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FACIAL PLASTICS: FUNCTIONAL RHINOPLASTY(TD WANG AND CZ JOHNSON, SECTION EDITORS)

Rhinoplasty in Kids: Why, How, and When

Lisa Morris[1]

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Abstract

Purpose of Review The purpose of this review is to summarize the current literature regarding rhinoplasty and septoplasty in the pediatric population. This review seeks to answer the question of the safety of pediatric septorhinoplasty and long-term outcomes after pediatric septorhinoplasty.

Recent Findings Pediatric rhinoplasty and septoplasty are recognized as safe procedures in appropriately selected patients. The Nasal Obstructive Symptom Evaluation (NOSE) scale was found to be valid and reliable in the pediatric population. There is an increasing trend of performing rhinoplasty in younger adolescents and children, especially with cleft lip nasal deformity.

Summary Pediatric septoplasty and rhinoplasty can be done safely with minimal impact on nasal and facial growth. For children with severe nasal airway obstruction, earlier surgical treatment may improve nasal function and subsequent facial growth. Surgical outcomes may be unpredictable and revision rates are higher than adults. Long-term follow-up and results are lacking in the literature.

Keywords Pediatric rhinoplasty · Pediatric septoplasty · Pediatric nasal surgery · Timing of surgery

Introduction

Pediatric nasal surgery, including both septoplasty and functional rhinoplasty, has been a controversial topic due to the risks of operating on a growing nose (Table 1). Pediatric septoplasty is performed to correct the obstructive deviations of the nasal septum that contribute to nasal obstruction. Pediatric rhinoplasty alters the external structure of the nose, including the nasal bones, upper and lower nasal cartilages, and nasal soft tissue envelope. It can be performed with or without a septoplasty. Pediatric nasal surgery is generally defined by ages < 14–16 years old for girls and < 16–18 years old for boys [1–3]. Accepted practice over the past century has been to delay surgical repair until the patient has reached skeletal maturity, except in rare cases. This dogma has been challenged in recent literature. More recent studies show conservative surgical intervention with both pediatric septoplasty and pediatric rhinoplasty can be performed safely [4, 5•, 6–8, 9•, 10, 11••]. The purpose of this study is to review the recent literature regarding the safety of pediatric rhinoplasty, the indications, surgical maneuvers, and at what age this should be performed.

Historical Perspective

Controversy with pediatric nasal surgery dates back over 100 years ago with nasal deformities and growth restrictions reported in the literature prompting recommendations to delay surgical repair until a patient reaches skeletal maturity [12, 13]. Initially presented by Freer in 1902 [14], pediatric submucosal septoplasty was performed but with minimal understanding of the structural role of the septum and lack of knowledge that it is the growth center for the nose and face. Follow-up of these early patients over the next few decades reported significant growth disturbances of the nose in some patients [12, 13]. In 1916, C.H. Hayton reported on

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✉ Lisa Morris
Lmor17@lsuhsc.edu

[1] Louisiana State University Health Sciences Center-New Orleans, 533 Bolivar Street, Suite 566, New Orleans, LA 70112, USA

Table 1 Risks of operating on a growing nasal structure

- Growth restriction of the nose
- Growth restriction of the facial skeleton
- Altering normal growth patterns and appearance of the nose
- Causing scar tissue, damage to cartilage, structural weaknesses, and septal perforations
- Temporary improvements that do not offer long lasting results
- Unsatisfactory esthetic or functional result once skeletal maturity is reached

53 patients aged 6–14 years of age who underwent submucous resection of deviated septal cartilage, always leaving at least a narrow dorsal strut, but not always a caudal strut. Follow-up 2–7 years later demonstrated no septal perforations, 92% had beneficial breathing results, but 35% showed nasal deformity. These deformities were primarily reported as saddle nose deformities and widening of the nasal dorsum [13]. As a result of this high rate of deformation, pediatric nasal surgery fell out of favor except for limited cases including acute nasal trauma, septal abscess and hematoma, nasal dermoid, and some cleft nasal deformities [15]. Septoplasty and rhinoplasty procedures prior to skeletal maturity were universally discouraged except for rare instances [15].

