Septoplasty in children

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ABSTRACT

Objectives: *Physicians have long had concerns about the potential harmful effects of pediatric septoplasties on the nasoseptal growth process because septal cartilage is important for the growth and development of the face.*

Methods: *In this review article, pediatric septoplasty and its indications are discussed, together with a literature survey. In addition, overviews of development of the nasal skeleton from neonate to adult, nasal growth, and cartilaginous septum are presented. Important issues and comments on pediatric septoplasties are provided.*

Results: *During septoplasty procedures, elevation of the mucoperichondrium unilaterally or bilaterally does not negatively affect growth of the face. Stabilization of the septum may be easier when mucosal elevation is performed unilaterally. The nasal floor mucosa should not be elevated so to avoid damage to the incisive nerves. Corrections and limited excisions may be done from the cartilaginous septum. Separation of the septal cartilage from the perpendicular plate, especially at the dorsal part, should not be performed because this area is important for the length and height of the nasal septum and nasal dorsum. Incisions or excisions should not be performed through the growing and supporting zones, especially at the sphenoethmoid dorsal zone.*

Conclusion: *If there are severe breathing problems related to the septal deviation, septoplasty should be performed. In the majority of cases, septal surgery may be conducted in 6-year-old children. However, if necessary, septal surgery may be performed in younger children and even at birth.*

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The role of septal cartilage in the growth and development of the face has long been a concern of clinicians. It is believed to have a central role in midface development; thus, septal surgery in children is considered potentially problematic. It is becoming increasingly evident that traumatic damage to the septal cartilage can lead to significant dental, palatal, and facial abnormalities.[1,2] Early correction of nasal obstruction may have several important benefits in addition to developmental issues. Neonates up to age 6 months may be obligate nasal breathers. Therefore, nasal obstruction in infants can lead to significant respiratory distress, oxygen desaturation, and cyanosis. Relieving nasal obstruction early reduces the risk of serious airway compromise as a result of upper respiratory infections or other inflammatory conditions. Also, septal deviation has been associated with increased incidences of snoring, viral upper respiratory tract infections, bronchitis, and sinusitis in children.[3] Also, systemic complications of chronic partial airway obstruction (*i.e.*, pulmonary hypertension or cor pulmonale) can be avoided.[4]

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Nasal trauma, abscess, or a mass in the nose may cause progressive deformity in the growing nose of the pediatric patient and also cause functional or psychosocial effects.[5] There is a possible risk of damage to growing points during septal surgery in children. In recent years, there has been increasing recognition that nasal septal deformities can be repaired without damaging or changing nasal and facial development. Moreover, malocclusion, dental problems, facial deformities, and pulmonary problems may develop when nasal septal surgery is not performed during childhood.[6–8] Nasal septal surgery may be performed on children without disturbing the development of the nasal and midfacial structures.[8–11] It has been reported that surgery is successful in children. However, this surgery should be conservative and minimal, and should be restricted to the pathologic area.[12]

Adil *et al.*[13] reported that the most common indications for septal surgery were posttraumatic deformities and severe airway obstructions. They indicated that children with nasal obstruction and deformity could safely undergo nasal corrective surgery before adolescence. In this review, nasal growth in children who have undergone septal surgery are presented through a detailed literature search.

Nasal Skeleton in Children

In Neonates. Nasal bones connect with the frontal and maxillary bones fibrous fibers. Upper lateral cartilages support these bones. The periosteum firmly connects to the perichondrium of the underlying cartilage at the caudal margin of the nasal bones. Upper lateral cartilages and the nasal septum constitute the septodorsal cartilage.[14] Cartilaginous septum reaches from the sphenoid to the columella. Ossification of the septal cartilage starts near the anterior skull base. The vomer is observed as the vomeral wings, which represent the thin layer of the bone. The vomeral wings connect with the inferior part of the vomer.[15]

From Neonate to Adult. The septodorsal cartilage of neonates and adults differs. In adults, ≥60% of the septum consists of osseous components. Chondral (perpendicular plate) and desmal (vomer) ossification are responsible for the osseous components. Cartilaginous septum is mainly connected to the anterior rim of the perpendicular plate. The extension of upper lateral cartilages is seem 5–10 mm under the nasal bones.[14]

