Applications of Fat Grafting in Pediatric Patients

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Abstract

Keywords

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- ▶ scars

Autologous fat grafting has become a widely utilized technique for a variety of cosmetic and reconstructive procedures. Its potential for volume restoration and tissue regeneration has made it a popular method for treating soft tissue defects in both adult and pediatric populations. While autologous fat grafting in the pediatric setting is not as well characterized as it is in the adult setting, various reports have demonstrated the safety and utility of its applications in nonadult patient populations. In this article, we present the first comprehensive review of the current applications of autologous fat grafting in pediatric patients. Specific challenges to fat grafting in the pediatric setting and future applications will also be discussed.

Clinical applications of autologous fat grafting are broad and include a multitude of procedures in aesthetic and reconstructive plastic surgery. Several prominent applications include breast augmentation, breast recontouring, rhinoplasty, and facial rejuvenation.¹ Although mainly described in adults, autologous fat grafting has also been used in the pediatric population for a variety of functional and reconstructive purposes.² Literature to date has described the role of fat grafting in the treatment of congenital defects such as cleft lip and palate, as well as the treatment of secondary soft tissue defects associated with congenital disorders such as Parry–Romberg syndrome and Poland syndrome.^{2–5} In addition, its applications in the management of scars and functional deficiencies related to velopharyngeal insufficiency have also been described.^{2,6}

Despite increasing popularity of autologous fat grafting in the pediatric population, pediatric fat grafting faces many of the same challenges seen in adults, with the most notable being unpredictable resorption rates.^{2,7} Moreover, at present, the literature on fat grafting in the pediatric setting is sparse, and data on long-term outcomes and graft survival rates remain limited. Nevertheless, existing reports describing pediatric fat grafting have shown considerable levels of

safety, efficacy, and patient satisfaction.⁸ Continued investigation into autologous fat grafting in children and adolescents will be important moving forward to fully understand the clinical potential of this treatment modality in the pediatric setting.

Clinical Applications

Reconstructive Applications

Autologous fat grafting has been described in the pediatric setting for the management of a variety of craniofacial, chest, and breast soft tissue deficiencies associated with congenital disorders, including craniosynostosis, craniofacial microsomia, Parry–Romberg syndrome, Poland syndrome, pectus excavatum, and cleft lip. A small number of reports have also described fat grafting to be a valuable approach to pediatric scar management.

Craniofacial

Craniosynostosis

Craniosynostosis is a developmental anomaly characterized by the premature fusion of one or more cranial sutures, often

resulting in significant distortion of the cranium and craniofacial asymmetry.^{9–11} Cranial vault remodeling is the standard treatment option for patients with craniosynostosis.¹¹ Despite adequate surgical correction of involved cranial sutures, small postoperative contour deformities can sometimes persist or recur.¹⁰ Previous reports have described autologous fat grafting as a method to correct these contour deformities following craniosynostosis repair.^{10,12,13} In 2018, a case series analyzing post-craniosynostosis repair asymmetry in patients with a mean age of 6 years was published by Castro-Govea et al. The authors used autologous fat grafts (mean volume = 19 mL) enriched with adipose-derived stem cells (ADSCs) to correct asymmetry and improve facial appearance with high levels of reported patient and family satisfaction.¹⁰ A 2006 study also reported positive outcomes in nine patients with a mean age of 16 years who underwent autologous fat augmentation for the correction of cranioplasty-related contour deficits.¹²

Autologous fat grafting has also been used to improve craniofacial appearance in older patients with unrepaired craniosynostosis. In 2019, Kalantar-Hormozi et al demonstrated the safety and efficacy of fat grafting for anterior plagiocephaly in a case series of 15 adult and pediatric patients who had not undergone prior craniosynostosis repair.¹³ Average age of these patients was 19 years, and mean volume of injected fat was 36.6 mL. Minimal complications were observed, and the majority of patients achieved adequate correction of their cranial deformities.¹³ While no studies investigating the long-term outcomes of fat graft retention in this setting were found, these limited case series suggest positive overall results of fat grafting in pediatric patients with craniosynostosis.

