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Enhancing Face Transplant Outcomes: Fundamental Principles of Facial Allograft Revision

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Background: Facial transplantation (FT) has become a feasible reconstructive solution for patients with devastating facial injuries. Secondary revisions to optimize functional and aesthetic outcomes are to be expected, yet the optimal timing and approach remain to be determined. The purpose of this study was to analyze all facial allograft revisions reported to date, including the senior author's experience with 3 FTs.

Methods: A literature review was performed, with 2 reviewers independently conducting title and abstract screening, followed by a full-text review. All articles mentioning FT revision surgeries were evaluated. The medical records of the senior author's 3 FT recipients were additionally reviewed.

Results: Initially, 721 articles were captured and 37 were included in the final analysis. Thirty-two FTs were reported to have involved posttransplant allograft revisions, with FT recipients undergoing a mean of 4.8 ± 4.6 revision procedures. The mean duration between FT and the first revision procedure was 149 ± 179 days. A wide spectrum of revisions was identified and categorized as involving the soft tissues, craniofacial skeleton, dentition, oronasal cavity, salivary glands, facial nerve, or ocular region. In the senior author's experience, when indicated, posttransplant occlusal changes and integrity of the donor–recipient intraoral interface were successfully addressed with secondary procedures without allograft compromise or loss.

Conclusions: The worldwide experience shows that secondary procedures are nearly ubiquitous after FT and can be safely performed at various timepoints. The authors thereby establish 5 distinct categories of facial allograft revisions and define 7 critical principles to optimize posttransplant procedures. *(Plast Reconstr Surg Glob Open 2020;8:e2949; doi: 10.1097/GOX.0000000000002949; Published online 17 August 2020.)*

INTRODUCTION

Facial transplantation (FT) has significantly evolved since its inception over 15 years ago and is now considered a feasible reconstructive option for facial deformities that could not be satisfactorily corrected using conventional reconstruction. One unique aspect of FT is its en bloc approach, which allows the restoration of multiple facial subunits in a single, albeit complex, surgery. However, subsequent additional procedures to refine the facial allograft should be expected to optimize final aesthetic and functional outcomes. Staged reconstruction is not a novel concept, as seen in procedures involving the use of tissue expansion and in most flap-based reconstructions.[1,2] Revisions are considered essential to conventional reconstruction in an effort to recreate aesthetic subunits, accentuate facial features, and recruit local tissue.[3,4] Anticipated revision was thereby described as 1 of the 7 critical concepts necessary to achieve aesthetically satisfactory results in craniofacial microsurgical reconstruction.[5]

In practice, revision of a facial allograft poses a unique set of challenges. Complications related to wound healing and infection in the setting of immunosuppression, the potential for triggering acute rejection, and the risk of vascular compromise have all been described.[6,7] There is currently limited understanding of the optimal approach

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to surgical revision following FT.[8,9] We therefore examined the indications, timing, operative approach, and outcomes of all FT revisions documented in the literature, including the senior author's experience with 3 FTs. We hypothesize that despite these inherent risks, FT revisions are commonly performed for a wide spectrum of indications at various timepoints along the postoperative course and that satisfactory outcomes can be safely achieved.

METHODS

A literature review was conducted using the PubMed/MEDLINE database, from inception to September 30, 2019. The search included keywords and subject headings pertaining to FT (Table 1). Title and abstract screening was performed independently by 2 reviewers, followed by full-text review. All articles published by the primary FT team, including surgical and clinical follow-up details, were included. All included revisions were those specifically performed on the donor allograft; surgical interventions on the recipient's face or on other areas of the body, such as gastrostomy or tracheostomy sites, were excluded. Studies in languages other than English, conference abstracts, news articles, short communications, and animal and cadaveric studies were excluded. The following variables were collected from all FT recipients included: surgical team, location and date of transplant, age, sex, indication, and allograft type. Number of revisions, time to first revision, and number of anesthetic events for both aesthetic (eg, fat grafting) and functional (eg, palatal fistula repair) revisions were also collected and reported as mean ± SD when available. The medical records of the senior author's 3 FT recipients were also reviewed to collect these variables in abidance with Institutional Review Board approval (clinicaltrials.gov; NCT02158793 and NCT01140087). Mean and SD were calculated with Microsoft Excel 16.33 (Microsoft, Redmond, Wash.).

RESULTS

Figure 1 depicts the process of article selection. A total of 721 articles were initially identified, of which 37 articles met eligibility criteria for data extraction. Data on revision procedures were available for 32 FTs, including all 3 FT recipients under the care of the senior author (E.D.R.) (Table 2). Overall, FT recipients underwent a mean of 4.8 ± 4.6 allograft revision procedures (2.2 ± 3.2 aesthetic and 2.6 ± 2.3 functional procedures, Table 3). The mean duration between FT and subsequent secondary procedures was 149 ± 179 days (aesthetic, 261 ± 214 days; functional, 104 ± 102 days). In the senior author's experience with facial allograft revisional surgery, the development of posttransplant occlusal changes and the integrity of the donor–recipient intraoral interface were successfully addressed when needed with secondary procedures. All patients underwent both aesthetic (mean 6.3 ± 2.5 at a mean interval of 108 ±71 days posttransplant) and functional revisions (mean 7.0 ± 3 at a mean interval of 61 ±102 days posttransplant). There was no incidence of allograft compromise or loss.

