Fat Grafting to Improve Results of Facelift: Systematic Review of Safety and Effectiveness of Current Treatment Paradigms

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Abstract

Background: Autologous fat grafting is a helpful supplement to facelift surgery that helps to combat age-related volume loss of facial structures. Despite the widespread prevalence of combined facelift and fat-grafting, significant procedural variation exists between providers.

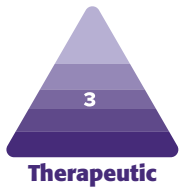
Objectives: The primary purpose of this systematic review was to study the efficacy and complication rates of facelift with lipofilling compared with facelift alone.

Methods: A systematic review of the Cochrane Library and MEDLINE databases as completed was undertaken to identify all clinical reports of fat grafting combined with facelift surgery based on the following key terms: ("fat grafting" OR "lipotransfer" OR "lipofilling" OR "fat transfer") AND ("facelift" OR "rhytidectomy" OR "SMASectomy" OR "facial rejuvenation"). Data on techniques, outcomes, complications, and patient satisfaction were collected.

Results: The systematic review was performed in April 2017. In total, 248 articles were identified for review. After application of exclusion criteria, 15 primary studies were included in this review. Various facelift techniques were reported, including deep-plane or sub–superficial musculoaponeurotic system (SMAS) facelift, SMAS facelift, modified minimal access cranial suspension lift, component facelift, midface lift, SMAS plication, SMAS-stacking/SMASectomy, and SMASectomy. The most common locations of fat graft injection included the nasolabial folds, tear troughs, temporal regions, midface/cheek/malar eminence, marionette groove, lips, and ear lobes. The addition of fat grafting to facelift surgery resulted in significant improvements in facial volume and aesthetic assessments.

Conclusions: Combined facelift and fat grafting is a safe and efficacious means to simultaneously address age-related ptosis and volume loss. Further research is required to validate and improve existing treatment modalities.

Level of Evidence: 3



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Facial aging is a dynamic, multifactorial process that reflects the combined effects of decreased skin elasticity, loss of subcutaneous tissue volume, and underlying bone resorption.[1] Loss of subcutaneous fat plays a major role in creating aesthetic disharmony in the aging face. However, the human face does not age uniformly. The recent identification of multiple, distinct compartments of fat in the face has greatly affected the understanding of facial aging.[2-5] Through these anatomic studies, it was revealed that there is not one large confluent mass of subcutaneous fat in the face, but rather multiple distinct compartments. Ptosis and atrophy of these compartments combined with the aging of skin, connective tissue, and bony structures of the face create a dynamic and complex process of facial aging.

In a youthful face, transitions between subcutaneous fat compartments are smooth. With aging, such transitions become more pronounced with abrupt contour changes occurring between these regions. Moreover, the ligaments of the face lose structural integrity with age.[6] These ligaments create a support system that suspends the midfacial fat compartments and attenuation of these retaining ligaments results in gravitational descent of facial fat. The visual stigmata of midfacial aging often corresponds to the areas of ligamentous attachment. Lambros[7,8] and Lambros and Amos[9] emphasized that age-related facial changes occur as a result of ligament laxity and volume loss.

Facelift surgery dates from the early part of the 20th century. These early facelift procedures were limited to skin excision without subcutaneous undermining and did not address the 3-dimensional aspects of facial aging.[10-14] Recognizing the limitations of the subcutaneous facelift, Aufricht[15] pioneered the concept of deep tissue plication. Further innovation occurred when surgeons began to transition from subcutaneous to subfascial dissection planes. Skoog first published descriptions of the subfascial facelift in 1974.[16] Mitz and Peyronie[17] later outlined a distinct anatomic subfascial layer known as the superficial muscular aponeurotic system (SMAS). Since then, SMAS-platysma facelifting, wide skin undermining, and extensive fat removal have gained worldwide popularity. However, even as the facelift procedure evolved to include wider undermining and SMAS manipulation, it was still primarily performed as a 2D procedure.

Soft tissue atrophy has gained acceptance as one of the most critical 3D elements of facial aging. Thus, the correction of volume loss has become an important component of facial rejuvenation treatments, particularly in the region of the midface. Fat grafting has been used successfully for soft tissue augmentation since 1893.[18] Autologous fat has been considered as an ideal filler for soft tissue augmentation because it is biocompatible, readily available, abundant, inexpensive, and can be harvested easily and repeatedly, with minimal trauma to donor sites. Coleman[19] first described a technique for 3D lipostructure; a safe, long-lasting method of filling and supporting the face with an intricate layering of infiltrated autologous fat. This method allows the tissues to be sculpted in order to achieve 3D augmentation of facial elements. However, a major limitation of fat grafting is that its initial take can vary widely from 30% to 80%.[20]

In recent years, a large majority of plastic surgeons have adopted fat grafting as an important supplement to facelift surgery.[21] However, little information exists in the plastic surgery literature regarding the safety, effectiveness, longevity, or complications of fat grafting combined with facelift. Thus, the purpose of this systematic review was to study the outcomes and complication rates of facelift with lipofilling compared with facelift alone.