Animal studies in the decades that followed helped us to better understand the growing septum and nasal structures. The growth centers of the nasal septum were well delineated, and studies were carried out to understand how nasal trauma and surgical interventions would affect growth of the nose and facial structures [16]. The first report of long-term outcomes in conservative pediatric rhinoplasty was reported in 1981 by Ortiz-Monasterio et al. In this study, rhinoplasty performed on 8- to 12-year-old children showed no growth disturbance and satisfactory outcomes at 15 years of age. The pendulum began to swing back near the turn of the millennium with McComb and Coughlin in 1996 and Salyer et al. in 2003. These authors reported their 18-year and 33-year history, respectively, of primary rhinoplasty results for infants with cleft lip nasal deformity [17, 18]. The goal of primary rhinoplasty was to create near normal appearance to the nose but only involved undermining of soft tissues and repositioning of the lower lateral cartilages. Long-term follow-up into skeletal maturity revealed lasting improvement in nasal appearance with minimal effect on nasal growth. It was also noted by Salyer et al. that elimination of nasal airway obstruction at a young age helped with long-term structural results.

Traditional teaching of delaying reconstruction of the nose until skeletal maturity remained the cornerstone in the literature. Recent studies have challenged this thinking, stating that intervening early on severe deformities may lessen the structural abnormalities as the child ages [4, 10, 11••, 19]. Surgeon practice has also shown a trend of increased numbers of prepubertal nasal surgeries. Multiple studies utilizing the American College of Surgeons National Surgical Quality Improvement Program-Pediatric (NSQIP-P) database have demonstrated this with surgeon billing practices [9•, 20•, 21]. A study by Kamil et al. included 1378 patients under 18 years of age who underwent rhinoplasty between 2012 and 2015 with a mean age of 10.3 years old.

With more studies including the pediatric patient, the literature has shown that rhinoplasty and septoplasty in this age group can be done safely. The previous study by Kamil et al. in 2019 reported a low 30-day complication rate of 1.52% for pediatric rhinoplasty [9•]. A systematic review of pediatric septoplasty in 2020 showed no major disturbances in facial growth and only minor nasal anomalies [11••].

Anatomy and Growth

The pediatric nose differs from the adult nose. Intricate understanding of these differences is necessary for the rhinoplastic surgeon to avoid untoward injury to the growing nose. On external evaluation, the pediatric nose has a larger nasolabial angle, less tip and dorsal projection, a shorter columella, shorter nasal dorsum, rounded nares, and flatter nasal tip [16, 19]. The pediatric nasal structure is more cartilaginous than the bone. In infants, the septal cartilage extends from the nasal tip anteriorly and reaches the sphenoid bone posteriorly. The bony perpendicular plate of the ethmoid and the vomer begin to ossify and grow towards each other in the posterior septum, making contact with the other between 6 to 10 years of age [1, 16]. The nasal bones are separated in the midline by an open suture, making them easier to displace with trauma [22]. The upper lateral cartilages extend completely underneath the nasal bones up to the skull base. These join with the septal cartilage forming the "T-bar," which is the primary support of the young pediatric nose [16]. As the child grows, the upper lateral cartilages migrate caudally and are replaced by the ossifying cribriform plate [3, 19]. Importantly, there are 2 growth centers of the nose located in the nasal septum, the sphenodorsal zone and the sphenospinal zone. (Fig. 1) [23]. The *sphenodorsal zone* extends from the sphenoid rostrum and along the dorsum of the nose. This controls growth of the length and height of the nasal dorsum [1, 6, 16, 24]. The *sphenospinal zone* extends from the sphenoid to the anterior nasal spine and controls the forward growth of the maxilla [4, 6, 24, 25]. The septospinal ligament connects the cartilaginous septum to the premaxilla and bridges the growth of the septal cartilage to the facial bones [16]. There are 2 periods of significant nasal growth: (1) from 2–5 years of age and (2) during puberty [6]. The pubertal growth phase occurs between ages 12 and 16 years for females and ages 15 and 18 years for males [1]. After the last growth spurt, nasal