Craniofacial Microsomia

Craniofacial microsomia commonly involves hemifacial hypoplasia affecting facial bones and overlying soft tissue.¹⁴ Craniofacial microsomia presents unilaterally in 85% of cases, often resulting in facial asymmetry.¹⁵ While treatment options for craniofacial microsomia-associated mandibular defects have been studied extensively, much less investigation on the surgical treatment of the overlying soft tissue deformity has been performed.¹⁴ Bony operations such as mandibular distraction osteogenesis can effectively improve the mandibular deformities. However, distraction alone is often unable to sufficiently improve the facial asymmetry.¹⁶ Autologous fat grafting has been described as a surgical adjunct to improve the contour and facial symmetry in these patients.¹⁴

A 2019 systematic review of 38 articles evaluated the surgical treatment options for the soft tissue deformities seen in patients with craniofacial microsomia.¹⁴ In this review, Sinclair et al reported that while microvascular free flaps could provide greater volume augmentation in fewer total procedures, structural fat grafting could achieve a higher degree of facial symmetry with significantly lower complication rates (27.1 vs. 4.2%, respectively).¹⁴ Patients who underwent fat grafting in this study ranged from 3 to 25 years and received grafted volumes between 15 and 198 mL. Patients of all Pruzansky classes were involved and fat grafts were utilized

both alone and as adjuncts to other treatments such as bony surgeries. The authors also emphasized that to achieve adequate volume augmentation and symmetry of the face, multiple sessions are required; patients who received fat grafting underwent an average of 2.7 sessions with a range of 1 to 6 sessions. The application of serial fat grafting largely depends on the severity of the soft tissue defect. Mild to moderate soft tissue deficiencies can be managed by serial fat grafting alone, whereas more severe deficiencies typically require free tissue transfer with subsequent fat graft contouring.¹⁴ In summary, while several studies have demonstrated the benefits of autologous fat grafting in correcting soft tissue deformities in pediatric patients with craniofacial microsomia, the literature in this context is limited to a single retrospective cohort, a case control study, and a handful of case series.^{14,16–19}

Parry–Romberg Syndrome

Parry–Romberg syndrome is a rare congenital disorder characterized by the progressive atrophy of soft tissue on one side of the face followed by spontaneous remission and stabilization of soft tissue volume. This hemifacial atrophy often leads to significant facial asymmetry and a poor aesthetic appearance. While the classical treatment for hemifacial soft tissue atrophy in Parry–Romberg syndrome has been microsurgical free flap reconstruction, autologous fat grafting in this setting has been found to be equally effective, less invasive, and associated with decreased donor site morbidity and operative time compared with free flap reconstruction (► **Fig. 1**).²⁰

Application of fat grafting in Parry–Romberg syndrome is often tailored to the severity of disease. In patients with mild disease, smaller volumes of 1 to 3 mL can be injected into focal areas, such as the periorbital and glabellar regions, for effective facial contouring. Patients with more severe phenotypes may require larger volumes up to 400 mL and multiple lipofilling treatments to achieve complete volume correction and facial symmetry.²⁰ Notably, the amount of fat graft used in the initial transfer may be limited due to decreased elasticity of the affected skin and its fixation to underlying structures. The first injection improves the quality of the tissue, making subsequent fat transfers more effective.^{20,21}

To facilitate more accurate surgical planning of volume correction and minimize potential for repeat grafting, volume replacement in Parry–Romberg syndrome is generally recommended after the soft tissue atrophy has stabilized.³ As it may take several years for the disease to stabilize, patients with Parry–Romberg syndrome typically undergo lipofilling as adults.^{20,22,23} Only a few case reports and series have described fat grafting in pediatric patients with Parry–Romberg syndrome. Ages of these patients ranged from 9 to 17 years old.^{20,24–27} In one case, a 15-year-old patient with Parry–Romberg syndrome received fat grafting within a year of her disease stabilization. She ultimately underwent three fat grafting sessions at 6-month intervals with improved facial asymmetry.²⁴ Notably, another case study of a 9-year-old boy with Parry–Romberg syndrome demonstrated excellent results when fat grafting was performed during the active phase of the disease, despite preferred timing of treatment after disease stabilization.²⁷ Based on a systematic review of 31 articles