Nasal Growth in Children

In white individuals, adolescent growth of the nose was observed between ages 8 and 12 years in girls. In boys, maximum growth appeared at 13 years. The growth velocity curve showed the steepest descending slope at 13.4 years for adolescent girls and at 14.7 years for adolescent boys.[16–18] Safe ages for rhinoplasty are reported as 16 years in girls and 17 years in boys.[6] Height, depth, and inclination are essentially complete for nose growth at 16 and 18 years in girls and boys, respectively.[19] These ages were reported as 12 years in girls and 15 years in boys in terms of maturation of nasal height and the nasal bridge.[20] In Switzerland, nasal length and growth showed increases until age 20 years in women and 25 years in men.[18]

Development of the Nasal Skeleton in Children. In growing children, nasal skeletal dimensions increase. Bony and cartilaginous parts of the nasal skeleton will change[21] as follows:

- Regressive changes. The intracranial parts of the dorsolateral cartilages show regression, and, at the anterior skull base, are replaced by the osseous cribriform plate. In exploring nasal dorsum fistulas in 4-year-old children, the dorsolateral cartilages may still be found that extend as far as the nasofrontal suture.[14]
- Progressive ossification. Progressive ossification occurs at the cartilaginous septum, and the perpendicular plate expands from an area near the anterior cranial base in the caudoventral direction.[22,23] Ossification in the perpendicular plate reaches the vomeral alae on both sides of the septal cartilage after the age of 10 years.[24] Overlap of the vomeral wings and perpendicular plate was demonstrated in adolescence.[14]
- Support of the nasal dorsum. The septodorsal cartilage is the main support of the nasal dorsum, and it is based on the sphenoid in younger children. Septal cartilage separates from the sphenoid after expansion of the perpendicular plate.[24] In children and adults, the septum firmly connects to the premaxilla through the spinoseptal ligament.[14]
- Nasal septum and choanae. The nasopharyngeal rim of the nasal septum is formed by the inferior (median) part of the vomer. The cartilaginous nasal septum and the perpendicular plate are based on the sphenoid and not represented in the choanal rim of the septum.[14]
- Septovomeral junction. Septal cartilage remains in the bony canal. It is formed by vomeral wings and the perpendicular plate (vomeral tunnel), and may reach the sphenoid.[22] This "sphenoid tail" will ultimately ossify in most individuals.[25,26] If a vomer ala is formed on one side only, then a cartilaginous sphenoid tail can be found extending alongside the incomplete vomer bone.[14] In 25% of human fetuses, deformity of the posterior septum occurs. In particular, the junction of the cartilaginous septum with the vomer and perpendicular plate increases to 37% at birth.[27] The reason has been reported to be the imbalance of "the overdeveloping septum and the pressure of the surrounding structures," *i.e.,* the bony facial skeleton. In another study, the percentage of deformity range of the anterior and posterior septum was 57%.[28]

Postnatal Growth of the Human Nasal Septum. The growth rate of the nasal septum exclusive of the vomer is at its maximum in the newborn and slows gradually to reach a plateau at age ≥20 years. The dimensions of the cartilaginous part demonstrate a rapid increase to a maximum at the age of 2 years. Later growth of the total septum is due to development of the perpendicular plate by ongoing ossification of septal cartilage at the septoethmoidal junction. Apparently, the ossification is balanced by formation of new cartilage. Mitotic activity and expansion of the intercellular matrix contribute to compensating for the loss of cartilage by ossification.[29]

Cartilaginous Nasal Septum: Thicker Zones, Thinner Parts. In newborns, the septum cartilage, which reaches from the sphenoid to the columella, demonstrates a specific morphologic organization of thicker and thinner parts.[30,31] The transverse diameter may vary from 0.4 to 3.5 mm. The thickest cartilage is found near the junction with the sphenoid rostrum, with a decrease in the more-anterior parts.[14] Two zones of thicker cartilage may be seen that extend into the anterior part of the septum, the lower zone being the basal rim of the cartilaginous septum, which reaches from the sphenoid to the anterior nasal spine and the more-dorsal one, which extends from the sphenoid to, and supports, the nasal dorsum. The thinnest cartilage is found between the sphenospinal and sphenodorsal zones, and the slightly thickened caudal rim of the septum.[14]

