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CLINICAL PAPER

Reconstruction of Nasal Cleft Deformities Using Expanded Forehead Flaps: A Case Series

Manikandhan Ramanathan · Pendem Sneha · Ananthnarayanan Parameswaran · Naveen Jayakumar · Hermann F. Sailer

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Abstract
Introduction Reconstruction of the nasal clefts is a challenging task considering the nasal anatomic complexity and their possible association with craniofacial defects. The reconstruction of these defects needs extensive amounts of soft tissue that warrant the use of forehead flaps. Often presence of cranial defects and low hairline compromise the amount of tissue available for reconstruction warrenting tissue expansion.
Aim To evaluate the efficacy of tissue expansion in reconstruction of congenital nasal clefts.
Subjects and Methods 9 patients with congenital nasal clefts involving multiple sub units were taken up for nasal reconstruction with expanded forehead flaps. The average amount of expansion needed was 200 ml. The reconstruction was performed in 3 stages.
Results Expanded forehead flaps proved to be best modality for reconstruction providing the skin cover needed for ala, columella and dorsum with minimal scarring at the donor site.
Conclusion Expansion of the forehead flap is a viable option for multiple sub unit reconstruction in congenital nasal cleft deformities.

Keywords Nasal cleft deformities · Tessier facial clefts · Forehead flaps · Tissue expansion

Introduction

Nose is often perceived as an artistic alignment of multiple aesthetic subunits of definite symmetry and proportion, the exact replication of which is complex. The process of nasal reconstruction has undergone constant evolution since its infancy in 16th century raising our contemporary level of expectations to achieve a complete aesthetic and functional reconstruction. The first step towards this started with the process of identification and definition of these congenital nasal clefts in total. A clear distinction has now been laid down to facilitate a complete description of these defects which may range from minimal alar field defects to partial or complete arhinia.

Often these defects can be associated with other complex craniofacial and intra cranial anomalies which can range from agenesis of corpus-callosum to Holoprosencephaly [1], proboscis, etc., which can be incompatible with life. The primary aim of congenital nasal reconstruction is to reconstitute the skeletal framework with preservation of its physiologic function along with the correction of the craniofacial skeleton. Creation of a sound bony foundation of the mid-face in these patients prior to nasal reconstruction is essential.

Apart from the osseo-cartilaginous skeletal framework, an adequate brace of soft tissues (internal mucosal and external skin cover) are essential for successful nasal reconstruction. Modifying of the primary defect to achieve internal mucosal lining and transposition of the adjacent skin and adnexal structures in the form of regional flaps for external cover, with strategic placement of scars at the

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junction of the nasal subunits helps us achieve a near total aesthetically gratifying nasal reconstruction.

By far, the most common source of skin for external cover involves the use of paramedian forehead flap. However in cases with extensive nasal defects like partial arhinia, and in scenarios with a low hair line, the quantum of tissue available could be deficient warranting the expansion of paramedian forehead area prior to flap harvest. This paper aims to review a series of cases of congenital facial cleft who have undergone staged nasal reconstruction using expanded paramedian forehead flap and chondral cartilage.

Subjects and Methods

Nine patients with Tessier 0–3 facial clefts with nasal defects were taken up for nasal reconstruction. Seven patients presented with alar field defects (2 bilateral 5 unilateral) and 2 patients with partial arhinia (Table 1). The patients with partial arhinia also had agenesis of the nasal septum. A preliminary computed tomographic work up was carried out in all these patients to rule out any craniofacial and intracranial anomalies. All cases were planned for staged nasal reconstruction using a cartilage frame work (conchal and/or chondral) and a paramedian expanded forehead flap. We tried using forehead flap without expansion in two of our cases but the poor esthetic outcome due to extensive scarring secondary to tension along the suture line (forehead) and difficulty of closing the secondary defect primarily necessitating the use of skin graft has prompted us to use expanded forehead flaps in these patients. Septal reconstruction was undertaken along with nasal reconstruction using winged bilateral intra oral labial mucosal flaps and chondral cartilage graft. The following were the inclusion criteria followed:

1. Patients with congenital nasal clefts needing multiple sub unit reconstruction including all the three anatomical layers (internal mucosal lining, cartilage frame work and external skin).
2. Patients with defects of size greater than 1.5 cm and with low hair line.
3. Patients with associated craniofacial defect (open metopic suture and encephaloceole/meningoceole).