Table 1. PubMed/MEDLINE Comprehensive Search Strategy for Articles on Facial Transplantation

	PubMed/MEDLINE
Search Terms	"Facial Transplantation" [MeSH:no exp] "face transplant*" [tw] "facial transplant*" [tw] "face transplantation" [tw] "facial transplantation" [tw] "face allotransplantation" [tw] "facial allotransplantation" [tw] "facial vascularized composite allotransplantation" [tw] "face vascularized composite allotransplantation" [tw] "face vascularized composite allograft" [tw] "facial vascularized composite allograft" "face allograft" [tw] "facial allograft" [tw] "face composite tissue allotransplantation" [tw] "facial composite tissue allotransplantation" [tw] "face composite tissue allograft" [tw] "facial composite tissue allograft" [tw]

DISCUSSION

To our knowledge, this is the first comprehensive review of all reported secondary revisions to date in the FT literature, with additional provision of a detailed account of the senior author's experience with 3 consecutive FTs. Our findings show that secondary procedures after FT are commonly performed for both aesthetic and functional purposes. The spectrum of indications is broad and includes planned, elective surgery for aesthetic reasons, unplanned functional corrections, emergent take-back to the operating room, or even end-stage salvage procedures involving partial or total facial allograft removal (Table 2). Timing of revisions varies greatly, with the first revision occurring, on average, within 5 months posttransplant but reported as early as postoperative day (POD) 1 and as late as 10 years after the index procedure. As demonstrated by our cohort of FT recipients, secondary procedures can be

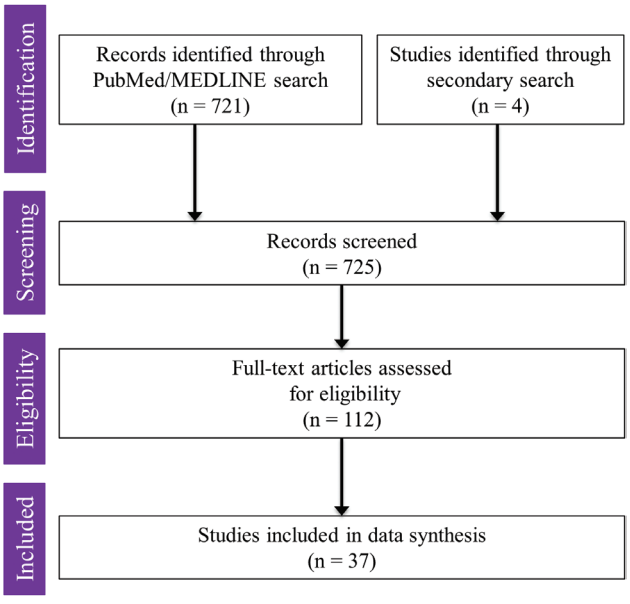

Fig. 1. Article selection process.

Table 2. Face Transplants Performed to Date with All Reported Secondary Revisions

Patient	Surgical Team	Location, Date of Transplant	Recipient (age, sex)	Indication, Allograft Type	Secondary Allograft Revisions				
					Soft Tissue	Craniofacial Skeleton, Dental	Oronasal Cavity, Salivary Glands, Facial Nerve	Ocular	Additional
1	Devauchelle Dubernard	Amiens, France, 11/2005	38, F	Animal attack, partial	—	—	Revision for parotid duct stenosis	—	Partial allograft removal (CR) + forearm flap reconstruction
2	Guo	Xi'an, China, 04/2006	30, M	Animal attack, partial	Scar revision Excess tissue removal Transposition flap (mouth deviation)	—	—	Orbital floor repair with cartilage (autologous)	—
3	Lantieri	Paris, France, 01/2007	29, M	NF, partial	Excess skin removal	—	—	—	—
4	Siemionow	Cleveland, Ohio, 12/2008	45, F	Ballistic trauma, partial	—	—	—	B/L ectropion repair	—
5	Lantieri	Paris, France 03/2009	27, M	Ballistic trauma, partial	Excess skin removal (×2)	—	—	—	—
6	Lantieri	Paris, France 04/2009	37, M	Third-degree burn, partial	—	—	—	—	Debridement of infected/ necrosed tissue
7	Pomahac	Boston, Mass. 04/2009	59, M	Electrical burn, partial	Revision of B/L cheek scars (×4) Excess tissue removal Chin implant Advancement, tightening, resuspension of allograft (×3) Lower lip reconstruction with musculomucosal flap	Teeth extraction (advanced decay) Osseointegrated dental implants	—	Fistula repair (medial canthus) Tarsorrhaphy	—
8	Lantieri	Paris, France, 08/2009	33, M	Ballistic trauma, partial	Excess skin removal	B/L mandibular osteotomy + orthodontic treatment (malocclusion)	Facial nerve, coaptation revision + "Temporal muscle transfer" (facial palsy)	—	—
9	Cavadas	Valencia, Spain, 08/2009	42, M	ORN after malignancy, partial	—	MSSO (tongue nodule excision)	Tongue nodule excision (pseudo-sarcomatous spindle cell)	—	—
10	Devauchelle Dubernard	Amiens, France, 11/2009	27, M	Ballistic trauma, partial	—	—	—	—	Partial allograft removal (CR) + forearm flap reconstruction
11	Gomez-Cia	Seville, Spain, 01/2010	35, M	NF, partial	—	—	—	—	Hematoma evacuation
12	Barret	Barcelona, Spain, 03/2010	30, M	Ballistic trauma, full	B/L rhytidectomy	LeFort I osteotomy (malocclusion)	Oro-cutaneous fistula repair BT injection (sialocele)	B/L blepharoplasty	Reanastomosis (venous thrombosis)