Nasal Skeleton Growing after Nasal Fractures. In young children, septum fractures with or without associated fractures of the bony nasal pyramid occur rather frequently. The effects of these fractures on facial development are seldom reported. In a 4-year-old girl, after nasal trauma, treatment included a closed reduction of the dislocated bony pyramid and fractured parts of the septum.[14] One year later, the nasal dorsum appeared to be normal; however, in the following years, further growth resulted in a progressive deviation of the nasal septum and dorsum at the age of 8 years, with a further increase in deformity during the adolescent growth spurt.[14]

Facial Development in Patients with Septal Cartilage Loss. Pirsig[32] reported on three patients ages 16 years with a history of facial injury at a young age. Loss of cartilage of the septum at the age of 3 years completely impeded the "extra growth" of the nose and maxilla, which, under normal conditions, is responsible for the gradual transition of the baby face into the adult profile. In children older at the onset of the abscess, followed by destruction of the septum cartilage, the negative effects on later facial growth appeared to be less prominent. The time of injury and the amount of destruction of the nasal septum have long-term effects on midfacial growth. The younger the child, the greater the effect on midfacial growth.[32] If there is septal cartilage loss or if septal surgery is performed, follow-up of these children should be extended until after the adolescent growth spurt.[14]

Pediatric Septoplasty

Historical Overview. Pediatric septoplasty surgeries have been performed since the 1970s.[33] In 1975, 10 subjects with unilateral cleft nose had surgery. The follow-up results showed that nasal growth of the cleft side of the nose was not affected by early primary nasal surgery.[34] Triglia *et al.*[35] state that the perichondrium should be left intact and no wide cartilaginous resections should be made. The areas of contact between the septum, the vomer, and the perpendicular lamina of the ethmoid should be reconstituted, and, finally, the remodeled cartilage should be repositioned in septoplasties in children.[35] Béjar *et al.*[36] used anthropometric measurements to analyze the outcomes of external septoplasty in 28 children ages 6 to 15 years after a mean follow-up of 3.4 years. They concluded that external septoplasty does not affect most aspects of nasal and facial growth, other than a potential negative influence on growth of the nasal dorsum.[36]

Walker *et al.*[37] did not find any long-term effect of external septorhinoplasty on nasal or facial growth. Sixteen children with septal disease anterior to the nasal spine were followed-up for >2 years. In all the cases, the cartilaginous septum was totally excised, refashioned, and then reinserted. In 10 of these 16 children, measurements were within the range of age- and sex-specific normative data.[36] In a retrospective study by Tasca and Compadretti,[38] the mean follow-up time of children who had undergone nasal septum surgery was 12.2 years. The results for 44 Italian patients (25 male and 19 female patients) who had undergone pediatric septoplasty were compared with age-specific normative data for North American white subjects. Nasal dorsum length, apart from the nasolabial angle measurement, was significantly reduced in female patients compared with controls ($p = 0.04$), whereas that of male patients was not significantly reduced ($p = 0.08$). In both sexes, the nasolabial angle of patients who had undergone extracorporeal septoplasty (by removing and repositioning of the quadrangular cartilage) was significantly less than that of patients undergoing conservative septoplasty (by minimal septal resection). Moreover, for both sexes, patients treated by external septo-

Table 1 **What should be done or not to be done in pediatric septoplasties***

In Pediatric Septoplasty	Do	Do Not
To prevent facial deformities#	Preventive intervention on nasal septal deformities#	
To prevent malocclusion#	Preventive intervention on nasal septal deformities#	
Mucoperichondrium preservation for septal surgery§	Do to avoid significant growth retardation; it can be done unilaterally or bilaterally§	
Age¶	Commonly perform at age 6 years, but, if necessary, it can be done earlier¶	
Nasal floor mucosa elevation§		Do not do, to avoid damage to the incisive nerves§
Incisions or excisions§		Do not do through the growing and supporting zones, especially at the sphenoethmoid dorsal zone§
At the dorsal part: separation of the septal cartilage from the perpendicular plate§		Do not do, because this area is very important for the length and height of the nasal septum and nasal dorsum§
Crista septi or spina vomeri resections§	Allowed; they will not damage nasal development§	
To prevent septal perforation§	Defects in the cartilaginous septum should be reconstructed§	
Septospinal ligament transaction§		Do not do, to prevent forward growth of the upper jaw§
Separation of upper lateral cartilages from the septum bilaterally or unilaterally§		Do not do; they should be reconnected to prevent deviations of the cartilaginous nasal dorsum§
Implantation of alloplastic or biomaterials in the growing septum§		Do not do because septal growth may be disturbed§