The Protocol was discussed and carried out with patients' informed consent and agreement with the institutional ethical board.

Surgical Technique

Stage I

The first stage involved placement of an injectable tissue expander of 70–250 cc volume. The volume of the expander was determined by the amount of expansion needed as dictated by the size of the defect. The silicone expander was placed in the forehead through a small incision in the hair line. Intra operative expansion was achieved by injecting 10–15 ml of sterile normal saline solution. The process of expansion continued for an average duration of 3 weeks at a frequency of two injections per week with a volume of one tenth the total volume of the expander at every interval. Expansion was considered adequate once the amount of tissue achieved was equivalent to twice the size of the primary defect by width and length.

Stage II

The skeletal subunits were reconstructed using chondral graft from the 9th and 10th ribs. The internal mucosal lining for the lateral ala and rim were reconstituted using lateral cutaneous turn over flaps (Fig. 1) from the skin adjacent to the primary defect and expanded paramedian forehead flap was used to restore the external skin defecit. Paramedian forehead flaps were either trilobed (Fig. 1)

Table 1 Details of the patients included along with the type of defect and the flap design

Sl no	Primary defect	Associated craniofacial anomalies	Volume of expansion	Areas reconstructed
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2	Partial arhinia	None	250 cc	Nasal dorsum, Bilateral alae, Columella
3	Bilateral Tessier 2 Cleft	None	250 cc	Bilateral Alar reconstruction
4	Bilateral Tessier 2 cleft	Open anterior and posterior fontanelle and metopic suture	200 cc	Bilateral Alar reconstruction
5	Unilateral Tessier 2 Left	None	70 cc	Unilateral Alar reconstruction
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9	Unilateral Tessier 2 Left	None	70 cc	Unilateral Alar reconstruction



Fig. 1 Design of the bilobed forehead flap along with cutaneous turn in flap for restoration of the mucosal lining

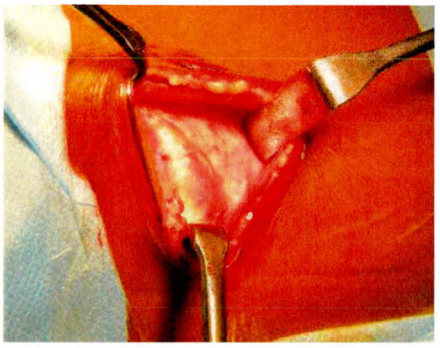


Fig. 2 Harvest of 9th and 10th ribs for nasal dorsum and columellar reconstruction

(cases 1, 2 where columellar reconstruction was needed) or bilobed (cases 3, 4 only lateral alar reconstruction was needed) based on unilateral supra trochlear pedicle. The flap was thin at the distal end involving the subdermal plexus only, which minimized the amount of debulking needed. The proximal end of the flap was 1.5 cm wide starting at the medial brow and involved the periosteum to maintain a sturdy viable pedicle. Care was taken to ensure that the junction of the flap and native tissue was placed at the junction of two adjacent subunits and the sub units of reconstruction were redefined in order to prevent the flap ending in more conspicuous areas of the nose.

Stage III

The third stage involved the division of the pedicle and flap debulking which was performed any time after 3 weeks of flap inset along with reconstitution of the skeletal frame work with chondral cartilage graft (Fig. 2).

Two cases of different flap designs (Case 1: Trilobed flap the distal extent was 1 cm longer to facilitate columellar and dorsal reconstruction; Case 3: Bilobed flap for anatomical multilayered reconstruction of the bilateral ala) have been presented here.