METHODS

Search Strategy

The primary outcome evaluated in this review is aesthetic improvement of combined facelift with fat graft compared with facelift alone. Additionally, fat retention rates, and complication rates are evaluated. A systematic review of the Cochrane Library and PubMed databases from inception to September 2019 was completed to identify all clinical reports of fat grafting combined with facelift surgery based on the following key terms: (“fat grafting” OR lipotransfer OR lipofilling OR “fat transfer”) AND (facelift OR rhytidectomy OR smasectomy OR “facial rejuvenation”). Search limits were restricted to English-language articles. Animal studies, reviews, case reports, and studies on fat grafting for non–plastic surgery applications were excluded.

Article Selection

Titles and abstracts were reviewed to identify pertinent articles. The retrieved articles were then reviewed in their entirety and their reference lists were further reviewed for additional relevant publications. The initial review was conducted in May 2017 by authors M.S. and S.M., and a third reviewer F.M.B. collaborated in the review update carried in September 2019. The reviewers examined each qualifying article and disagreements were settled by consensus. Articles discussing outcomes or safety of combined facial fat grafting and facelift surgery were included. Articles without quantifiable data were excluded. The ROBINS-I (Risk Of Bias In Non-randomized Studies—of Interventions) was used to assess bias.

Data Extraction

Data extracted from articles included authors, date of publication, type of study, evidence level, number of patients,

surgical technique, fat harvest location and processing method, volume retention, investigator assessment, and complications.

RESULTS

A literature database search revealed 143 articles. Review of the references of these articles revealed 158 additional articles. These 301 articles were reviewed manually for relevance and any additional studies not captured by the initial search were included following bibliographic review. After application of the exclusion criteria, a total of 15 primary studies were included in this review for full-text reading, consisting of 9 retrospective studies, 5 prospective studies, and 1 comparative study.[22-36] No randomized controlled trials were found. The included studies were published between September 2006 and April 2017. According to the Oxford Center for Evidence-Based Medicine 2011 guidelines, the levels of evidence were III (3 studies), IV (11 studies), and V (1 study).

Fifteen studies involving 1116 cases were included in the systematic review and their characteristics are shown in Tables 1-3. The patients included in these studies were predominantly female aged 45 to 65 years old. Mean follow-up time varied from 3 to 61 months, with most studies specifying at least 3 to 6 months of follow-up as inclusion criteria for patient participation.

Four studies evaluated the aesthetic improvement achieved by performing fat grafting along with facelift, compared with facelift alone. Additionally, 5 studies evaluated aesthetic improvement of the fat graft and facelift surgery over no procedure. Six studies compared volume retention after fat graft to the face with facelift, although only 4 studies used objective measurements. Six studies reported complications and complication rates for the combination of fat graft and facelift surgery.

Aesthetic Improvement

In 2006 Pontius and Williams[22] published a retrospective chart review of 40 patients, comparing a randomly selected group of 30 patients who had undergone midface-lift without fat transfer with a group of 10 patients who received fat transfer in addition to a midface-lift. All included patients had complete photographic and medical records and at least 6 months of follow-up. The degree of aesthetic improvement was assessed by 3 independent blinded evaluators. A chi-square test for independence showed a statistically significant aesthetic improvement for fat-grafted nasolabial folds and tear troughs.

In 2011 Willemsen et al[23] conducted a retrospective chart review of 50 patients who underwent minimal access cranial suspension (MACS) lifting alone and compared their results with those of 42 retrospective cases of MACS lifting with adjuvant lipofilling. A t test showed that patients who underwent combined MACS lifting and lipofilling had better aesthetic outcomes than patients who underwent MACS lifting alone as determined by a photographic ranking system judged by a single-blind panel of 5 plastic surgeons and a single-blind panel of 5 medical students. They demonstrated significant improvements in the tear trough/nasojugal groove and the malar eminence; however, there was no significant difference between treated and untreated nasolabial folds.