**Adapted from Refs. 6, 14, 33, 38, 39, 42, 44.*
#From Refs. 38,39,42.
§From Ref. 14.
¶From Ref. 33.

plasty had a significantly reduced nasolabial angle compared with controls, whereas patients who underwent endonasal septoplasty had similar values to those of controls.[38]

D'Ascanio *et al.*[39] reported that obligate children who were mouth breathing (due to nasal septum deviations) demonstrate facial and dental anomalies in comparison with nose-breathing controls. In this cephalometric study, children with obligate mouth breathing secondary to nasal septal deviations had increased upper and lower anterior facial height, a larger gonial angle, and a significantly retrognathic position of the maxilla and the mandible in comparison with nasal-breathing controls.[39]

Indications for Pediatric Septoplasty. From infancy to adulthood, nasal shape changes. Dorsal septal cartilage is the main supporting structure of the nose. In other words, it is a facial growth center. Septal cartilage loss causes facial syndromes of the nose, maxilla, and orbita. If nasal growth is affected, then the growth of the whole face is also affected. Trauma in childhood and malformations can cause functional impairments similar to those caused by surgical treatments.[40] Congenital or acquired malposition of the nose should be treated if it affects nasal functions.[41] Yilmaz *et al.*[42] reported that, for decisions about surgery, nasal obstruction is a relative indicator, whereas obstructive sleep apnea syndrome and nasal obstruction that occur during sleep are decisive factors. They used a very conservative approach for septoplasty and usually performed surgery when there was advanced nasal septal deviation in children.[42]

Pediatric septoplasty indications have been described as absolute and relative indications. The more common indication is nasal obstruction. However, a deviated nasal septum alone is rarely sufficiently important to be the sole cause of obstructed breathing. A detailed examination should be performed to exclude another cause or coexisting pathologies before considering septoplasty.[43]

Indications for pediatric septoplasty are the following[43]:

- Septal abscess
- Septal hematoma
- Severe deformity secondary to acute nasal fracture
- Cleft lip and nose
- Severe obstructive sleep apnea with complete blockage of the nasal pathway
- A severely deviated septum that causes significant nasal airway obstruction (It should be investigated by rhinomanometry when possible).

Techniques and Outcomes of Pediatric Septoplasty

Techniques. Recently, several investigators reported that nasal septal deformities that lead to nasal obstruction should be treated without damaging or affecting nasal and facial growth.[6,38] Furthermore, some investigators indicate that early preventive intervention on nasal septal deformities prevents malocclusion, dental problems, facial deformities, and pulmonary problems.[38,39,42] Reconstructive septal surgery may not cause significant growth retardation in children if the mucoperichondrium is preserved.[44] If there are severe breathing problems related to the septal deviation, then septoplasty should be performed.[14] Lawrence[33] reported that, in the majority of cases, septal surgery might be performed in 6-year-old children. However, if necessary, septal surgery should be performed in younger children and even at birth.