Case 1: A 13 year old female patient of non consanguineous parentage reported to us with a Tessier 0 facial cleft with partial arhinia. Complete craniofacial examination revealed the following findings (Fig. 3a, b):

Congenital agenesis of septum
Partial agenesis of the nasal dorsum and the lateral ala
Naso-maxillary hypoplasia
Agenesis of the pre-maxillary segment of the maxilla.
Low hair line

CT analysis revealed no other craniofacial/intra cranial anomalies. A staged external nasal reconstruction was performed using an expanded trilobed paramedian forehead flap (Figs. 4, 5a, b) based on the left supratrochlear artery. The primary defect was modified to create the cutaneous lateral turn over flaps from the area adjacent to the cleft site to reconstitute the inner nasal lining and the

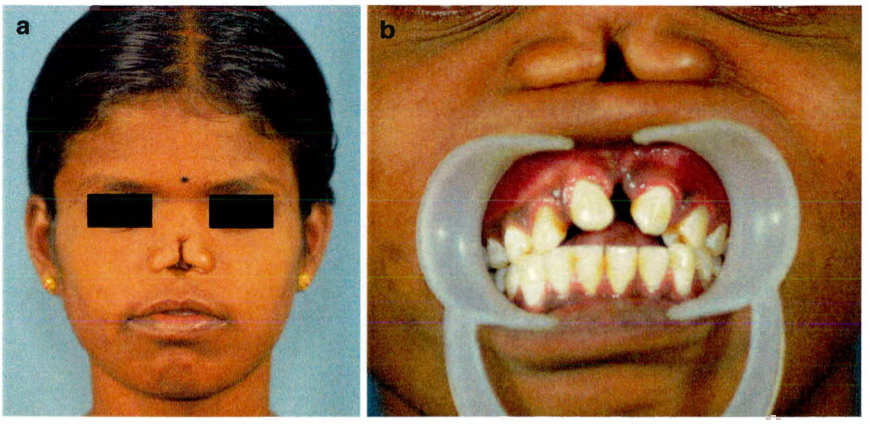


Fig. 3 Case 1 Pre-operative images showing **a** partial arhinia with agenesis of nasal septum **b** Maxillary hypoplasia with missing pre-maxilla



Fig. 4 Images at the end of tissue expansion of 250 cc

conchal cartilage graft was used to reconstruct the lateral alar skeletal units. The secondary defect on forehead was closed primarily without tension. The third stage involved the division of the flap with reconstruction of the nasal dorsum using chondral graft along with nasal tip defining procedures. Septal reconstruction was performed using bilateral intra oral winged labial mucosal flaps and chondral cartilage graft.

Orthodontic alignment (Fig. 6) was performed to close the pre-maxillary dento alveolar defect followed by prosthetic rehabilitation. A lower anterior segmental osteotomy was performed to settle the occlusion and the problems associated

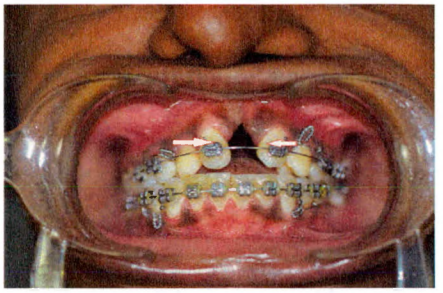


Fig. 6 Direction of the movement of the teeth to close the space secondary to missing pre-maxilla

with lower lip pout. A similar strategy for nasal reconstruction was followed for the second patient (Fig. 7a, b).

Case 3: A 17 year old male patient of non consanguineous parentage reported to us with a bilateral Tessier 2 facial cleft with Alar field defect.

Craniofacial examination did not reveal any other co-morbidities. Accordingly staged nasal alar reconstruction was planned for this patient with expanded bilobed paramedian forehead flap. The results are shown in the (Fig. 8a, b).

Discussion

Complete/partial nasal reconstruction is a complex task that demands high level of understanding and skill. The process of nasal reconstruction has been in a state of evolution since its infancy in 16th century and a thorough understanding of the pathological anatomy of the nasal cleft has raised the contemporary bars of reconstructive process. To note, isolated nasal clefts are rare congenital