Fig. 1 An 8-year-old patient with Parry-Romberg syndrome presented to our institution with resultant left-sided hemifacial hypoplasia. The patient underwent a series of three fat grafting sessions over a span of 2 years. Fat was injected into left cheek and temple area. (A) Before fat grafting, (B) post first injection (15 cc), (C) post second injection (11.5 cc), and (D) post third injection (10 cc).

involving both adult and pediatric patients with Parry-Romberg syndrome, fat grafting was able to achieve positive aesthetic outcomes with reduced complications, cost, donor site morbidity, and operative time compared with reconstruction with free tissue transfer. Overall, lipofilling has gained acceptance as a safe and reliable treatment option for volume restoration in patients with Parry-Romberg syndrome.²⁰

Cleft Lip

Patients who undergo cleft lip revision are often left with nasolabial tissue deficiencies despite successful correction of their primary defect.⁴ These deficits can result in a flat upper lip, indistinct philtral columns, and vermillion border deficiency.^{28,29} Historically, secondary revision techniques, such as z-plasty and V-Y advancement, have been used to correct this volume deficiency.⁴ However, these procedures create additional facial scars and rely on adjacent areas that are already relatively devoid of soft tissue.³⁰ Autologous fat grafting has been used following cleft lip revision to replenish nasolabial volume and avoid the undesirable shortcomings of alternative procedures.^{4,30} Fat grafts in these cases are preferably taken from the abdomen. Injection volume typically ranges from 1 to 3 mL for a single region to 7 to 10 mL if multiple areas are to be treated. Most commonly injected areas are the philtral column bordering the repaired lip, the upper lip vermillion, and the alar base to replenish the common tissue deficient areas.³⁰

Multiple studies have demonstrated the long-term safety and efficacy of fat grafting for residual cleft lip deficiencies, reporting improved fullness, contour, and overall cosmesis of the upper lip.²⁹⁻³¹ One remaining question in this field is optimal timing of fat grafting. While most studies report the application of fat grafting long after cleft lip repair, two studies have reported positive outcomes of fat grafting at the time of cleft lip primary repair in infants.^{32,33} Despite these promising outcomes, data regarding fat grafting following cleft lip revision remain relatively limited.^{4,29-34}

Chest and Breast

Poland Syndrome

Poland syndrome is a rare congenital condition characterized by the unilateral absence or underdevelopment of the

chest wall muscles and associated limb deformities, including syndactyly or brachydactyly, on the ipsilateral side. The exact etiology of Poland syndrome is unknown but is thought to be related to disruption of the blood supply to the embryonic tissues that give rise to the chest wall and hand.³⁵ Clinically, patients often present with breast hypoplasia and thoracic abnormalities, including subclavicular hollowing and absence of the sternal head of the pectoralis major muscle and an anterior axillary fold. Long bones, rib cage, cartilage, skin, breast, and subcutaneous tissue can all be malformed on the affected side.^{35,36} In males, chest wall asymmetry is a major issue.³⁶ In females, breasts are also abnormal in both size and position, making breast asymmetry a major issue.^{36,37} Autologous fat grafting has been used alone, and more often in conjunction with traditional reconstructive techniques such as flaps and implants, to fill the volume and contour deficits seen in patients with all grades of severity of Poland syndrome.³⁶

Chest wall reconstruction in males with Poland syndrome can involve autologous fat grafting, customized chest wall implants, or flap-based reconstruction depending on the severity of the deformity. In milder cases, autologous fat grafting can be an effective option for minor contour and bulk defects that may not necessitate implants or larger scale reconstructions. More severe cases are typically treated with customized chest wall implants or autologous reconstruction with free or pedicled flaps, with additional fat grafting to correct contour deficits. In females with Poland syndrome, flap reconstructions or breast implants with or without tissue expansion are commonly needed to reconstruct the breast. Autologous fat grafting in this population typically serves as an adjunct to standard breast reconstruction options.³⁶