Table 2 **Articles for septoplasty in children**

Study	Type of Study	No. Patients	Age	Aim of the Study	Results
Can *et al.* [12]	Prospective	26 Patients underwent septoplasty	Aged between 6 and 15 years	To evaluate results of the septoplasty during childhood, objectively, with the help of acoustic rhinometry	There was a statistical significance between pre- and postoperative MCSA of groups 2 and 1 + 2
2005		21 Control without septal deformities	Study group:		There was statistical significance between the control group and groups 1, 2, and 1 + 2 in terms of MCSAs; MCSAs on the pathologic side and total volumes on the pathologic side
			Group 1 with only anterior septal deviation (8 patients) and group 2 with both anterior and posterior septal deviations (18 patients).		Surgery is successful in children.
					It should be restricted to only the pathologic area and should be conservative
					Acoustic rhinometry is an objective method for the evaluation of nasal septal deformities and surgical success
Adil *et al.* [13]	Retrospective	54 Patients	Pediatric patients	To review the investigators' experience with corrective nasal surgery in pediatric patients	Indications for surgery were posttraumatic deformities (n = 36) and severe airway obstruction (n = 48).
2014			Male patients <16 years old and female patients <14 years old		The mean follow-up period was 646 days (~21 mo) (range, 8–4062 days)
					Five patients underwent a staged procedure, and no patients underwent a revision procedure for unsatisfactory results
					Children with nasal obstruction and deformity can safely undergo nasal corrective surgery before adolescence
Meng *et al.* [19]	Evaluation of lateral head cephalograms	17 Male and 23 female patients	7–18 years old	To evaluate for age changes in morphology and position of the nose with reference to the pterygomaxillary vertical plane	(1) Increments in nose height, depth, and inclination are essentially complete in girls by 16 years of age, whereas continue to increase in boys ≥18 years old
1988				The study was confined to persons with normal facial profiles, normal overjets, and class I molar relationships; 4 linear and 2 angular dimensions were measured	(2) The ratio of upper to lower nose heights remains at ~3:1 from 7 to 18 years old in both sexes; (3) the ratio of nose depth to sagittal depth of the underlying skeleton changed from 1:2 at 7 years in both sexes to 1:1.5 in male subjects and 1:1.6 in female subjects at 18 years; (4) although upper nose inclination was similar for the 2 sexes, lower nose inclination was slightly larger in female subjects, especially after the age of 10 years; (5) persons with greater increments in nose depth than in nose height or in nose depth than in the sagittal depth of the underlying skeleton, develop larger upper nose inclinations
Akgüner *et al.*, [20] 1998	A cephalometric study	140 Female and 140 male subjects	11 and 17 years old	Age-related growth changes in the bony and cartilaginous framework of the nose were evaluated	Nasal height and nasal bridge length became fully mature in boys at 15 years old and fully mature in girls at 12 years old
			They had class 1 skeletal and dental patterns		The upper nasal dorsum, lower nasal dorsum, anterior nasal depth, and posterior nasal depth exhibited continuous growth up to 14 years old in boys and 2 years earlier in girls; nasal tip protrusion approached its mature size in boys at 15 years old and at 13 years old in girls; although the lower dorsum rotated forward slightly, rotation of the upper dorsum was not significant during adolescence
Béjar *et al.*, [36] 1996	Anthropometric measurements	28 Patients who underwent external septoplasty surgery for severe nasal obstruction caused by septal deviation anterior to the nasal spine	Between the ages of 6 and 15 years	To assess the impact of external septoplasty surgery on nasal growth in children	Twenty-nine percent of nasal dorsum measurements and 57% of nasal dorsum indexes were {mt]2 standard deviations from the mean, which indicates a predominance of short nasal dorsum; external septoplasty does not affect most aspects of nasal and facial growth, but it may negatively influence growth of the nasal dorsum
Tasca and Compadretti[38]	Retrospective study	44 Patients	25 Male patients and 19 female patients, undergone septoplasty during childhood by endonasal approach	To evaluate the effects of pediatric nasal septum surgery in a long-term follow-up by anthropometry	The nasolabial angle of the female patients was significantly reduced compared with the controls (p = 0.04), whereas that of the male patients was reduced compared with the controls (p = 0.08).

Table 2 **Continued**

Study	Type of Study	No. Patients	Age	Aim of the Study	Results
2011		Control group of healthy subjects	Reassessed after a mean follow-up of 12.2 years		This measurement seems to be influenced by the type of operation because it has been noted that the nasolabial angle of patients treated surgically by extracorporeal septoplasty were significantly lower than those of patients treated surgically by conservative septoplasty
			Nasal measurements consisted of 5 linear parameters, 3 angular parameters, and 3 proportional index		Pediatric septoplasty may be indicated in selected cases of obstructing nasal septum deformities; the operation, performed *via* endonasal approach, does not interfere with the normal growing nasal process
Dispenza *et al.*,[44] 2009	Retrospective	46 Subjects	4 and 12 years old	To contribute in identifying the correct selection criteria for surgical management of pediatric patients and in selecting the most appropriate surgical technique	The best results were obtained when they correct all evident alterations of nasal septum and pyramid at a single stage
			16 Patients with septal deviation without nasal pyramid alterations, underwent septoplasty 30 Patients with nasoseptal deviation 16 Patients; mean age, 9 years (range, 6–12 years), followed up for a mean 12 years after septoplasty 14 Patients, mean age 9 years (range, 6–12 years), followed up a mean 14 years after septorhinoplasty		Immediate correction of septum alone with delayed management of nasal pyramid deformity leads to a poorer outcome