Willemsen et al[35] conducted a retrospective review evaluating the effect of platelet-rich plasma (PRP) on recovery time and aesthetic outcome. They examined the results of 82 patients who underwent 1 of 4 procedures: fat grafting alone, fat grafting with PRP, MACS lift with fat grafting, and MACS lift with fat grafting and PRP. In addition to comparing self-reported recovery time, the authors evaluated aesthetic outcome via a questionnaire given to a panel of 10 plastic surgeons who judged aesthetic outcomes from randomized pictures of patients. The evaluators did not participate in the surgeries and were unaware of the treatment given to each patient. Thirty-seven patients who had 3-month follow up pictures where assessed for aesthetic improvement. The addition of PRP was noted to improve the aesthetic outcome of lipofilling and MACS lifting combined with lipofilling, and reduced recovery time for lipofilling alone.

In 2015 Pezeshk et al[24] published a retrospective chart review comparing 65 consecutive patients who had undergone rhytidectomy without lipofilling and 65 patients presenting who had undergone rhytidectomy with autologous fat transfer to the superficial compartments. The average follow-up was 1 year. The data were analyzed with a paired t test and statistically significant differences were found in pre- and postoperative Fitzpatrick Wrinkle Scale scores in both patients with concomitant fat grafting (average difference, 0.84; $P < 0.01$) and without fat grafting (average difference, 0.39; $P < 0.01$).[28] Patients who received autologous fat transfer to the superficial perioral compartments during a rhytidectomy had a 2 times more significant improvement in perioral wrinkles and cosmesis than those who did not.

Kappos et al[25] conducted a survey of patients who underwent facelifts with or without additional facial rejuvenation procedures and with or without lipofilling performed by a single surgeon. Thirteen patients underwent facelift without additional facial rejuvenation procedures and without lipofilling, and 26 had facelift surgery with additional lipofilling. The mean follow-up interval was 61 months. Patients were sent a FACE-Q questionnaire, a validated questionnaire developed to measure patient

Table 1. Summary of Collected Data

Study	No. of patients	Groups	Average age (years)	Location of fat harvest	Volume injected	Areas injected	Follow-up length	Metric	Volume retention	Investigator assessment
Kappos et al, 2017[25]	67	Group 1 (facelift alone): 13; group 2 (facelift + lipofilling): 26; group 3 (facelift + nonlipofilling rejuvenative procedure): 28	NA	NA	Mean = 15.31 mL (10.5-28.5 mL)	Cheeks, tear troughs, nasolabial and labiomandibular creases	Mean follow-up: 61 months (9-108 months)	FACE-Q	NA	Patients with facelift + lipofilling were significantly more satisfied in 3 subscales: overall facial appearance, aging appearance appraisal, and satisfaction with cheekbones vs facelift alone and facelift with any other nonlipofilling rejuvenative procedure
Kaye et al, 2016[32]	159	NA	59	NA	NA	NA	NA	NA	NA	The percentage of complications observed for the combined PAVE procedure was not higher than those reported in the literature for each treatment entity
Boneti et al, 2016[33]	25	NA	NA	Abdomen	15-31 mL	Nasolabial folds, marionette lines, upper and lower lips, chin creases, temporal hollows lateral zygoma, infraorbital rim	2 years	NA	"Excellent fat retention in the temples at 2 years"	Results showed excellent improvement in perioral, periorbital, and cheek rejuvenation
Hammoudeh et al, 2016[34]	130	Group 1 (facelift alone): 65;group 2 (facelift with ear lipofilling): 65	Medial thigh or central abdomen	NA	1 mL	Ear lobule	1 year	Three independent observers utilizing a customized numeric ear lobule volume grading scale	NA	Group 1 (facelift alone) mean pre/postoperative difference 0.2 ($P = 0.42$); group 2 (facelift plus ear lipofilling) mean pre/postoperative difference 1.02 ($P < 0.0001$)
Sasaki, 2015[30]	236	Group 1 (fat alone): 92;group 2 (fat/PRP): 106;group 3 (fat/SVF): 9;group 4 (fat/PRP/SVF): 29	Hip rolls and/or anterior abdomen	NA	10 mL	Deep medial cheek fat, medial suborbicularis fat, lateral subobicularis fat, superficial nasolabial fat, superficial medial fat)	1 year	Vectra 3D	12 months: group 1: 38.3 [12.9] mL; group 2 68.5 [39.5] mL; group 3: 72.9 [50] mL; group 4: 69.7 [35.2] mL	PRP, SVF, and PRP/SVF supplementation of processed fat resulted in significantly increased mean graft retention over baseline control at 12 months
Mailey et al, 2015[31]	9	NA	60 [6.7] (47-66)	NA	Total amount: 10-70 mL (mean, 36 [19] mL);temporalis region: 2-5 mL;glabellar region: 1-3 mL;buccal region: 3-7 mL;perioral region: 2-10 mL;supramental crease: 1-3 mL	Midface, lower face, neck	Median: 4.8 months	Vectra 3D	Positive volume changes: forehead, temples, and cheeks (median changes, 0.9 [4.3] mL, 0.8 [0.47] mL; and 1.4 [1.6] mL); negative volume changes: nasolabial folds, marionette basins, and neck/submental regions (median changes, −1.0 [0.37] mL, −0.4 [0.9] mL, and −2.0 [4.3] mL) midface: mean + 2.97 mL for the right and + 2.78 mL for the left);lower face: mean, −5.73 mLneck: mean, −4.75 mL	NA
Pezeshk et al, 2015[24]	130	Group A (rhytidectomy without fat transfer): 65; group B (rhytidectomy with fat transfer): 65	NA	Medial thigh or central abdomen	1-2 mL	Perioral superficial fat compartments	Average: 1 year	Photography, modified Fitzpatrick Wrinkle Scale	NA	Group A: average difference, 0.39 ($P < 0.01$); group B: average difference, 0.84 ($P < 0.01$)