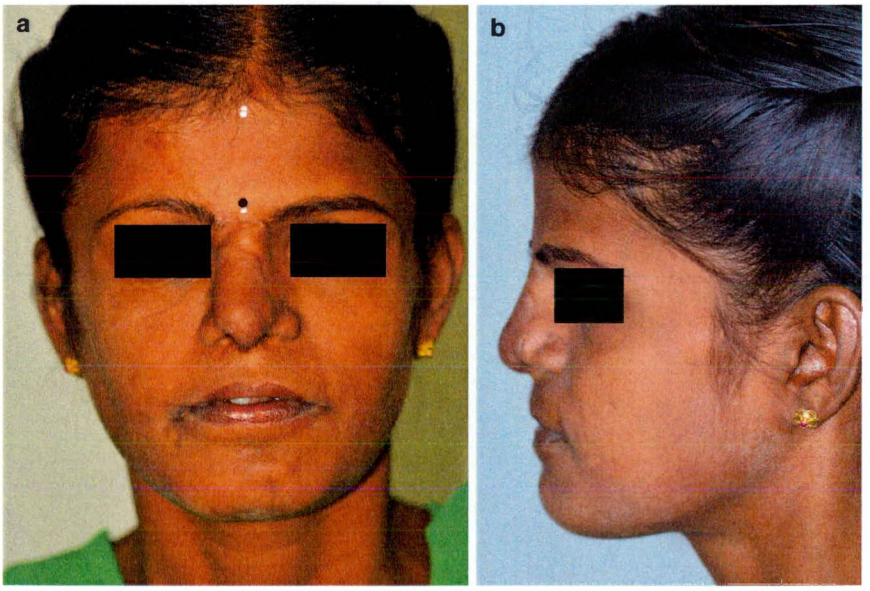


Fig. 5 **a, b** Post-operative images after flap division and flap revision and lower sub apical osteotomy for occlusal correction



Fig. 7 **a, b** Case 2: Pre-operative and post-operative images of the patient after nasal reconstruction with expanded forehead flap



Fig. 8 **a, b** Case 3: Pre-operative and post-operative images of the patient with Tessier 2 nasal cleft bilateral

anomalies with a reported incidence of 1 in 20,000–40,000 cases [2]. Often these can have craniofacial extensions or may be associated with cleft lip and palate [3]. They may also be associated with other craniofacial malformations and intra cranial issues considering the synchronous development of the craniofacial structures.

Development of the nasal cavity similar to the face, occurs in early fetal life between 3rd and 10th weeks. It starts with the formation of the nasal placodes, the epithelial thickenings dividing the fronto-nasal process into medial and lateral nasal processes. The placodes continue to deepen leading to the formation of the nasal cavity which is separated from the oral cavity by the buccopharyngeal membrane. The anterior aspect of this cavity differentiates into alar and capsular fields which lead to the formation of the lower and upper lateral cartilages and nasal bones respectively. Thus the congenital defects in these areas are called alar field defects and capsular defects respectively [4]. Seldom the teratogens can completely hamper the developmental process of the nasal placodes leading to complete arhinia or partial arhinia that need more complicated approach of reconstruction.

Comprehensive reconstruction of the nose is complex, however, a structured approach to reconstitute the morphology with reconstruction of the skeletal framework and soft tissues has helped achieve satisfactory results [5]. Alar field defects can be treated at an early age but in case of complete nasal reconstruction, as in cases of partial or complete arhinia, surgical procedures should be taken up after the second growth spurt as the maxillary growth is nearly complete which will lay down the appropriate skeletal foundation for complete nasal reconstruction. Complex craniofacial clefts are often associated with encephalocoeles and hypertelorism which need to be addressed prior to the aesthetic component of the nasal reconstruction. A successful approach to reconstruction can be obtained by multilayered reconstruction as follows:

Skeletal Frame Work

The restoration of the skeletal frame work is an important step in the reconstruction of the nose as the (1) Cartilage framework prevents the collapse of the lateral walls during inspiration, (2) Maintains the nasal contour. (3) Prevents the cephalic retraction of the alar margins. This plays an important role in maintaining the airway patency. Congenital nasal clefts often need the reconstruction of the nasal dorsum along with the columella and the alar domes that need enormous amount of cartilage. The minimal quantum of the chonchal cartilage available and agenesis of the nasal septum make chondral cartilage the only viable option. Though alloplastic materials like Silicones, Medpore and PDS are options to be considered for the reconstruction, they are often associated with problems of rejection, infection, and resorption of the underlying nasal bones. Apart from this, rigid materials like Medpore lack the elasticity of the nasal tip which is often not acceptable.