(*Continued*)

Table 2. (*Continued*)

Patient	Surgical Team	Location, Date of Transplant	Recipient (age, sex)	Indication, Allograft Type	Secondary Allograft Revisions				
					Soft Tissue	Craniofacial Skeleton, Dental	Oronasal Cavity, Salivary Glands, Facial Nerve	Ocular	Additional
13	Lantieri	Paris, France, 06/2010	35, M	NF, full	Autologous fat grafting (×2)	—	—	Excess skin removal (palpebra) Canthopexy	Allograft removal (CR)
14	Pomahac	Boston, Mass., 03/2011	25, M	Electrical burn, Full	Excess skin removal (face/neck) (×3) LTR Rhytidectomy with SMAS plication (×3) Neck lift Fat grafting (B/L cheeks, L temporal region)	B/L coronoidectomy (restricted MROM) Osseointegrated dental implants	Sialocele drainage BT injection (sialocele)	B/L eyebrow lift (×2) Excess tissue removal (eyelid) (×2) Canthopexy (×3) V-Y AF medial canthus BT injection (lacrimal gland)	—
15	Lantieri	Paris, France, 04/2011	45, M	Ballistic trauma, partial	Excess skin removal (cervical)	Teeth extraction + B/L "temporal tendon section" Hardware removal (Zygomatic bone)	Sialocele drainage Smooth–hard palate closure Oronasal fistula repair attempt (persistent)	—	—
16	Lantieri	Paris, France, 04/2011	41, M	Ballistic trauma, partial	—	Revision for mandibular septic pseudoarthrosis	—	—	—
17	Pomahac	Boston, Mass., 04/2011	30, M	Electrical burn, full	Excess tissue removal (×2) LTR Recontouring and resuspension of allograft	Recontouring (bony nose) + hardware removal	—	B/L V-Y AF (persistent medial canthus elevation, causing conjunctival exposure and tearing)	—
18	Pomahac	Boston, Mass., 05/2011	57, F	Animal attack, full	—	Osseointegrated dental implants	Palatal fistula repair attempts (×3, recurrent) with AF Masseter to facial nerve transfer with great auricular nerve interposition graft	Orbital floor fistula repair (×2, recurrent)	—
20	Ozkan	Ankara, Turkey, 01/2012	19, M	Burn, full	Rhytidectomy + botox injection	Rhinoplasty	—	—	—
23	Rodriguez	Baltimore, Md., 03/2012	37, M	Ballistic trauma, full	Lipectomy (submental) Hypertrophic scar excision	LeFort III osteotomy, midface advancement (malocclusion) Tooth extraction	Palatal fistula repair	Coronal eyebrow lift B/L blepharoplasty Tarsal grip tightening (ectropion)	—

(*Continued*)

Table 2. (*Continued*)

Patient	Surgical Team	Location, Date of Transplant	Recipient (age, sex)	Indication, Allograft Type	Secondary Allograft Revisions				
					Soft Tissue	Craniofacial Skeleton, Dental	Oronasal Cavity, Salivary Glands, Facial Nerve	Ocular	Additional
24	Ozkan	Ankara, Turkey, 05/2012	35, M	Thermal burn, full	—	—	—	Levator muscle plication Ectropion repair	—
26	Pomahac	Boston, Mass., 02/2013	44, F	Chemical burn, full	Resuspension of lower lip Z-plasty of right neck (burn contracture) Readvancement of allograft neck skin	—	—	Eyelid levator reattachment into tarsal plate Excess tissue removal (eyelid) Lateral tarsal strip (B/L ectropion)	—
28	Ozkan	Ankara, Turkey, 07/2013	26, M	Ballistic trauma, full	—	Orthognathic surgery (malocclusion)	—	—	Abscess drainage (infraorbital) + hardware removal
29	Ozkan	Ankara, Turkey, 08/2013	54, M	Ballistic trauma, full	—	—	—	—	Excision ulcerative nodule (DLBCL) Allograft removal + ALT free flap reconstruction
31	Ozkan	Ankara, Turkey, 12/2013	22, M	Ballistic trauma, partial	Scar revision	—	—	—	—
33	Papay	Cleveland, Ohio, 09/2014	44, M	TINI, partial	—	—	Palatal dehiscence and fistula after failed repair (obturator) BT injection (sialocele)	—	I&D abscess + VAC
34	Pomahac	Boston, Mass., 10/2014	31, M	Ballistic trauma, full	Fat grafting (×2) Resuspension of allograft + revision allograft–recipient interface Closure of mandibular incision dehiscence	Condylectomy, removal of facial hardware over zygomatic arch (for limited MROM)	Palatal fistula repair	—	Neck washout
36	Volokh	Saint-Petersburg, Russia, 05/2015	22, M	Electrical burn, partial	—	—	—	—	Thrombectomy (donor vein) (×3) "Vein graft from lower leg"