Table 1. Continued

Study	No. of patients	Groups	Average age (years)	Location of fat harvest	Volume injected	Areas injected	Follow-up length	Metric	Volume retention	Investigator assessment
Gerth et al, 2014[29]	26	Puregraft vs centrifugation	55 [11]	Thigh or abdomen	Mean: 8.88 [3.78] mL	Cheek, inferior orbital rim	17 [6.8] months	Vectra 3D	Puregraft: 41.2% [24.4%];centrifugation: 32%;patients < 55 years (n = 12): 53.0%;patients > 55 years (n = 14): 31.1% (P = 0.01);without facelift (n = 19): 47.6%;with facelift (n = 7): 23.8% (P < 0.001)	NA
Willemsen et al, 2014[35]	Group I: 25;group II: 18;group III: 17;group IV: 22	Group I: fat grafting only;group II: fat grafting and PRP;group III: MACS-lift and fat grafting;group IV: MACS-lift, fat grafting, and PRP	35-65	Thigh	13-23 mL in each side of the face	Superficial planes: temporal region, crow's feet area, and anterior part of the cheek;deeper planes: malar eminence, suborbicularis oculi fat, tear trough, central part of the midface, nasolabial folds, marionette folds	3 months	Photography, visual analog scale	NA	The aesthetic outcome of groups II and IV was significantly better than that of groups I and III
Rohrich et al, 2014[28]	100	NA	NA	NA	Average: 2 mL per fat compartment;total average per face: 12 mL (range, 8-14 mL);nasolabial fold: average 2 mL fat per side	Deep malar compartments, nasolabial fold	At least 6 months	Photography; nasolabial fold scale;malar prominence scores	NA	Average lifting: 12.24%;average malar projection increase: 13.47%;the average nasolabial score for the 0 grade improved from 1.5% preoperatively to 21.5% postoperatively;average malar prominence convexity improved from 6% preoperatively to 28% postoperatively
Pallua and Wolter, 2013[36]	12	NA	66.75 [8.01]	Submental, jawline	Nasolabial folds: 1-2 mL per side;marionette grooves: 1-2 mL per side;upper lip: 2-3 mL	Nasolabial folds, marionette grooves, upper lip, lower lip, temporal area, midface region	3-12 months	Photography; transcutaneous Doppler imaging	Very stable, with only a slight decrease in volume	Skin quality scores: 1.45 [0.54] at 3 months and1.47 [0.69] at 12 months
Willemsen et al, 2011[23]	92	Group A (MACS lifting alone): 50 patients;group B (MACS lifting with lipofilling): 52 patients	50.8 (40-63)	Thigh (preferred) or abdomen	Between 13 and 23 mL	Superficial planes: lower lid/tear trough, temporal area;deep planes	6-46 months	Photography	NA	Combined MACS lifting and lipofilling yielded overall cosmetic results that were significantly better than the results achieved with MACS lifting alone
Swanson, 2011[26]	75	Patients who met study criteria: 71;controls: 4	NA	NA	NA	NA	NA	Photography	NA	Mean reduction in apparent age: 6.0 years (range, 0.8-14.2 years) vs no change for the control patients (P < 0.01);average reduction in apparent age after a facelift alone: 4.6 years;patients treated with fat injection looked 2 years younger on average (not significant)
Swanson, 2011[27]	5	NA	56.8 (42-71)	Medial thigh (preferred), abdomen, or lateral thigh	Right cheek: mean 9.1 mL (range, 4.0-12.0 mL);left cheek: mean 8.5 mL (range, 4.0-11.5 mL);all facial sites: mean 45.2 mL (range, 20.0-61.0 mL)	Nasojugal groove (tear trough), right cheek, left cheek	6 months	MRI	Malar thickness showed significant increases at the time of the 1-month follow-up appointments (P < 0.01); this increase was maintained at the next follow-up appointment (P < 0.01);average increase in malar projection: 0.66 cm for the right cheek and 0.60 cm for the left cheek	NA