In these scenarios chondral cartilage remains the mainstay for reconstruction of the skeletal framework. The cartilage of the 10th rib serves as a source of columellar strut while the cartilage from the 8th and/or 9th ribs can be used for the restoration of the dorsum and the lateral ala.

Tissue engineered cartilage is a potential source of graft material that might fulfill the criteria of an ideal graft material for nasal reconstruction [7, 8].

The Inner Mucosal Lining

Congenital nasal clefts are often associated with abnormalities of the septum and may also be associated with classic cleft lip and palate. These conditions preclude the use of the mucosal septal flaps [6], bipedicled Bucket handle flaps and the labial vestibular flaps for mucosal lining. Inferior turbinate mucosal flaps [9] and composite septal hinged flaps may be options when the nasal defects are not associated with cleft lip and palate. We prefer the use of cutaneous turn in flaps from the skin adjacent to the defect (Fig. 6) over other local rotation flaps. This flap seems to be superior compared to the rest, as they help in reorienting the primary defect margins which will aid in placing the suture lines at the junction of the adjacent sub units and improve the aesthetics. Moreover it does not disrupt the existing internal nasal lining [10, 11].

Skin Cover

Various local flaps have been used for restoring the nasal skin deficit. The most common being the para-median forehead flap and the nasolabial flap. The use of banner flaps and bilobed flaps is often restricted for smaller defects secondary to trauma and tumor excisions and these flaps may distort the soft tissues when used for defects larger than 1.5 cm [12]. Composite graft transfer though appears as a lucrative option, does not provide adequate amount of tissue and there would be an inadvertent difference in the texture of the tissue compared to the native tissue. Superior based nasolabial flap is a choice for alar defects however it leaves a trap door defect secondary to contraction [11]. Defects of the nasal dorsum, tip and the ala greater than 2 cm are best reconstructed with paramedian forehead flap. Single stage paramedian flap was first described by Converse et al [13] who deepithelialised the flap and tunneled it under the nasal dorsum.

Para-median forehead flap is our choice for pediatric nasal reconstructions as the amount of tissue available is greater and often can be enhanced by the use of tissue expanders which can be placed on definite skeletal base. The expanded tissue is more vascular and has the surface texture similar to the nasal skin [14]. This also provides an additional advantage in children who tend to have a low hair line which may restrict the length of the flap being harvested. Anterograde blood flow from the supra trochlear and the angular arteries and the retrograde flow from the infra orbital artery allow the extension of the base of the flap below the level of the super ciliary arch which will aid in providing adequate tissue for the columellar reconstruction without the problems of tip distortion. Apart from the above the closure of the secondary defect after the flap harvest would be tension free. The process of expansion can be combined with the recreation of the skeletal framework with the placement of the cartilage frame work in the sub dermal plane prior to expansion which will restrict the number of surgical procedures needed in complete nasal reconstruction of congenital nasal clefts [15]. In spite of all the versatility of the expanded paramedian forehead flap, it is important to be cautious regarding:

1. Appropriate tailoring of the expanded flap is essential to avoid multiple future revision surgeries.
2. Hyperkeratinisation and pigmentation of the expanded skin may be avoided by reducing the exposure to sunlight and this may need a chemical peel at a later date.

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Gesendet: Samstag, 3. Januar 2015 06:11
An: Doris Schneider
Betreff: DR MANI CHENNAI
Anlagen: nasal reconstruction using forehead flaps.pdf

DEAR PROF., ERICA AND MRS DORIS

regards and wishing you a wonderful 2015 for all in CCI.

it was nice to hear regarding your trips to nepal and pakistan, myanmar.

i am just sending new article published in our indian journal with prof as one of the authors.