(*Continued*)

Table 2. (*Continued*)

Patient	Surgical Team	Location, Date of Transplant	Recipient (age, sex)	Indication, Allograft Type	Secondary Allograft Revisions				
					Soft Tissue	Craniofacial Skeleton, Dental	Oronasal Cavity, Salivary Glands, Facial Nerve	Ocular	Additional
37	Rodriguez	New York, N.Y. 08/2015	41, M	Thermal burn, full	Debridement + final advancement of posterior scalp allograft Lip advancementDebridement (nose/eyelids) Excision of excess mucosa (lips), CTR B/L ear meatoplasty (canal stenosis) Lipectomy (submental) B/L cheek AF	—	Sialocele drainage (×2)	Excision conjunctival granuloma B/L ectropion release and primary repair Coronal brow lift Direct B/L brow lift	Hematoma evacuation (×2) Repair of posterior occipital artery (iatrogenic injury)
38	Tornwall	Helsinki, Finland, 02/2016	34, M	Ballistic trauma, partial	—	Teeth extraction (3 teeth)	Palatal fistula repair (×3 attempts) Sialocele drainage Debridement of intraoral wound	—	—
41	Rodriguez	New York, N.Y., 01/2018	25, M	Ballistic trauma, partial	B/L cheeks CTR Neck CTR	Mandibular hardware removal + ORIF of left mandible (nonunion) Repeat ORIF of left mandible (fractured plate) + left coronoidectomy	Hyoid and genioglossus advancement Palatal and floor-of-mouth wound debridement and reapproximation Placement of B/L Stensen duct stents (sialoceles) Extended B/L maxillary antrostomy Debridement of mucosal/submucosal tissue, muscle, and bone associated with mandibular plate fracture	Canthoplasty (x2) Eyelids CTR (×2) Endoscopic DCR (NLD obstruction, epiphora)	Hematoma evacuation
43	Lassus	Helsinki, Finland, 03/2018	58, M	Ballistic trauma, full	—	—	Palatal fistula repair	—	—

AF, advancement flap; ALT, anterior lateral thigh; B/L, bilateral; CR, chronic rejection; CTR, complex tissue rearrangement; DCR, dacryocystorhinostomy; DLBCL, diffuse large B-cell lymphoma; F, female; I&D, incision and drainage; LTR, local tissue rearrangement; M, male; MROM, mandibular range of motion; MSSO, mandibular sagittal split osteotomy; NF, neurofibromatosis; NLD, nasolacrimal duct; ORIF, open reduction internal fixation; ORN, osteoradionecrosis; SMAS, superficial muscular aponeurotic system; TINI, trauma-induced necrotizing inflammation; TMJ, temporomandibular joint; VAC, vacuum-assisted closure. ×2, ×3, ×4 denotes the number of times the same procedure was performed during separate anesthetic events.

Table 3. Summary of All Secondary Facial Allograft Revisions Performed to Date

	Aesthetic Revision	Functional Revision	Overall
Mean number of revisions	2.2 (±3.2)	2.6 (±2.3)	4.8 (±4.6)
Time to first revision, d	261 (±214)	104 (±102)	149 (±179)
Mean number of anesthetic events	1.2 (±1.5)	2 (±1.6)	2.6 (±2.0)

safely performed at different timepoints along the posttransplant course with satisfactory long-term outcomes. Informed by this comprehensive review, we divide revisional surgeries into 5 distinct categories.

Classification of Secondary Revisions

Soft-tissue Revisions

Secondary revisions involving the soft tissues are most common and are inclusive of nearly all aesthetic posttransplant revisions. Soft tissue revision revolves around 3 main principles: allograft augmentation, enhancement of facial contouring, and tissue resuspension.

Over time, facial allografts sustain volume loss and atrophy that affect the soft tissues as well as the muscle and bone.[10] Autologous fat grafting, commonly performed for facial rejuvenation and aesthetic soft tissue augmentation, has been described in FT recipients.[8,11–15] However, in addition to the anticipated complications (including iatrogenic fat embolization, leading to vascular compromise and tissue necrosis, stroke, or blindness), fat grafting in FT recipients has also been reported to trigger acute rejection requiring pulsed steroid therapy.[8,16] Fat grafting can also be used to enhance facial contour, particularly in areas such as the malar prominence or periorbital region. Conversely, suction lipectomy can address contour irregularities and was successfully performed on 2 of our FT recipients to address excess submental fat and to improve facial contour, with special attention to maintain a safe distance from the allograft's vascular pedicles. A generous soft-tissue envelope is deliberately included at the time of the transplant to account for a postoperative edema and to allow for a tension-free closure (Fig. 2).[17] Therefore, secondary revisions involving removal of the redundant tissue and potential scar revision are to be expected and planned for accordingly. Patient 1 had excess periorbital tissue intentionally included in the initial allograft to avoid subsequent lagophthalmos. He later underwent successful bilateral blepharoplasties to address the redundant skin and to minimize the contrast between the allograft and native tissues.