Autologous fat grafting can reduce the need for implants or complement other methods of chest wall reconstruction to improve muscle and breast contour.^{36,37} Treatment of Poland syndrome with autologous fat grafting alone avoids complications associated with the use of exogenous materials or flaps and has been shown to have high patient satisfaction rates.³⁸ Moreover, in more severe cases of Poland syndrome, the latissimus muscle can be hypoplastic preventing the use of a pedicled latissimus flap and requiring an alternative, effective method of chest reconstruction.³⁹ Autologous fat grafting may

serve as a reasonable alternative when flaps are not a feasible option.^{37,39}

Cases of fat grafting in pediatric patients with Poland syndrome are rare, and there are limited data on the long-term outcomes of this treatment strategy. However, Coudurier et al and Delay et al each reported effective and stable results of breast reconstruction in complimentary 6- and 11-year follow-up studies of a patient with severe Poland syndrome treated solely with autologous fat grafting. Five grafting sessions were performed in this patient, each several months apart.^{37,39} La Marca et al presented a case series of 10 patients with Poland syndrome and mean age of 16 years who were also treated with fat grafting alone. These patients had a mean follow-up of 51 months and demonstrated high patient satisfaction without complications.³⁸ In the few studies described in the literature, fat grafting has been shown to be a useful technique to correct chest bulk and contour defects in pediatric patients with Poland syndrome.^{36–39}

Pectus Excavatum

Pectus excavatum is a deformity characterized by depression of the anterior chest wall due to overgrowth of the rib cage. Primary repair of pectus excavatum often leaves residual contour defects in the anterior chest wall. A recent study by Facchini et al described the use of autologous fat grafting to treat these residual defects and improve chest contour following minimally invasive pectus excavatum repair.⁴⁰ Mean satisfaction score was increased from 1.8 to 2.7 (0 = unacceptable, 1 = acceptable, 2 = good, 3 = very good, 4 = excellent) after fat grafting, suggesting a beneficial application of fat grafting in chest wall refinement following pectus excavatum repair.⁴⁰ Fat grafting has also been described in the treatment of breast asymmetry in these patients, yielding natural results and high patient satisfaction.⁴¹ Despite these positive outcomes, fat grafting to the sternal area can pose a challenge. The abundance of ligaments and restriction of subcutaneous tissue in the sternal area can result in poor graft survival. Overall, there are no studies to date specifically investigating the long-term viability of autologous fat grafts in pediatric patients with pectus excavatum.⁴⁰ The two case series describing autologous fat grafting for the management of pectus excavatum included a mixture of adult and pediatric patients; however, they all found fat grafting to be a useful treatment modality for patients with pectus excavatum.^{40,41}

Iatrogenic Breast Injury

Literature on autologous fat grafting in the management of iatrogenic tissue damage in pediatric patients is extremely limited. Only a few cases describe autologous fat grafting in the treatment of breast asymmetry secondary to iatrogenic breast bud injury.^{42,43} Ho Quoc et al reported two patients who developed asymmetric breasts as a result of breast bud injury from childhood thoracotomies.⁴² Fat grafting successfully improved the breast asymmetry in these patients. Although these patients received fat grafting as adults, iatrogenic damage to the chest wall or breast buds from thoracotomy or tumor resections can often occur during childhood.⁴² Patients may thus undergo fat grafting to

restore breast symmetry during adolescence if their breast growth has stabilized.

Scars

Autologous fat grafting has become a popular tool used for the treatment of scars. Many studies have demonstrated the benefits of autologous fat grafting in improving scar appearance, skin characteristics, scar related pain, and volume restoration of scarred tissue.^{44,45} These benefits are more commonly reported in adult patients, and evidence for these same effects in the pediatric population is relatively scarce.^{44,45} A small number of case reports have demonstrated improvements in scar appearance in pediatric patients after treatment with fat transfer combined with other techniques, such as z-plasty, pulsed dye laser, and ablative fractional laser resurfacing.^{46,47} Another study demonstrated improved appearance and functionality of surgical scars in children after fat grafting alone.⁴⁸ In contrast, one randomized controlled trial demonstrated that single treatment with autologous fat grafting in pediatric patients did not improve the appearance of mature burn scars compared with normal saline injections.⁴⁵ The overall lack of data regarding fat grafting for scar management in the pediatric setting and reports of conflicting outcomes suggest that further investigation is required to better understand this particular application.

Functional Applications

Autologous fat grafting has also been described as a treatment option to restore function, mainly in pediatric patients with velopharyngeal insufficiency and cleft palate.