kindly see the attchment

looking forward for a wonderful 2015 ahead

dr mani
chennai

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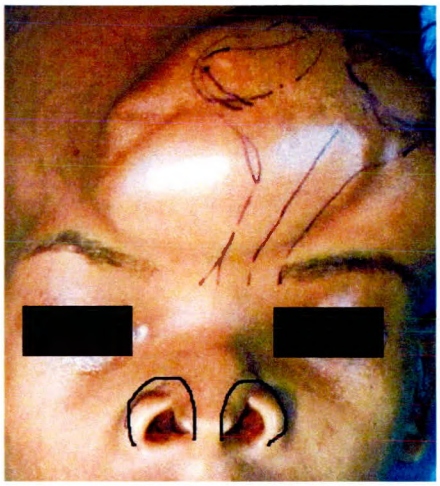


Fig. 1 Design of the bilobed forehead flap along with cutaneous turn in flap for restoration of the mucosal lining

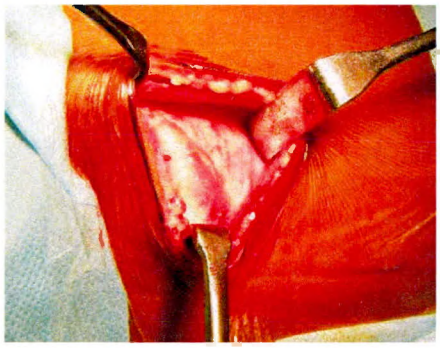


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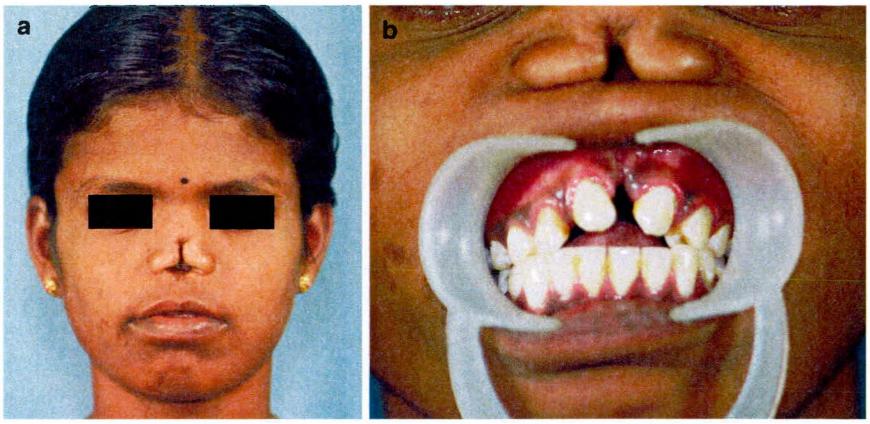


Fig. 3 Case 1 Pre-operative images showing **a** partial arhinia with agenesis of nasal septum **b** Maxillary hypoplasia with missing pre-maxilla



Fig. 4 Images at the end of tissue expansion of 250 cc

conchal cartilage graft was used to reconstruct the lateral alar skeletal units. The secondary defect on forehead was closed primarily without tension. The third stage involved the division of the flap with reconstruction of the nasal dorsum using chondral graft along with nasal tip defining procedures. Septal reconstruction was performed using bilateral intra oral winged labial mucosal flaps and chondral cartilage graft.

Orthodontic alignment (Fig. 6) was performed to close the pre-maxillary dento alveolar defect followed by prosthetic rehabilitation. A lower anterior segmental osteotomy was performed to settle the occlusion and the problems associated

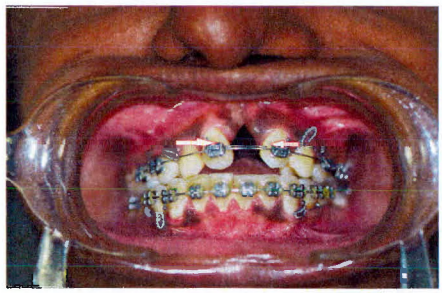


Fig. 6 Direction of the movement of the teeth to close the space secondary to missing pre-maxilla

with lower lip pout. A similar strategy for nasal reconstruction was followed for the second patient (Fig. 7a, b).

Case 3: A 17 year old male patient of non consanguineous parentage reported to us with a bilateral Tessier 2 facial cleft with Alar field defect.

Craniofacial examination did not reveal any other co-morbidities. Accordingly staged nasal alar reconstruction was planned for this patient with expanded bilobed paramedian forehead flap. The results are shown in the (Fig. 8a, b).