Table 1. Continued

Study	No. of patients	Groups	Average age (years)	Location of fat harvest	Volume injected	Areas injected	Follow-up length	Metric	Volume retention	Investigator assessment
Pontius and Williams, 2006[22]	40	Group 1 (midface lift without fat transfer): 30;group 2 (midface lift with fat transfer): 10	NA	NA	NA	Tear trough, malar eminence, submalar region, nasolabial crease	Minimum 6 months	Photography	NA	Tear trough: significant difference by group ($P < 0.01$);malar eminence: no significant difference by group ($P = 0.21$);submalar region: no significant difference by group ($P = 0.13$);nasolabial crease: significant difference by group ($P < 0.01$)

MACS, minimal access cranial suspension; MRI, magnetic resonance imaging; NA, not available; PRP, platelet-rich plasma; SVF, stromal vascular fraction.

satisfaction and quality of life based on patient-reported outcomes. The authors used a rank analysis of covariance to compare subgroups and found significantly increased patient satisfaction in overall facial appearance, aging appearance appraisal, and satisfaction with cheekbones in patients with adjuvant lipofilling.

Swanson[26] demonstrated a reduction in apparent age in 71 consecutive patients who underwent deep-plane facelift in combination with other cosmetic procedures, as assessed by 198 independent evaluators from the general public who were asked to judge the patient's age in pre- and postoperative photographs. Independent t tests were used to compare means between 2 groups. The mean reduction in apparent age for all surgical patients was 6.0 years (range, 0.8-14.2 years) vs no change for the control patients ($P < 0.01$). The average reduction in apparent age after a facelift alone was 4.6 years. Additionally, patients treated with fat injections looked 2 years younger, but this finding did not reach statistical significance.

Volume Retention (Fat Survival)

Swanson[27] prospectively evaluated a set of 5 patients by measuring, via magnetic resonance imaging (MRI), the thickness of malar fat pads before and after deep-plane facelift with fat injections.[35] The change in malar fat pad thickness was measured, and the level of greatest projection on axial images before and after surgery was compared. Repeated-measures analysis of variance was used to compare measurements across time. Correlations were tested via Pearson correlations. A significant increase in malar thickness was found at both the 1-month follow-up ($P < 0.01$) and subsequent follow-up appointment ($P < 0.01$). The average increase in malar projection was 0.66 cm for the right cheek and 0.60 cm for the left cheek.

Rohrich et al[28] reviewed 100 consecutive facelift patients who also underwent simultaneous facial fat grafting to the nasolabial fold, deep malar, and high/lateral malar fat compartments. All patients had a 6-month follow-up. Before and after pictures were analyzed with a computer software developed to quantify variations in specific topographic facial landmarks. The authors demonstrated a 12.5% average lift of the most projected malar point and a 13.47% increase in the average malar projection.

Gerth et al[29] conducted a prospective analysis of 26 patients who underwent autologous fat transfer to the midface, 7 of whom had a concurrent facelift, based on preoperative and postoperative pictures captured with a Vectra 3D camera and software. After a mean follow-up of 17 months, the authors reported a 41.2% fat graft retention with closed-membrane filtration vs 32% fat graft retention for centrifuged fat. Results of a Welch's t test showed the difference was significant ($P < 0.03$).[29] Retention was significantly higher in patients younger than 55 years (53.0% vs 31% for older patients; $P = 0.001$) and lower in patients who underwent rhytidectomy (23.8% vs 47.6% for nonrhytidectomy patients; $P < 0.001$). Additionally, the authors observed a "rebound" effect for volume retention, with the lowest being in the 6- to 9-month range and increasing thereafter.

Sasaki[30] conducted a prospective study of 266 patients, evaluating the safety and efficacy of SMAS-plication facelift combined with midface fat grafting with addition of PRP or stromal vascular fraction (SVF). Preoperative and postoperative pictures at 3, 6, 9, and 12 months where taken with a Vectra 3D camera. Analysis of variance was used to evaluate statistical significance. The authors found that supplementation of lipoaspirates with PRP, SVF, and PRP/SVF resulted in significantly increased mean graft retention over fat alone at 12 months. The authors observed an initial reduction of volume at the third month, but the cell-assisted groups recovered slowly over the 6- to 12-month period, whereas in patients injected with fat alone volume continued to decline.