MCSA = minimal cross-sectional area.

Verwoerd and Verwoerd-Verhoef[14] stated that elevation of the mucoperichondrium unilaterally or bilaterally may not negatively affect growth of the face. When mucosal elevation is made unilaterally, stabilization of the septum will be easier but may lead to secondary deformity, especially in children. The nasal floor mucosa should not be elevated, to avoid damage to the incisive nerves. After separation of the adherent fibrous tissue from the deviated or overlapping cartilaginous fragments, the septum can be mobilized. Thereafter, the septum will be reconstructed on the midline. For this purpose, corrections and limited excisions may be performed. Incisions or excisions should not be conducted through the growing and supporting zones, especially at the sphenoethmoid dorsal zone.

Separation of the septal cartilage from the perpendicular plate, especially at the dorsal part, should not be performed because this area is important for the length and height of the nasal septum and nasal dorsum. When an excision is made at the basal rim of the cartilaginous septum, outgrowth of the nasal dorsum will not be observed. However, the septospinal ligament should be intact, and resection should not be performed at the anterior part of the septum. Crista septi or spina vomeri resections may not damage nasal development.[14]

To prevent septal perforation, defects in the cartilaginous septum should be reconstructed. For this purpose, removed septal cartilage parts may be used by reshaping them appropriately for the defect area. To prevent forward growth of the upper jaw, the septospinal ligament should not be transected because it connects the cartilaginous septum in the midline. Nasal bones should not be mobilized together with septal reconstruction to prevent postoperative instability.[14] If the caudal rim of the septal cartilage is luxated, then it should be repositioned into the columellar pocket and be sutured between the medial crura of the alar cartilages.[14] In cases of upper lateral cartilages separated from the septum bilaterally, they should be reconnected to prevent deviations of the cartilaginous nasal dorsum.[14] With implantation of alloplastic or biomaterials to the growing septum, septal growth may be disturbed (Table 1).

Children often have a deformation of the middle and posterior regions of the septum. In this case, we recommend endoscopic septoplasty with targeted correction of problem areas, without hemitransfixion incision, which leaves the front part of the septum intact. Tasca and Compadretti[38] reported 44 Italian patients, comprising 25 male patients and 19 female patients, who had undergone septoplasty during childhood by using the endonasal approach and who were reassessed after a mean follow-up of 12.2 years. They concluded that pediatric septoplasty might be indicated in selected cases of obstructing nasal septum deformities. The operation, performed *via* an endonasal approach, may not interfere with the normal nasal growth process (Table 2).

Outcomes. In pediatric septoplasty, assessment of outcomes is important.[42] Can *et al.*[12] used acoustic rhinometry for measuring childhood septoplasty outcomes and concluded that it served as an objective tool for evaluation of surgical success. Kahveci *et al.*[45] found that improvement in the nose obstruction symptom evaluation score after septoplasty was correlated with nasal examination, visual analog scale score, and computed tomography measurement of the corrected deviated part of the septum. However, acoustic rhinometry was not correlated with the Nose Obstruction Symptom Evaluation score.

CONCLUSION

Surgical correction of septal deviation may be indicated, irrespective of age, if such deformity causes nasal stenosis and oral breathing. Conservative management may worsen the nasal morphology because a deviated nasal septum may exert traction during growth to normal alar and triangular cartilages not involved in previous trauma. Septal deviation during the rapid phase of development may cause irregular growth of the cartilaginous structure of the nasal vault.[44] We suggested to perform pediatric septoplasty under appro-

priate indications because not performing pediatric septoplasty may cause greater damage and facial growth may worsen.

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