Soft-tissue revisions are often required for resuspension of the allograft. Soft-tissue laxity and gravitational droop are known to develop over time, particularly with myocutaneous allografts.[18] To address this issue, skeletal subunits and retaining ligaments can be incorporated within the allograft.[8,17,19,20] Patient 1 experienced a ptosis that was most prominent in the forehead and periorbital regions due to the lack of bony attachment to the allograft in these areas; resuspension was performed via a coronal lift on POD 189. Patient 2 required 2 separate brow lifts for upper facial and brow ptosis, first via a coronal incision on POD 241, then with a direct brow lift on POD 1291. Lower eyelid retraction was addressed by resuspension of the orbicularis oculi muscle to the superficial layer of the deep temporal fascia, providing adequate support to the eyelid (Fig. 3).

Fig. 2. Immediate posttransplant result. Excess soft tissue envelope was deliberately included with the facial allograft to account for a postoperative edema and to allow for a tension-free closure. Printed with permission from and copyrights retained by Eduardo D. Rodriguez, MD, DDS.

Craniofacial Skeleton and Dental Revisions

Of the 46 FTs performed to date, 9 have included either the maxilla or mandible in isolation, while 17 have included both, with a varying number of teeth.[21] Malocclusion after jaw-containing FT has been described in at least half of these cases, including 2 of our patients.[21] This has been seen to develop throughout posttransplant recovery, despite a class I occlusion immediately posttransplantation.[9,22] This is thought to be related to the lack of proprioceptive registration and motor tone in the months following transplantation. To prevent the gradual development of malocclusion, early and preemptive initiation of orthodontic elastic treatment is suggested during the critical recovery period (Fig. 4).[21] If surgical correction remains necessary, our experience has shown that revisional Le Fort osteotomies can be safely performed with satisfactory outcomes. In an effort to protect the allograft's vascular pedicles, class III malocclusion in a type 3B FT can be corrected through a LeFort III advancement via the patient's coronal incision, rather than through a posterior mandibular setback at the bilateral sagittal split osteotomy site (Fig. 5).[9,21,23]

While the mandibular condyle has only once been included in a facial allograft, and en bloc transplantation of the entire temporomandibular joint has never been attempted, temporomandibular joint–related complications are common, and many patients may suffer from pain or restricted range of motion from soft tissue or

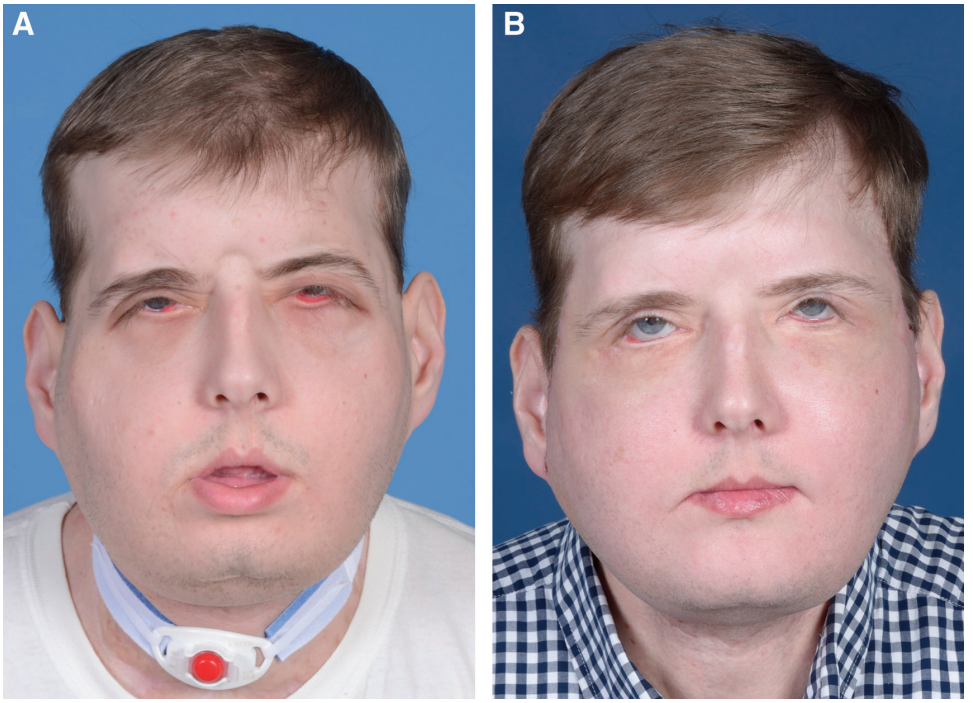

Fig. 3. Soft tissue revisions–allograft resuspension. After facial transplantation, patient 2 experienced upper facial and brow ptosis (A), which required 2 separate brow lifts, on POD 241 and 1291. B, Photograph of the patient 1 week after his second brow lift. Printed with permission from and copyrights retained by Eduardo D. Rodriguez, MD, DDS.