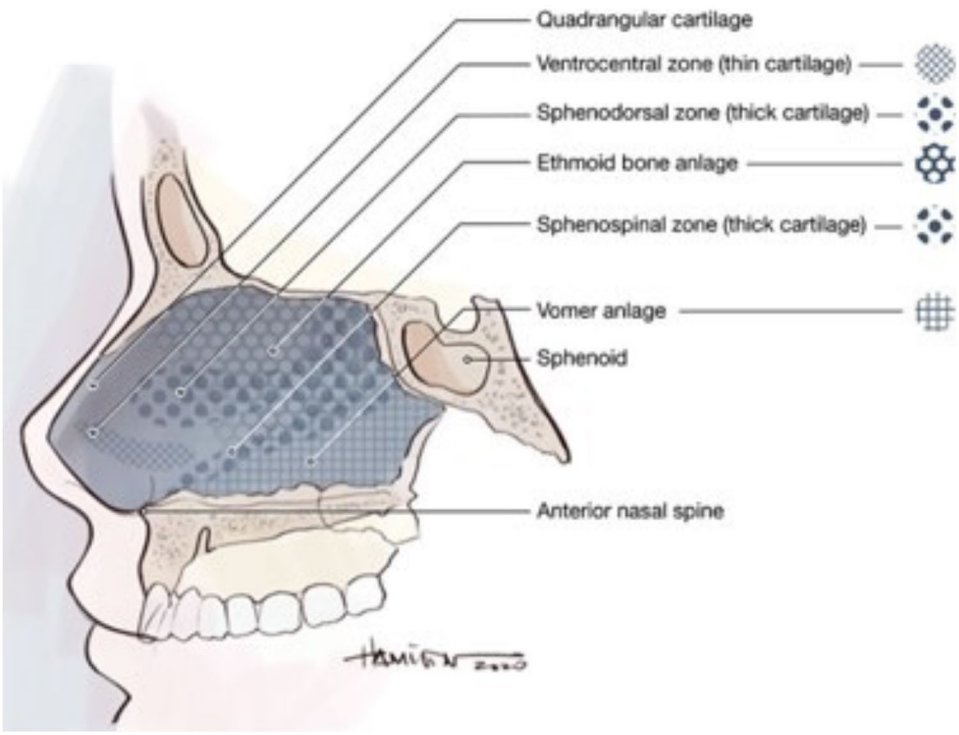

Fig. 1 Illustration of the neonatal septum demonstrating the sphenospinal and sphenodorsal zones. (Original illustration by Grant S. Hamilton, III. Courtesy of *Rhinoplasty Archive* at https://www.rhinoplastyarchive.com/articles/septal-surgery/pediatric-septoplasty.") [23]

growth continues at least to the age of 20 in women and 25 in men [26]. Injury to these growth centers has demonstrated detrimental effects on nasal and midface growth [24]. Even minor trauma or deviation occurring during nasal growth can cause progressive malformation via growth disturbances [27]. This is another principle that the pediatric rhinoplasty surgeon needs to consider in their decision making.

Why: Indications for Surgery

The goals of pediatric nasal surgery are to [16]:

- Improve nasal functioning
- Restore normal appearance
- Prevent future growth disturbances
- Mitigate psychosocial concerns

Most surgeons agree the absolute indications for operating on a child's nose prior to skeletal maturity include acute nasal trauma, septal hematoma, septal abscess, malignancy, congenital masses (nasal dermoids, gliomas, hemangiomas, etc.), and congenital deformities (cleft lip nasal deformities, Tessier facial clefts, piriform stenosis, etc.) [28]. Controversy exists in the relative indications in which severity may differ, including nasal airway obstruction (NAO), septal deviation, nasal valve collapse, and chronic nasal deformity. More recent studies argue not correcting a child's nasal deformity may contribute to further nasofacial deformity and cause increased NAO as the child grows [4, 11••, 19, 24].

