-body type giant cells often seen</td>
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<tr>
<td>10 days</td>
<td>Areas of necrotic adipose tissue. Regenerative proliferation of original fat cells mostly at periphery of lobules – includes proliferating adipose cells of the graft and host round “histocyte-like” cells that took up lipid and enlarged 14–21 days.</td>
</tr>
<tr>
<td></td>
<td>Further adipose cell breakdown.</td>
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<td></td>
<td>Increasing number of large host histocytes that appear to be picking up lipid with formation of droplets within their cytoplasm</td>
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<tr>
<td>30–60 days</td>
<td>Increasing numbers of large histocytes which peak at 2 months. Coalescing of fat globules in the cytoplasm</td>
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<tr>
<th>Group A</th>
<th>Fat alone</th>
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<tr>
<td>Group B</td>
<td>Fat with dextran beads</td>
</tr>
<tr>
<td>Group C</td>
<td>Fat with dextran beads soaked with cytochrome C (nonmitogenic control solution)</td>
</tr>
<tr>
<td>Group D</td>
<td>Fat with dextran beads soaked with basic fibroblast growth factor</td>
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Histologically, he noted extensive interlacing collagen formation between the adiposites that provide support for the known effects of basic fibroblast growth factor on mesenchymal cell lines. There was an increased uniformity in adipocyte size seen in 1 year grafts compared to 1 month grafts which may indicate a possible maturation of these more “immature” cells. Whether this represents repair of damaged adipocytes, preadipocyte differentiation, conversion of infiltrating macrophages or fibroblasts, or entrapped lipid material is speculative.

Carpaneda and Ribeiro (39) examined fat 2 months after transplantation and noted viable tissue only in the peripheral zone of 3.5 mm diameter cylindrical grafts. There was 60% loss of grafted tissue which occurred closer to the center. They reported, in 1994 (40), that graft viability depends on the thickness and geometric shape and is inversely proportional to the graft diameter if the diameter is greater than 3 mm. The maximum percentage of viability is 40% when the graft is no greater than 3.0 mm thick.

Niechajev and Sevchuk (41) reported 50% fat survival over 3.5 years after single fat transplantation with 50% overcorrection. They found that fat obtained under maximum negative pressure (−0.95 atm) results in partial breakage and vaporization of the fatty tissue. About two-thirds of the fat withstood the trauma of aspiration. Low pressure (−0.5 atm) resulted in smaller cell size (29% smaller than with aspiration at −0.95 atm) and they assumed that high pressure causes mechanical dislocation of the adipocytes which increases the risk of and sometimes causes cell breakage.

Courtiss (42) stated that fat grafting remains controversial and poorly understood and that “some surgeons have some impressive results, but most of us have many disappointing results.” Fagrell et al. (43) examined fat 6 months after implantation in the ears of rabbits. The fat implanted was obtained by:

1. Fat cylinder retrieved with 4.5 mm internal diameter syringe pushed into the fat and pulling the piston back.
2. Excised fat, 1 mg in weight.
3. Aspirated fat using 2 mm (14 gauge) cannula and syringe.

The tissue was examined by light microscopy and computer-assisted image analysis. There was no difference between the weight of the 6 month excised specimen (no weight loss) between the fat cylinder and excised fat, but there was a 59% loss of weight of the aspirated fat. The conclusion was that fat aspiration is traumatic and breaks up the cells. However, there was histologic evidence of viable fat cells in all transplants.

Jones and Lyles (44) harvested fat with a 60 mL syringe, 3.0 mm pyramid cannula, and locked the plunger at 35 mL. The harvested fat was washed three times with normal saline and gently agitated. Cell cultures were prepared and maintained for 1 day to 2 months. Microscopy disclosed maintenance of mature adipose cells without dedifferentiation into a precursor phenotype. There was very little evidence of cellular damage or debris.

Using photographs over a 6 year period of time, Coleman (45) demonstrated long-term survival of liposuctioned fat transplanted into the nasolabial fold. He stated that fat can migrate as the pressure of excess tissue forces the transplanted fat to shift and that fat can die from inadequate nutrition and oxygen from competition with other transplanted parcels of fatty tissue. Placement of fat into multiple tunnels allows closer location to nutrition. He concluded that fat survival is technique dependent and the primary reason for failure of long-term correction of the nasolabial fold is initial inadequate correction.

Sattler and Sommer (46) found that autologous fat, dried over sterile swabs and frozen at −20°C (lower temperatures down to −70°C are preferable) up to 2 years and then thawed at room temperature, contains only fat cells and no fibrous debris.

Ullmann et al. (47) added Cariel, a modified serum-free cell culture medium (MCDB 153), to aspirated human fat prior to reinjection into mice. Cariel contains essential and nonessential amino acids, vitamins, inorganic salts, trace elements, buffers, thyroxin, growth hormone, insulin, and sodium selenite. There was 46% of the weight of the fat remaining after 15 weeks in the group with Cariel compared to 29% in the control without Cariel. They concluded that the addition of nutrients enriched with anabolic hormones enabled the survival and take of more adipose cell in the graft. United States Patent (Lindenbaum) Composition and methods for enhancing wound healing. Patent No. 5461030. Date of patient: 24 October 1995.

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<thead>
<tr>
<th>Group</th>
<th>Weight retention after 12 months (%)</th>
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<tbody>
<tr>
<td>A</td>
<td>48.8</td>
</tr>
<tr>
<td>B</td>
<td>79.6</td>
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<tr>
<td>C</td>
<td>75.2</td>
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<tr>
<td>D</td>
<td>93.8</td>
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References