bony ankylosis related to their initial injury or subsequent interventions.[22,24] This can prompt posttransplant coronoidectomy or condylectomy.[8,22,25] Other revisions related to the craniofacial skeleton can include open reduction and internal fixation for nonunion at the donor–recipient bony osteosynthesis site or hardware failure.[25]

Finally, depending on the recipient's native dentition and the assortment of teeth included in the donor allograft, secondary dental procedures can be planned, including the placement of osseointegrated implants and the extraction of donor teeth as clinically indicated.[8,26,27] Despite the risks of immunosuppression, dental implants have been safely used with no increased risk compared with the immunocompetent population.[28]

Oronasal Cavity and Salivary Glands Revisions

Oronasal complications have been frequently described in maxillomandibular transplantation, including floor-of-mouth and palatal wound dehiscence, necrosis, or fistula formation (Table 2).[9,21,25,29] The donor–recipient palatal interface is thought to be a watershed area, which contributes to this complication. However, similar complications have been described even in the presence of adequate perfusion and appropriately tailored soft-tissue closure, highlighting the challenge of wound healing in the setting of immunosuppression.[30,31] Intraoral examination and monitoring in the immediate posttransplant period can be challenging, mandating a low threshold for intraoral examination, under anesthesia if necessary, in the event of any suspected complication. In our experience, intraoral revisions such as palatal repair can be safely performed as early as POD 11 or as late as postoperative month 9 with successful long-term results (Fig. 6).[9,25] The floor of the mouth requires particular attention, as suture line dehiscence and tongue retraction can result in airway narrowing or obstruction.[25]

Sialocele formation after FT is another commonly reported complication, often requiring botulinum toxin (BT) injections, drainage procedures, or stenting of the ducts.[8,12,17,25,29,32–34] Salivary collections should be prevented or promptly treated, as they have been shown to increase the risk for fistula formation, compromise wound healing, and lead to a severe infection in the setting of immunosuppression.[35] As detailed by Frautschi et al,[32] salivary glands should ideally be excluded from the facial allograft. However, it is worth noting that recipient salivary gland leakage has been described in 2 FTs that excluded the donor glands, which was possibly due to the posterior displacement of the native submandibular gland by the allograft and/or a difficult intraparotid facial nerve dissection.[26,36] In our experience, sialoceles can be successfully treated with stenting of Stensen's ducts. BT can be used as a less invasive alternative; by blocking the cholinergic innervation of the salivary gland, it can promote healing through scar tissue formation. However, BT injections are not without risks, as transient paralysis of the facial nerve branches due to such injections has been reported.[37] Increased risk of bacterial overgrowth and sialolith formation secondary to the decrease in salivary flow is also possible.[38] Of the 4 FTs that required postoperative injection of BT for sialocele management, all had complete resolution; 3 were performed on the

Fig. 4. Patient 3 underwent orthodontic treatment with elastics, starting on posttransplant day 11 for class II malocclusion with an open bite that developed posttransplantation. A, The photograph was taken after 1 month into the treatment. B, Normal allograft occlusion was restored after 10 months of orthodontic treatment. C, The patient at 2 years after transplantation, with mild anterior open bite. Printed with permission from and copyrights retained by Eduardo D. Rodriguez, MD, DDS.

donor salivary glands,[29,33,39] while the fourth involved the recipient's native glands.[36]

In view of its anatomic relationship with the parotid gland, facial nerve dissection for optimal coaptation and postoperative function is a fundamental consideration. Although our patients have not required any facial nerve revisions to date, 2 FT recipients were reported in the literature to have required such procedures. One patient had no motor recovery on the right side after 11 months. This was attributed to swelling, leading to tension and ultimately affecting the quality of the coaptation. After revision of the facial nerve coaptation, the patient was able to achieve complete mouth closure within 12 months.[40] Another patient underwent FT requiring a great auricular nerve graft to bridge a 3.5-cm gap noted during neurorrhaphy secondary to a soft-tissue swelling. She underwent revision 11 months after FT for unilateral facial weakness, with a masseter-to-facial nerve transfer and a great auricular nerve interposition graft. Nineteen months after facial nerve revision, she demonstrated improved facial movement, strength of contraction, and symmetry of voluntary movement, with continued progress at 31 months post-revision. This led to the development of an algorithm for facial nerve management, advocating for facial nerve coaptation close to the target muscles to avoid synkinesis, and maximization of donor facial nerve length recovery by retrograde dissection into the parotid to the nerve's upper and lower divisions to account for swelling. In case of nerve length deficiency, a motor nerve graft should be considered. Postoperatively, if no function is recovered by 9–12 months, re-exploration with nerve transfer should be attempted.[41] These 2 cases demonstrate the feasibility of facial nerve revision with satisfactory outcomes.