Mailey et al[31] used Vectra 3D imaging to evaluate volume changes in 9 patients who underwent facelift and fat graft. After a mean follow-up of 4.8 months, the authors reported positive changes in facial volume in the forehead

Table 2. Utilized Facelift and Fat Processing Techniques

Study	Facelift technique	Fat processing method
Kappos et al, 2017[25]	High bilamellar SMAS-lift	Coleman technique
Kaye et al, 2016[32]	SMAS facelift	NA
Boneti et al, 2016[33]	Not discussed	Fat filtering and emulsification until liquid suspension obtained
Hammoudeh et al, 2016[34]	SMAS "stacking" or SMASectomy	Centrifugation (1200 rpm for 3 minutes)
Sasaki, 2015[30]	Lateral SMASectomy or SMAS-plication face lift	Coleman technique
Mailey et al, 2015[31]	SMAS-based facelift and necklift	Celution device (Cytori Therapeutics, Inc., San Diego, CA)
Pezeshk et al, 2015[24]	Individualized component facelift	Centrifugation (1200 rpm for 3 minutes)
Gerth et al, 2014[29]	Deep-plane facelift; transconjunctival blepharoplasties were performed before fat grafting	Puregraft closed-membrane filtration system
Willemsen et al, 2014[35]	Modified MACS lift	Centrifugation (3000 rpm for 2.5 minutes);Biomet GPS-III device (3000 rpm for 15 minutes)
Rohrich et al, 2014[28]	Individualized component facelift, open neck lift	NA
Pallua and Wolter, 2013[36]	SMAS facelift	Centrifugation (3000 rpm for 2 minutes)
Willemsen et al, 2011[23]	Modified MACS lift	Centrifugation (3000 rpm for 3 minutes)
Swanson, 2011[26]	Sub-SMAS facelift	NA
Swanson, 2011[27]	Deep-plane facelifts	Centrifugation (3000 rpm for 3 minutes)
Pontius and Williams, 2006[22]	Midface lift	Centrifugation (3500 rpm for 3-5 minutes)

MACS, minimal access cranial suspension; SMAS, superficial musculoaponeurotic system.

(median, 0.9 mL), temples (median, 0.8 mL), and cheeks (median, 1.4 mL) and negative changes in nasolabial folds (median, –1.0 mL), marionette basins (median, –0.4 mL, and neck/submental regions (median, –2.0 mL).

The recipient areas injected varied substantially from author to author. Common locations of fat graft injection included the nasolabial folds, tear troughs, temporal regions, midface/cheek/malar eminence, marionette groove, lips, and ear lobes. The average total amount of fat injected per face ranged from 8.9 to 45.2 mL. When injected volumes were stratified by location, a range of 2 to 5 mL was injected per temporal area, 1 to 3 mL per glabellar area, 1 to 4 mL per midface region, 1 to 10 mL per nasolabial fold, 1 to 2 mL per marionette groove, 1 to 4 mL per perioral, and 1 mL per earlobe treated.

Safety Assessment

The follow-up duration ranged from 3 months to 5 years. Data on the incidence of complications were limited. We did not have precise data on the perioperative management of these patients. Six studies reported safety outcomes or rates of adverse outcomes (Table 4). Pezeshk et al[24] noted that there were no complications such as cellulitis, hematoma, or fat necrosis associated with transfers as well as no need for revisionary surgery. Patients in a study reported by Sasaki[30] and Boneti et al[33] experienced transient postoperative swelling with no complications persisting beyond 6 weeks. Similarly, Pallua and Wolter[36] found that 11 patients (92%) experienced swelling and hematoma, 2 patients (17%) experienced wound-healing disorders, and no patients required revisionary surgery. Gerth et al[29] indicated 1 case (3.8%) of donor-site hematoma, no surgical site infections, and 4 (15.3%) patients requiring fat-transfer touch-up procedures. Kaye et al[32] reported minor swelling and asymmetry from fat grafting and transient pigmentation changes resulting from the use of chemical peels, but noted that these complications did not occur at a rate higher than to be expected from performing each procedure individually.