There is no consensus on what severity of nasal obstruction requires surgical intervention. Severe NAO has been found to create obligate mouth breathers, which over time can contribute to jaw and dental abnormalities [29•]. A 2021systematic review and meta-analysis of the effect of mouth breathing on facial skeletal development in children demonstrated underdevelopment of the jaw in children who were chronic mouth breathers. It also showed maxillary and mandibular backward and downward rotation, steep occlusal plane, and a tendency of labial inclination of the upper anterior teeth [29•]. A thorough understanding of the cause of NAO is paramount prior to developing a surgical plan. NAO can have numerous causes in addition to a septal deviation or nasal valve collapse which may need to be addressed prior to considering nasal surgery (Table 2) [28, 29•, 30].

The Nasal Obstruction Symptom Evaluation (NOSE) scale was introduced in 2004 to evaluate subjective nasal obstructive symptoms. This is a disease specific quality of life instrument and is routinely used in the evaluation of adult nasal obstruction [30]. Recent studies have found the NOSE scale is valid and reliable in the pediatric population

Table 2 Causes of nasal airway obstruction (NAO)

Adenoid hypertrophy	Septal deviation	Congenital masses
Turbinate hypertrophy	Nasal valve collapse	Septal hematomas
Nasal polyps		Septal abscesses
Allergic rhinitis	Midface hypoplasia	
Chronic sinusitis	Piriform stenosis	

[30, 31]. The authors demonstrated significant improvement in QOL after both septoplasty and functional rhinoplasty in these patients after a 2–4-month postoperative follow-up. Manteghi et al. performed a prospective study utilizing this quality-of-life measure in 136 patients with a mean age of 15.7 years old, finding statistically significant improvement in NOSE scores post septoplasty and functional septorhinoplasty 3.6 months after surgery [32].

How: Surgical Techniques

The current literature suggests pediatric nasal surgery can be performed with minimal nasal and facial growth inhibition [4, 19]. There is consensus in the literature that conservative techniques should be employed in both pediatric septoplasty and pediatric rhinoplasty procedures. There is disagreement however as to what this entails.

Pediatric Septoplasty

Conservative surgery should be the goal. The following techniques have been recommended in the literature.

- When performing a septoplasty in a child, the surgery should be limited to the pathologic area only [4].
- Elevation of mucoperichondrial flaps will not affect growth, however care should be given to avoid tears or damage to these flaps [16, 28]. Limiting flap elevation to only one side of the quadrangular cartilage will provide further stability of the septum [16].
- Fractures and cartilage deviations should be identified and whenever possible, mobilization and repositioning of the cartilage should be performed. Greenstick fractures must be converted to a full fracture before reduction [28].
- Scoring of the concave surface of cartilaginous septum and horizontal mattress molding sutures can straighten a bowed septum but may be unpredictable [16, 22]. If repositioning is insufficient in correcting the nasal obstruction, conservative cartilage resection can be performed, but avoid incisions through the sphenodorsal and sphenospinal zones [28]. This includes much of the area typically resected in adults.
- Avoid separating the quadrangular cartilage from the perpendicular plate of the ethmoid.
- Consider reconstructing a significant septal defect by straightening and replacing any excised cartilage to minimize the risk of septal perforation or scar tissue that has no growth potential [16]. This repositioned cartilage is at risk for recurrent deviations or dislocations. It may benefit from the use of a polydiaxone scaffold (PDS plate) to secure the cartilage pieces into proper position [16, 22]. PDS plate can be placed on one side of the septum to offer further support when needed [16].
- A luxated caudal septal deflection can be released and repositioned into a columellar pocket and sutured between the medial crura [16, 22]. However, full release of the septospinal ligament may disrupt forward growth of the upper jaw [16].
- Resection of the bony deviation of the premaxillary crest and the vomer with mobilization or partial resection does not disturb the outgrowth of the nose [16].
- Quilting sutures and/or splints should be used to avoid intraseptal blood collection and subsequent abscess and cartilage necrosis [16].

Pediatric Rhinoplasty

Conservative pediatric rhinoplasty maneuvers are recommended; however, the extent of surgery and specific techniques are not agreed upon. The following are numerous authors' recommendations; however, little knowledge is available about the use of specific techniques in this population.