Ocular Revisions

More than half of the FTs performed to date have included periorbital components, with 15 cases reporting on ocular and periocular complications and nearly all requiring revisions.[8,12,17,20,41–52] The most common complications include lower eyelid ectropion secondary to horizontal laxity and lagophthalmos. Prompt identification and correction of periorbital complications is critical, as the resulting exposure keratopathy can lead to corneal scarring, ulceration, perforation, and potential blindness, particularly in patients with baseline vision compromise secondary to the initial injury. Revision surgeries (including tarsorrhaphy or V-Y advancement and repositioning of the medial canthus) have been described (Table 2).[8] Our 3 patients underwent periorbital revisions; the surgical details and outcomes of the first 2 have been recently covered in detail.[53] Recipients' initial injury and pretransplant interventions are important considerations in the anticipation of posttransplant outcomes and associated secondary procedures. Patient 3 underwent bilateral medial canthoplasties for telecanthus on POD 108, with lower eyelid tissue rearrangement for bilateral lower eyelid retraction and cheek ptosis. He had a persistent left telecanthus and eyelid malposition requiring return to the operating room on POD 248 for medial canthoplasty and tissue rearrangement. Additionally, he underwent endoscopic dacryocystorhinostomy for nasolacrimal duct obstruction and epiphora. At his most recent follow-up, he had preserved proper eyelid positioning, intact blink function and vision, and normal corneal and periocular sensory functions (Fig. 7). The present study and our clinical experience with 3 FT recipients highlight the prevalence of ocular complications after FT, the importance in recognizing these developments, and the feasibility of ocular and periorbital revisions in the posttransplant setting.

Fig. 5. Posttransplant photographs. Patient 1 developed class III malocclusion after facial transplantation. A, The recipient is shown before correction with Le Fort III advancement. Intraoperatively, the midface was disimpacted and advanced to restore class I occlusion. Normal occlusion was restored, as seen 11 months (B) and 5 years after craniofacial revision (C). Printed with permission from and copyrights retained by Eduardo D. Rodriguez, MD, DDS.

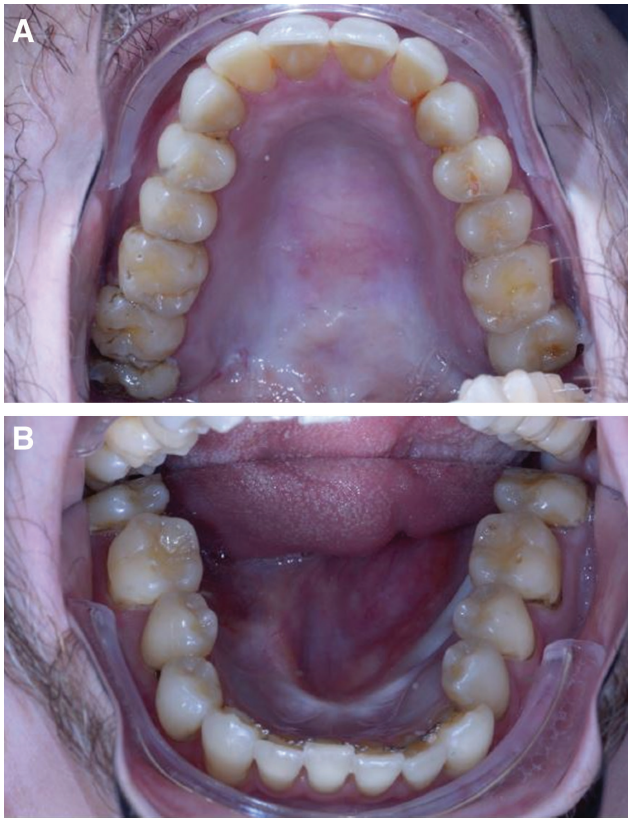

Fig. 6. Oronasal cavity revisions. At his latest follow-up appointment (2 years posttransplant), patient 3 continues to demonstrate satisfactory repair, with an intact palate (A) and floor of the mouth (B). Printed with permission from and copyrights retained by Eduardo D. Rodriguez, MD, DDS.

Additional Revisions

The vast majority of revisions described to date fall into 1 of the 4 categories described above; however, a few unplanned complications are better grouped as a distinct category, including those related to technical difficulty, iatrogenic injury, or rejection. Revisions for vascular complications, such as thrombosis or hematoma, debridement of tissue necrosis, and drainage of abscesses, have frequently been described.[25,33,54] Furthermore, at least 3 cases of chronic rejection requiring allograft removal with free flap reconstruction have been documented in the literature, while 1 case involving retransplantation was reported in the media.[55–58] These complications should serve as a reminder that despite best efforts to plan FT and subsequent revisions, vigilance is warranted for unexpected outcomes, including possible allograft loss requiring retransplantation, the ultimate secondary revision.

Critical Principles of Secondary Revisions after FT

Tissue losses must be "replaced in kind."[59] FT follows this principle through a single procedure as opposed to multistage autologous reconstruction. However, a mature approach to FT involves methodical reconstruction through a stepwise process. This begins with pretransplant preparatory procedures, such as tracheostomy, gastrostomy, and any necessary pretransplant foundational reconstructive efforts leading up to the transplant, followed by planned secondary procedures for outcome optimization. This approach is crucial to ensuring patient safety, setting appropriate expectations, and maximizing the quality of functional and aesthetic outcomes (Fig. 8).