DISCUSSION

Knowledge of facial anatomy and the corresponding changes that occur with aging is essential to the proper evaluation and treatment of patients who desire aesthetic surgery. Age-related loss of facial fat rarely exists as an isolated event. Although fat grafting of the aging face can

Table 3. Included Study Characteristics

Study	No. of patients	Type of study	Level of evidence
Kappos et al, 2017[25]	Group 1 (facelift alone): 13; group 2 (facelift + lipofilling): 26; group 3 (facelift + non-lipofilling rejuvenative procedure): 28	Prospective	IV
Kaye et al, 2016[32]	159 patients	Retrospective	IV
Boneti et al, 2016[33]	25	Retrospective	IV
Hammoudeh et al, 2016[34]	Group 1 (facelift alone): 65; group 2 (facelift with ear lipofilling): 65	Retrospective	IV
Sasaki, 2015[30]	Group 1 (fat alone): 92; group 2 (fat/PRP): 106; group 3 (fat/SVF): 9; group 4 (fat/PRP/SVF): 29	Prospective	III
Mailey et al, 2015[31]	9	Prospective	IV
Pezeshk et al, 2015[24]	130	Retrospective	IV
Gerth et al, 2014[29]	26	Prospective	III
Willemsen et al, 2014[35]	Group I: 25; group II: 18; group III: 17; group IV: 22	Retrospective	V
Rohrich et al, 2014[28]	100	Retrospective	IV
Pallua and Wolter, 2013[36]	12	Prospective	IV
Willemsen et al, 2011[35]	92	Retrospective	IV
Swanson, 2011[26]	75	Prospective	IV
Swanson, 2011[27]	5	Prospective	IV
Pontius and Williams, 2006[22]	40	Comparative	III

improve contour and create a smoother-appearing skin surface, it is of questionable benefit to patients with significant facial sagging and skin redundancy. Therefore, the contemporary approach to surgical rejuvenation of the face should consist of surgical lifts to reposition ptotic facial tissues with complementary fat grafting to restore areas that are truly volume depleted.[28,37]

A number of studies have examined variables that may influence fat graft retention. In a 2015 systemic review, Strong et al[38] found no evidence to suggest the existence of an optimal donor site with regard to cell viability or fat graft retention. Similarly, independent systematic reviews by Shim and Zhang,[39] Gir et al,[40] and Strong et al[38] concluded that there is currently no conclusive evidence to prove or support which one of the various fat harvesting methods is best. Newer processing methods involving closed-membrane filtration devices, as well as the use of PRP or SVF, show promise for increasing fat graft retention.[29,30]

A recent systemic review found that reported retention rates for facial fat grafting vary greatly from 13% to 68% after a year.[41] In our systemic review only Gerth et al[29] reported volume retention as a percentage, and it was within that range. Additionally, both Gerth et al[29] and Sasaki[30] observed a "rebound" effect for volume retention, with an initial decrease in retention followed by an increased in volume after a year. In a recent study Cohen et al[42] found a significant increase in facial volume after 2 years of simultaneous fat grafting and facelift, from 49.6% at the 1- to 2-month follow-up, to 73.64% at the 18- to 24-month follow-up. The authors hypothesize this may be explained by the graft replacement theory of Suga and Yoshimura, which suggests that grafted adipose tissue immediately dies after transplantation and is replaced by adipose-derived stem or progenitor cells.

Autologous fat is often described as an ideal soft tissue filler due to its biocompatibility, versatility, and relative permanence after initial resorption has taken place. However, despite these advantages, complications to this procedure have been described in the literature. These complications range from transient erythema, swelling, and ecchymosis to more serious problems such as calcification, nodule formation, sepsis, stroke, and blindness.[43-52] Kim et al[52] retrospectively analyzed the factors affecting complications of fat injections to the face. The overall complication rate was relatively low with 62 (4.9%) of 1261 patients suffering moderate complications, defined as chronic edema, calcification or fibrosis, acne, headache or dysesthesia, drooping, and irregularity. Moreover, serious complications such as blindness and stroke were not observed.

Table 4. Included Study Complications

Study	Complications	No. of patients
Kappos et al, 2017[25]	NA	67
Kaye et al, 2016[32]	Hematoma (3), temporary apraxia of the mandibular branch (2), minor asymmetry (5), temporary hyperpigmentation (5), permanent hypopigmentation (6), formation of skin miliae persisting longer than 2-3 months (5), prolonged erythema (3)	159
Boneti et al, 2016[33]	Mild swelling (3), bruising (2), scar (1), raised spot on cheek (2), posterior chin hematoma and edema (2); all complications resolved by 6 weeks	25
Hammoudeh et al, 2016[34]	None	130
Sasaki, 2015[30]	All patients experienced transient swelling to face lasting between 2-3 weeks; no complications beyond 6 weeks	236
Mailey et al, 2015[31]	NA	9
Pezeshk et al, 2015[24]	Cellulitis: 0%; hematoma: 0%; fat necrosis: 0%; revisions required: 0%	130
Gerth et al, 2014[29]	Donor-site hematoma: 1 (3.8%); surgical-site infections: 0 (0.0%); fat-transfer touch-up: 4 (15.3%)	26
Willemsen et al, 2014[35]	NA	Group I: 25; group II: 18; group III: 17; group IV: 22
Rohrich et al, 2014[28]	NA	100
Pallua and Wolter, 2013[36]	Swelling and hematoma: 92%; wound healing disorders: 17%; skin sloughing behind one ear: 17%	12
Willemsen et al, 2011[23]	NA	92
Swanson, 2011[26]	NA	75
Swanson, 2011[27]	NA	5
Pontius and Williams, 2006[22]	NA	40