- The open approach and transcolumellar incision have not been shown to cause growth restriction [19].
- Many accept osteotomies as safe procedures [1, 2, 10, 33, 34] however this may disrupt the underlying T-bar structure as the upper lateral cartilages extend fully under the nasal bones in young children. Verwoerd et al. cautions against osteotomies in conjunction with septal reconstruction due to disrupting overall nasal support.
- Many have reported dorsal reduction maneuvers with scissor, rasp, and osteotomes [10, 24, 27]. Hump reduction and the use of spreader grafts are discouraged by Verwoerd et al. as it also disrupts the T-bar and sphenodorsal growth zone [3, 16]. Shandilya et al. recommend deferring this maneuver until after the pubertal growth spurt [2].
- Cartilage grafts have been reported to be unpredictable [2] and discouraged by some [10] but are widely used by many authors [2, 24, 33]. Spreader grafts that require disruption of the T-bar structure should be avoided according to some [2, 22] but are routinely used by others to support the deviated nasal dorsum and address nasal valve collapse [24, 35].
- Tip suturing and onlay grafts will not disturb nasal growth [2, 18].
- Extracorporeal septoplasty should be avoided prior to skeletal maturity [4, 35].
- Cartilage donor sites reported include septal, auricular, and costal cartilage [24, 33, 35]. Autografts and allogenic rib grafts have been shown to be safe and effective [36].
- Grafts placed in the growing nose include columellar and dorsal struts, shield and batten grafts, onlay grafts, and lower lateral cartilage augmentation grafts [2, 24, 27].

The author agrees with Wright et al. that a graduated approach to surgical management is needed. Younger children should receive the most conservative approaches, when possible, as deformities will worsen with subsequent growth, both traumatic and iatrogenic. Clearly, further studies with long-term follow-up after skeletal maturity are needed to understand which techniques are appropriate and when to use them. The pediatric rhinoplasty surgeon needs to be decisive and thoughtful on what techniques are needed to address the area of obstruction while minimizing destabilization of the remaining structures, avoiding maneuvers that will affect normal nasal growth, and leaving adequate structure to aid in revision surgery in the future should this be needed.

When: Timing of Surgical Intervention

Optimal timing is just as elusive as ideal techniques. When possible, reconstructive nasal surgery should be deferred until after the pubertal growth phase or once skeletal maturity is reached. When indications are appropriate, early treatment is acceptable. Emergent intervention is needed on acute nasal trauma, septal hematomas/abscesses, malignancy, or other threatening conditions, despite patient age. Early intervention is generally accepted for primary cleft rhinoplasty, nasal dermoids, hemangiomas, and other congenital lesions.

Timing for treatment of NAO or severe nasal deformity is dependent upon surgeon judgment and shared decision-making with the patient and parents. The expected benefits of early intervention must be weighed against the possible adverse outcomes and subsequent nasal and midfacial growth [2]. Younger children are more susceptible to growth restriction with disruption of the growth zones than older children [3] and have higher rates of complication after surgery [9•]. Many authors advocate for septoplasty after 6 years of age to allow for completion of the first growth spurt, but earlier intervention can be performed safely and may prevent worsening of nasal and facial deformity [5•, 24, 28, 37]. Cooperation of the patient with postoperative care and management should be taken into consideration. The child needs to be compliant with splinting of the nose, avoiding nose blowing, digital manipulation of the nose, and physical activities that may put the repair at risk to further injury. Internal splints and permanent suture use may necessitate repeat anesthesia if the child is not cooperative with removal. Older children near the end of the pubertal growth phase may be treated more aggressively than those that have not yet started the pubertal growth phase [22]. Psychosocial concerns and their impact on the child may also prompt early intervention but discussion regarding realistic goals, risks of an undesired outcome, and the possibility of future revision surgery should be held with the parents and the patient.

Late Effects of Surgery

The pediatric rhinoplasty and septoplasty literature is limited in long-term follow-up that extends to skeletal maturity. This long-term follow-up is required to optimally evaluate the effect of surgical procedures on the growing nose and face [11••]. Authors that have followed outcomes at least to adolescence have shown trends worth discussion.