Velopharyngeal Insufficiency and Cleft Palate

Fat grafting in patients with cleft palates is mainly utilized to treat associated velopharyngeal insufficiency.³⁰ Velopharyngeal insufficiency is characterized by hypernasality and an audible nasal air emission during phonation due to inadequate velum closure of the posterior pharyngeal space. Velopharyngeal insufficiency can occur both before and after cleft palate repair, and the size of the velopharyngeal gap often determines the degree of speech impairment. While no consensus exists regarding the best treatment option for velopharyngeal insufficiency, autologous fat grafting has become an increasingly attractive approach to augment the posterior pharyngeal wall to narrow the gap.⁴⁹

When treating velopharyngeal insufficiency, autologous fat grafting has been shown to have positive speech outcomes when injected into various regions of the velopharyngeal space, including the soft palate and posterior and lateral pharyngeal walls.^{30,49} One study of 46 patients, who underwent autologous fat injection into the soft palate alone, demonstrated improved speech intelligibility and no complications. The average age in these patients was 5 years, and average length of follow-up was 12 months.^{49,50} Several case studies have also demonstrated improved speech outcomes after posterior pharyngeal wall augmentation with autologous fat.^{51–53} Autologous fat grafting with concomitant surgical repair such as z-plasty and sphincterpharyngoplasty can also improve air escape, speech quality, and velar mobility.^{49,54}

Autologous fat grafting for the treatment of velopharyngeal insufficiency has several notable disadvantages. Fat injection into the lateral or posterior pharyngeal wall has resulted in both stroke and patient death from iatrogenic injection into the internal carotid arteries and subsequent fat emboli. For this reason, the authors do not advocate pharyngeal wall injections. One other significant disadvantage is graft hypertrophy with fluctuating body habitus, which can lead to airway obstruction and severe obstructive sleep apnea. While this complication is relatively uncommon, Phua et al suggested that patients with syndromes associated with hypotonia may be at increased risk for this rare but notable complication.^{30,55}

Despite several disadvantages, in select patients with small focal closure gaps, autologous fat grafting provides a less invasive treatment option for velopharyngeal insufficiency. When performed into the velum alone, it is associated with lower morbidity and fewer complications than traditional surgical treatment options such as pharyngeal flaps, palatoplasty, pharyngoplasty, and synthetic implants.⁴⁹ While traditional surgical treatment options may be associated with more risks, they have favorable functional outcomes and are recommended for severe cases of velopharyngeal insufficiency.^{6,49} In summary, autologous fat grafting into the velum is a safe, effective, and minimally invasive treatment strategy for select groups of patients with mild velopharyngeal insufficiency.^{6,49}

Concerns and Complications

While certain complications of autologous fat grafting, such as unpredictable resorption rates and risk of fat emboli, may occur in both adult and pediatric populations, fat grafting in children may pose its own set of unique challenges. Specifically, children and peripubertal adolescents often exhibit active growth and weight gain that may influence graft integration and proliferation, making volume correction difficult to predict. Unfortunately, studies to assess and quantify the true impact of puberty on autologous fat grafts are yet to exist. Moreover, children with congenital conditions such as Parry-Romberg syndrome may exhibit higher resorption rates than the normal population.⁸ Children also have minimal fat stores compared with adults, potentially limiting available donor sites for autologous fat grafting.²

Future Applications

The ADSCs that reside in fat grafts have shown much potential to promote tissue regeneration.¹ One study of fat grafting in patients with craniofacial microsomia reported increased fat graft survival and a significant improvement in facial asymmetry with fat grafts supplemented with ADSCs. Surviving graft volumes at 6 months in grafts with and without ADSC supplementation were 88 and 54%, respectively.^{14,18} The addition of ADSCs to fat grafting for soft tissue augmentation in craniofacial microsomia and other congenital soft tissue disorders may prove to be a useful tool in the future.¹⁴

Conclusion

This article presents the first comprehensive review of the clinical applications of autologous fat grafting in pediatric patients. While the literature on fat grafting in the pediatric setting remains significantly limited compared with that in the adult setting, this modality of treatment has demonstrated high levels of safety and efficacy in reestablishing both appearance and function in a variety of pediatric conditions. With its well-documented volume restoring and tissue regenerating potential, autologous fat grafting in the pediatric population should be further investigated to expand its indications for pediatric patients as well as to establish best-practice guidelines moving forward.

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Conflicts of Interest

None declared.

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