Discussion

Complete/partial nasal reconstruction is a complex task that demands high level of understanding and skill. The process of nasal reconstruction has been in a state of evolution since its infancy in 16th century and a thorough understanding of the pathological anatomy of the nasal cleft has raised the contemporary bars of reconstructive process. To note, isolated nasal clefts are rare congenital

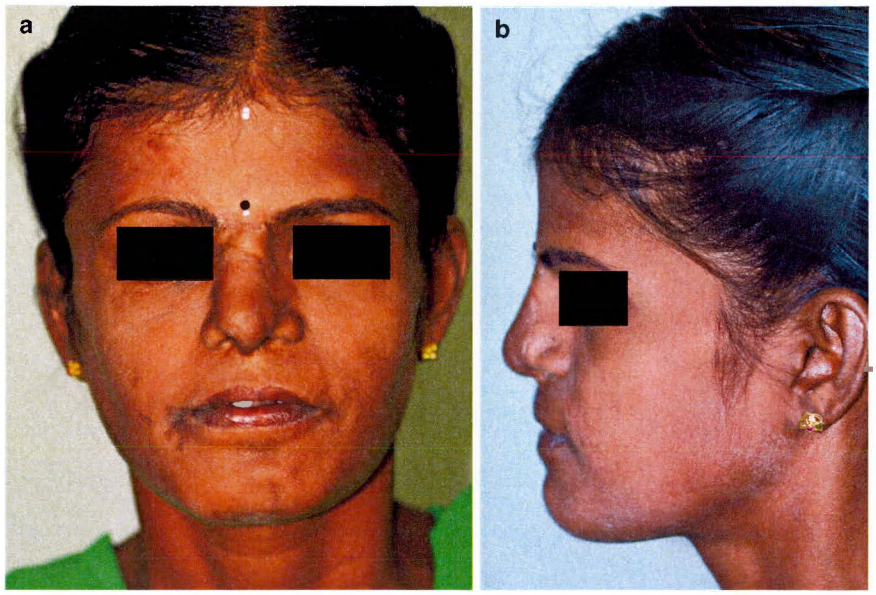


Fig. 5 **a**, **b** Post-operative images after flap division and flap revision and lower sub apical osteotomy for occlusal correction



Fig. 7 **a**, **b** Case 2: Pre-operative and post-operative images of the patient after nasal reconstruction with expanded forehead flap



Fig. 8 **a**, **b** Case 3: Pre-operative and post-operative images of the patient with Tessier 2 nasal cleft bilateral

anomalies with a reported incidence of 1 in 20,000–40,000 cases [2]. Often these can have craniofacial extensions or may be associated with cleft lip and palate [3]. They may also be associated with other craniofacial malformations and intra cranial issues considering the synchronous development of the craniofacial structures.

Development of the nasal cavity similar to the face, occurs in early fetal life between 3rd and 10th weeks. It starts with the formation of the nasal placodes, the epithelial thickenings dividing the fronto-nasal process into medial and lateral nasal processes. The placodes continue to deepen leading to the formation of the nasal cavity which is separated from the oral cavity by the buccopharyngeal membrane. The anterior aspect of this cavity differentiates into alar and capsular fields which lead to the formation of the lower and upper lateral cartilages and nasal bones respectively. Thus the congenital defects in these areas are called alar field defects and capsular defects respectively [4]. Seldom the teratogens can completely hamper the developmental process of the nasal placodes leading to complete arhinia or partial arhinia that need more complicated approach of reconstruction.