NA, not available.

Although complications can occur following facelift surgery, this is a relatively safe procedure. Gupta et al[53] reported the incidence of major complications following facelift surgery based on a large prospective, multicenter database (CosmetAssure, Birmingham, AL). In this retrospective review of 129,007 patients, 205 (1.8%) experienced major complications, defined as complications requiring an emergency room visit, hospital admission, or reoperation within 30 days of the procedure. Systemic complications occurred in only 37 (0.3%) patients. Incidence of major complications such as cardiac or pulmonary dysfunction, wound-related, and suspected or confirmed venous thromboembolism were less than 0.1% each.

The modern-day facelift is a combination of various techniques that have evolved over time as a result of our increasingly detailed understanding of the layered anatomic architecture of the face. The ideal facelift would be the one with the longest effectiveness, fewest complications, and highest patient satisfaction. Chang et al[54] performed a systematic review to compare different facelift techniques. The review revealed that there are currently no quality data to demonstrate the greater effectiveness or safety of one facelift technique over another. Which facelift technique to employ is largely dictated by the comfort level and experience of the surgeon as well as the precise areas of concern of the patient. The present review of current literature suggests concomitant fat grafting yields improved aesthetic outcomes, regardless of the facelift technique employed.

In this study, 6 articles reported complications. When encountered, the most common complications were transient swelling, bruising, and hematoma. There were no serious complications that lasted beyond 6 weeks. Unfortunately, the data are too limited to make definitive conclusions regarding the overall complication rates when fat grafting is combined with facelift compared to performing these operations separately.

However, it is worth noting that none of the patients in the 6 aforementioned studies on combined facelift/fat grafting experienced major complications. Thus, it appears

as though the complications of the combined procedure and their respective rates of occurrence were not noted to be unexpected or more frequent than facelift alone. Further studies are needed to elucidate more definitive complication rates of the combined procedure and differences in revision rates between combined facelift/fat grafting vs facelift or fat grafting alone.

Limitations of This Systematic Review

A limitation of the present systemic review is that it was not registered prospectively. Moreover, the small number of relevant articles identified and the level of evidence of the studies is suboptimal. Of the 15 reviewed articles, there were no randomized, controlled trials, only 6 studies were prospective, and only 5 had objective measure for volumetric data. Additionally, studies that compare facelift alone vs facelift with fat grafting are at risk of selection bias. As the principle of autonomy precludes randomization of treatment, it is possible that patients who underwent both procedures simultaneously had more room for improvement.

Additionally, the variability in approaches to fat grafting, facelift techniques, method of fat preparation, fat graft recipient location, patient age, and timing of evaluation, makes meta-analysis of limited value and reaching conclusive conclusions difficult. Another significant shortcoming is the short follow-up length of some studies, many less than 3 months after surgery, when swelling remains a significant factor. Finally, there was a lack of standardized objective analysis of effectiveness. Only 1 study used MRI data to objectively quantify results, whereas 4 used subjective evaluation of 3D photographs.

CONCLUSIONS

Based on the currently available data, concomitant fat grafting can improve the outcome of facelifts performed with a wide variety of different fat grafting and facelift techniques. This improvement has been shown to last a minimum of 6 to 12 months. Although the complication data are limited, none of the listed studies report increased adverse events when combining these 2 procedures. The addition of fat grafting to the facelift operation effectively addresses soft tissue atrophy and allows for a more complete and lasting facial rejuvenation. The ability of the surgeon to safely add additional rejuvenative procedures at the time of facelift and fat grafting potentially allows the surgeon to maximize the aesthetic outcome while simultaneously minimizing the amount of patient downtime compared with performing each procedure in succession. More prospective, randomized trials based on objective measurements and longer follow-up periods should be conducted to more definitively assess the outcomes and complications of concomitant fat grafting and facelift.

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