Shandilya et al. in 2007 reviewed 106 children who received rhinoplasty surgery between 3 and 19 years of age with a mean follow-up of 4.5 years. A variety of rhinoplasty techniques were performed, and a variation of cartilage grafts were utilized, both autogenous and homologous. The authors found that "good results achieved after initial surgery can be lost to the second spurt of growth during puberty." The surgical revision rate was found to be 16.9%. Bae et al. in 2013 looked at 64 patients, with a mean age of 16 years old, who underwent a rhinoplasty procedure with an average follow up of 5 years. Patients reported a postoperative esthetic dissatisfaction rate of 26.6% and difficulty breathing in 12.5% of patients. The subsequent surgical revision rate was 9.4%, with 6.3% considering surgical revision. They found no short-term healing complications but demonstrated re-deviation, tip depression, and widening of the dorsum over the follow-up period [2].

A systematic review of pediatric rhinoplasty was performed by Gupta et al. in 2016. The review included 7 studies (both the articles by Shandilya et al. and Bae et al. were part of the review). A total of 253 patients received a rhinoplasty between 7 months and 19 years of age. Surgical outcomes showed a complication rate of 39.6%, esthetic dissatisfaction of 11.8%, postoperative nasal obstruction of 5.6%, and a revision rate of 13.5%. The authors found rhinoplasty was safe in the pediatric population but revision rates appear higher than those reported for adults [6].

Maniglia et al. in 2016 reported on 202 children between the ages of 4 and 16 years with septal or nasal pyramid deviation. Surgical treatment included conservative submucosal septoplasty with limited excision of cartilaginous septal deviation, conservative excision of bony deviation, and repositioning of the cartilage and bone when possible. For rhinoplasty, an endonasal approach was performed via intercartilaginous incisions with dorsal hump removal as well as medial and lateral osteotomies. No tip work or grafting was performed. Maximum follow up was 180 days (6 months) with relapse or persistence of the deviated septum as the most frequent complication at 14%. The surgical revision rate during this follow-up time frame was 4.45%. The author discusses the possibility of inappropriate growth of the septum after surgery and the

necessity of secondary surgery in the future [10]. Fuller et al. in 2018 reported on 39 patients, with a mean age of 15.9 years at the time of septorhinoplasty, and an average follow up of 8.5 months. The majority of patients had septal cartilage used for grafting with spreader grafts being the most commonly placed graft. The authors showed significant improvement in NOSE scores but a 5% revision rate due to recurrent septal deviation [24].

These studies demonstrated an increased unpredictability associated with pediatric nasal surgery. Because the nose is still growing, there is a risk even minor imperfections may become severe. Much of the literature with long-term follow-up is found in the cleft lip nasal deformity population, in which rhinoplasty surgery is common. Primary rhinoplasty in infancy with soft tissue elevation and minimal cartilage repositioning is performed to create improved symmetry of the nose which has been shown to persist into adulthood [3, 20•]. A conservative intermediate rhinoplasty can be judiciously performed during childhood or adolescence if indicated for severe nasal obstruction or psychosocial concerns. Definitive septorhinoplasty is deferred until after skeletal maturity is reached and any orthognathic surgery is complete as this is the best chance to get a reliable and stable esthetic result [3, 20•]. This population often has a complex nasal and facial deformity requiring aggressive surgical intervention, which is best performed after growth is complete [38]. Children with severe noncleft-related nasal deformities or septal deviations may benefit from a similar graded approach.

Conclusion

Conservative and selective pediatric nasal surgery can be performed without significant negative effect on nasal or facial growth. Conservative techniques are recommended to minimize interruption to growth centers. Pediatric nasal surgery has been found to be effective in correcting nasal obstruction and deformity, but the duration of improvement is unpredictable in this population. Optimal results may be limited in duration as even minor deformities continue to grow. Patients, parents, and surgeons should discuss the limitations of the procedure, set realistic expectations, and be aware revision surgery may be necessary after nasal growth is complete. Further studies are needed that focus on indications, surgical techniques, and timing of interventions that include long-term follow up to skeletal maturity.

Compliance with Ethical Standards

Conflict of Interest The author declares no competing interests.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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•• Of major importance

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