Comprehensive reconstruction of the nose is complex, however, a structured approach to reconstitute the morphology with reconstruction of the skeletal framework and soft tissues has helped achieve satisfactory results [5]. Alar field defects can be treated at an early age but in case of complete nasal reconstruction, as in cases of partial or complete arhinia, surgical procedures should be taken up after the second growth spurt as the maxillary growth is nearly complete which will lay down the appropriate skeletal foundation for complete nasal reconstruction. Complex craniofacial clefts are often associated with encephalocoeles and hypertelorism which need to be addressed prior to the aesthetic component of the nasal reconstruction. A successful approach to reconstruction can be obtained by multilayered reconstruction as follows:

Skeletal Frame Work

The restoration of the skeletal frame work is an important step in the reconstruction of the nose as the (1) Cartilage framework prevents the collapse of the lateral walls during inspiration, (2) Maintains the nasal contour. (3) Prevents the cephalic retraction of the alar margins. This plays an important role in maintaining the airway patency. Congenital nasal clefts often need the reconstruction of the nasal dorsum along with the columella and the alar domes that need enormous amount of cartilage. The minimal quantum of the chonchal cartilage available and agenesis of the nasal septum make chondral cartilage the only viable option. Though alloplastic materials like Silicones, Medpore and PDS are options to be considered for the reconstruction, they are often associated with problems of rejection, infection, and resorption of the underlying nasal bones. Apart from this, rigid materials like Medpore lack the elasticity of the nasal tip which is often not acceptable.

In these scenarios chondral cartilage remains the mainstay for reconstruction of the skeletal framework. The cartilage of the 10th rib serves as a source of columellar strut while the cartilage from the 8th and/or 9th ribs can be used for the restoration of the dorsum and the lateral ala.

Tissue engineered cartilage is a potential source of graft material that might fulfill the criteria of an ideal graft material for nasal reconstruction [7, 8].

The Inner Mucosal Lining

Congenital nasal clefts are often associated with abnormalities of the septum and may also be associated with classic cleft lip and palate. These conditions preclude the use of the mucosal septal flaps [6], bipedicled Bucket handle flaps and the labial vestibular flaps for mucosal lining. Inferior turbinate mucosal flaps [9] and composite septal hinged flaps may be options when the nasal defects are not associated with cleft lip and palate. We prefer the use of cutaneous turn in flaps from the skin adjacent to the defect (Fig. 6) over other local rotation flaps. This flap seems to be superior compared to the rest, as they help in reorienting the primary defect margins which will aid in placing the suture lines at the junction of the adjacent sub units and improve the aesthetics. Moreover it does not disrupt the existing internal nasal lining [10, 11].

Skin Cover

Various local flaps have been used for restoring the nasal skin deficit. The most common being the para-median forehead flap and the nasolabial flap. The use of banner flaps and bilobed flaps is often restricted for smaller defects secondary to trauma and tumor excisions and these flaps may distort the soft tissues when used for defects larger than 1.5 cm [12]. Composite graft transfer though appears as a lucrative option, does not provide adequate amount of tissue and there would be an inadvertent difference in the texture of the tissue compared to the native tissue. Superior based nasolabial flap is a choice for alar defects however it leaves a trap door defect secondary to contraction [11]. Defects of the nasal dorsum, tip and the ala greater than 2 cm are best reconstructed with paramedian forehead flap. Single stage paramedian flap was first described by Converse et al [13] who deepithelialised the flap and tunneled it under the nasal dorsum.

Para-median forehead flap is our choice for pediatric nasal reconstructions as the amount of tissue available is greater and often can be enhanced by the use of tissue expanders which can be placed on definite skeletal base. The expanded tissue is more vascular and has the surface texture similar to the nasal skin [14]. This also provides an additional advantage in children who tend to have a low hair line which may restrict the length of the flap being harvested. Anterograde blood flow from the supra trochlear and the angular arteries and the retrograde flow from the infra orbital artery allow the extension of the base of the flap below the level of the super ciliary arch which will aid in providing adequate tissue for the columellar reconstruction without the problems of tip distortion. Apart from the above the closure of the secondary defect after the flap harvest would be tension free. The process of expansion can be combined with the recreation of the skeletal framework with the placement of the cartilage frame work in the sub dermal plane prior to expansion which will restrict the number of surgical procedures needed in complete nasal reconstruction of congenital nasal clefts [15]. In spite of all the versatility of the expanded paramedian forehead flap, it is important to be cautious regarding:

1. Appropriate tailoring of the expanded flap is essential to avoid multiple future revision surgeries.
2. Hyperkeratinisation and pigmentation of the expanded skin may be avoided by reducing the exposure to sunlight and this may need a chemical peel at a later date.

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