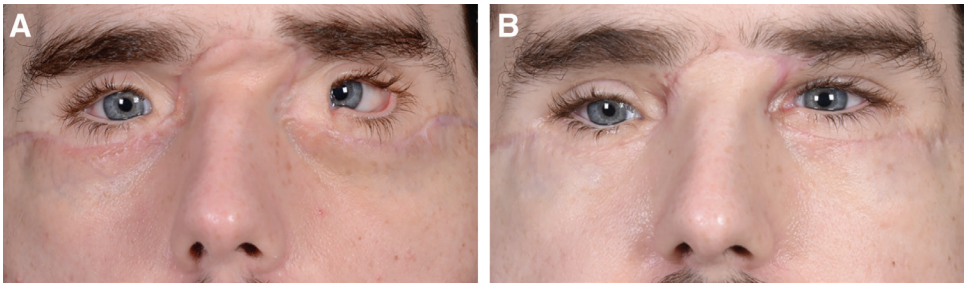

Fig. 7. Ocular revisions. After facial transplantation, patient 3 required ocular revisions for bilateral medial telecanthus and lower eyelid retraction (A). On POD 108, he underwent bilateral medial canthoplasties with lower eyelid tissue rearrangement. Due to persistent left telecanthus and eyelid malposition, he returned to the operating room on POD 248 for medial canthoplasty and tissue rearrangement. B, The photograph shows results 1 month after the last ocular revision, showing correction of telecanthus and eyelid positions. Printed with permission from and copyrights retained by Eduardo D. Rodriguez, MD, DDS.

Fig. 8. Face transplants performed by the senior author. Photographs of patient 1 (A and D), patient 2 (B and E), and patient 3 (C and F) before facial transplantation (A–C) and after facial transplantation and all revisional procedures (D–F). The senior author's experience with these 3 face transplant recipients demonstrates the safety and satisfactory long-term outcomes of facial allograft secondary revisions. Printed with permission from and copyrights retained by Eduardo D. Rodriguez, MD, DDS.

Table 4. Fundamental Concepts for Secondary Revision of Facial Vascularized Composite Allografts

1	Respect of aesthetic subunits	Use excess tissue at the time of transplantation; plan for subsequent debulking and excision, tissue rearrangement, and selective fat transfer for appropriate aesthetic unit contour and shape.
2	Defect and allograft boundaries	Adhere to strategic placement of incisions, soft tissue suspension, and scar excision, prioritizing aesthetic subunit borders over defect or allograft boundaries.
3	Tissue requirements	Address the composite nature of the facial area or secondary defect of interest. Surgical plans should be individualized based on color match, tissue requirement (skin, mucosa, fat, muscle, cartilage, or bone), and volume deficiency.
4	Bone and soft-tissue support	Manipulate the vascularized bone structure and osteosynthesis sites to adjust skeletal buttress support, occlusion, and facial projection.
5	Soft-tissue volume	Initial allograft inset should provide abundant soft tissue in excess of the base volume required to account for postoperative edema and potential resorption or contracture while providing the necessary shape for future resurfacing.
6	Timing	Early secondary revisions are appropriate in the emergent setting. Late revisions are safe when appropriately indicated. Plan the sequence of revisions according to diagnosed secondary deficits and in anticipation of time- and gravity-dependent allograft alterations to prioritize functional and aesthetic gains while preventing setbacks in functional recovery.
7	Preservation of primary anastomoses	Plan access sites, dissection planes, and choice of operative approach around the preservation of primary vascular anastomoses and nerve coaptations.

Building on the senior author's previous delineation of critical concepts for microsurgical reconstruction of facial defects,[5] we draw on our evolving experience to outline 7 fundamental concepts for secondary revision of facial allografts. These include the respect of aesthetic subunits, defect boundaries, tissue requirements, bone and soft-tissue support, soft-tissue volume, timing, and sequence of revisions, in addition to preservation of primary anastomoses (Table 4).

Limitations

Despite our efforts to capture all allograft revisions reported to date, our study is limited by its retrospective design and inconsistent reporting of technical and functional outcomes in the literature. The exact timing of certain revisions was not explicitly reported; instead, those were inferred using published data provided in figures and graphs, and converting "postoperative months or years" to "days". Only complications and revisions that have been reported in the literature could be included in our study, and it is possible that the data gathered is an underestimation of the true incidence of those occurrences in clinical practice. Finally, generalization and comparative outcome analysis was challenging due to the unique features of each FT, including mechanism of injury and resultant defect, time from injury to FT, pretransplant autologous reconstruction attempts, and allograft design and execution.

CONCLUSIONS

Secondary surgical revisions are a fundamental feature of posttransplant care of the FT recipient. The worldwide experience shows that revisions can be successfully performed at various timepoints, despite the potential risk of triggering acute rejection or vascular compromise of the allograft, with adequate healing in the setting of immunosuppression. Categorization of revisions into 5 distinct groups allows for a better analysis of outcomes and reveals 7 critical principles for safety and quality in posttransplant revisional surgeries. Future efforts should focus on development of a unified classification system linking the type of facial defect, corresponding optimal allograft design, anticipated potential complications, and recommended treatment algorithm incorporating secondary revisions.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

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