

Review Article

Primary Anterior Nasal Cleft Floor Reconstruction with Inceptive Obturpaedic Treatment

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Abstract

Primary anterior nasal floor reconstruction presents an additional challenge during primary cheiloplasty for cleft anomalies. Successful reconstruction of the anterior nasal floor requires a superior layer along the full length of the primary palate, achieved through a sequence of three distinct interventions. Obturpaedic treatment is utilising the neonatal and infant growth period to modulate presurgically the alveolar segments in aligning for an ideal gothic arch. The modulation aids in narrowing the anterior nasal floor, but also decreasing the width of the cleft lip defect and cleft defect of the secondary palate. Excess tissue at the lateral lip segment, as identified during the design of a cheiloplasty, can be used effectively as a muco-subdermoid tissue flap for the floor in the primary palate defect. The flap is pedicled at the buccal-lip-sulcus region, placed between the alveolar segments and connects at the secondary hard palate. Such a created mucosal layer in the anterior nasal floor also serves as a secure superior layer in supporting transplanted bone during secondary osteoplasty. After post-primary surgery, this layer avoids oro-nasal opening due to an effective secured flap between the primary palate and a reconstructed secondary hard palate. This subsequently leads during the paediatric growth phase and orthopaedodontic treatments to an advantage, which impacts the long-term. The combination of an essential obturpaedic and a precise primary surgical intervention significantly reduces the need of extensive secondary treatments, in aesthetic, functional and midfacial dysgnathial development during the paediatric growth and the post-orthopaedodontic periods.

Keywords: Cleft; Cleft Lip Palate; Cleft Lip Alveolus; Anterior Nasal Floor; Primary Anterior Nasal Floor Flap; Surgery; Obturpaedics; Orthopaedodontics; Orthodontics

Abbreviations

ANF: Anterior Nasal Floor; eANF: Extended Anterior Nasal Floor; PANFF: Primary Anterior Nasal Floor Flap; C: Cleft; L: Lip; A: Alveolus; P: Palate; hP: hard Palate; shP: secondary hard Palate; u: unilateral; b: bilateral

Introduction

The reconstruction of the extended Anterior Nasal Floor (eANF) in neonates and infants born with cleft anomalies specifically Cleft-Lip-Alveolus (CLA) and Cleft-Lip-Alveolus-Palate (CLAP) presents a significant pre-surgical and surgical challenge [1]. These challenges often arise from the apparent inadequate available tissue in the primary palate. Successful ANF construction has a profound, long-term impact on the development of the primary palate, with positive outcomes that extend well beyond the early paediatric growth and into subsequent orthopaedodontic treatments. Despite its importance, the complexity of eANF reconstruction has often been overlooked in this specialized medical of cleft anomaly treatment, where surgeons frequently focus solely on cleft lip repair without assessing the immediate oral defect posterior to the lip.

A critical aspect of comprehensive cleft management is the initiation of obturpaedic intervention immediately after birth, which serves as a critical first step in the comprehensive management of a cleft defect [2]. Currently, there are no established protocols that address the impact of presurgical obturpaedic treatment on the Anterior Nasal Floor (ANF), both before and after the primary surgery. The primary goal of obturpaedic treatment is essentially to reduce the severity of the cleft defect, enable more precise surgical planning and ultimately enhance long-term functional and aesthetic outcomes. The intricate manipulation of the ANF in neonates presents unique challenges; however, the use of obturpaedic treatment provides surgeons with more accurate information for decision-making, which leads to improved outcomes. An essential aspect of the primary surgical process is to avoid oro-nasal fistulae, particularly in the nasolabial, intersegmental alveolus regions and posteriorly within the primary palate. In primary cheiloplasty, superfluous tissue from the cleft lip is used to create an extended flap that closes the defect along the entire primary palate for CLA and CLAP anomalies [3]. This approach aims to create fusion between the primary and the secondary palate. The complexity of achieving full-length ANF closure during primary surgery has not been thoroughly addressed in existing literature, highlighting a significant gap in the current cleft anomaly treatment practices.

Methods: Obturpaedics and Flap Surgery

Obturpaedics: Treatment of Primary Plate

In neonates diagnosed with u+bCLA and u+bCLAP, the immediate cleft deformity posterior to the lip extends beyond the buccal-alveolar region to encompass the ANF along the primary palate. For feeding and obturpaedic treatment this part of the cleft anomaly as the congenital primary palate with the cleft alveolar arch must temporarily be covered immediately after birth [2]. Obturpaedic intervention typically commences within two days after birth, with the duration and the type of appliance varying according to the severity of the alveolar arch deformity. Common devices include the Functional Jaw Orthognathic Suction and Drinking Plate (FJO) with additional Lip Moulding (Fig. 1) or a Naso-Alveolar Moulding device (NAM1) [2,4-7]. In cases of bilateral cleft, a more firm and forceful Lip Moulding is required in retro-positioning the prolabium-premaxilla complex. The envisaged obturpaedic outcome is to achieve a relatively normal gothic alveolar arch thereby narrowing the cleft defect at the eANF [8]. After the obturpaedic phase, with a more ideally-formed gothic arch, the need for extensive future orthopaeddontic treatment is significantly reduced during the critical phases of paediatric growth [9].

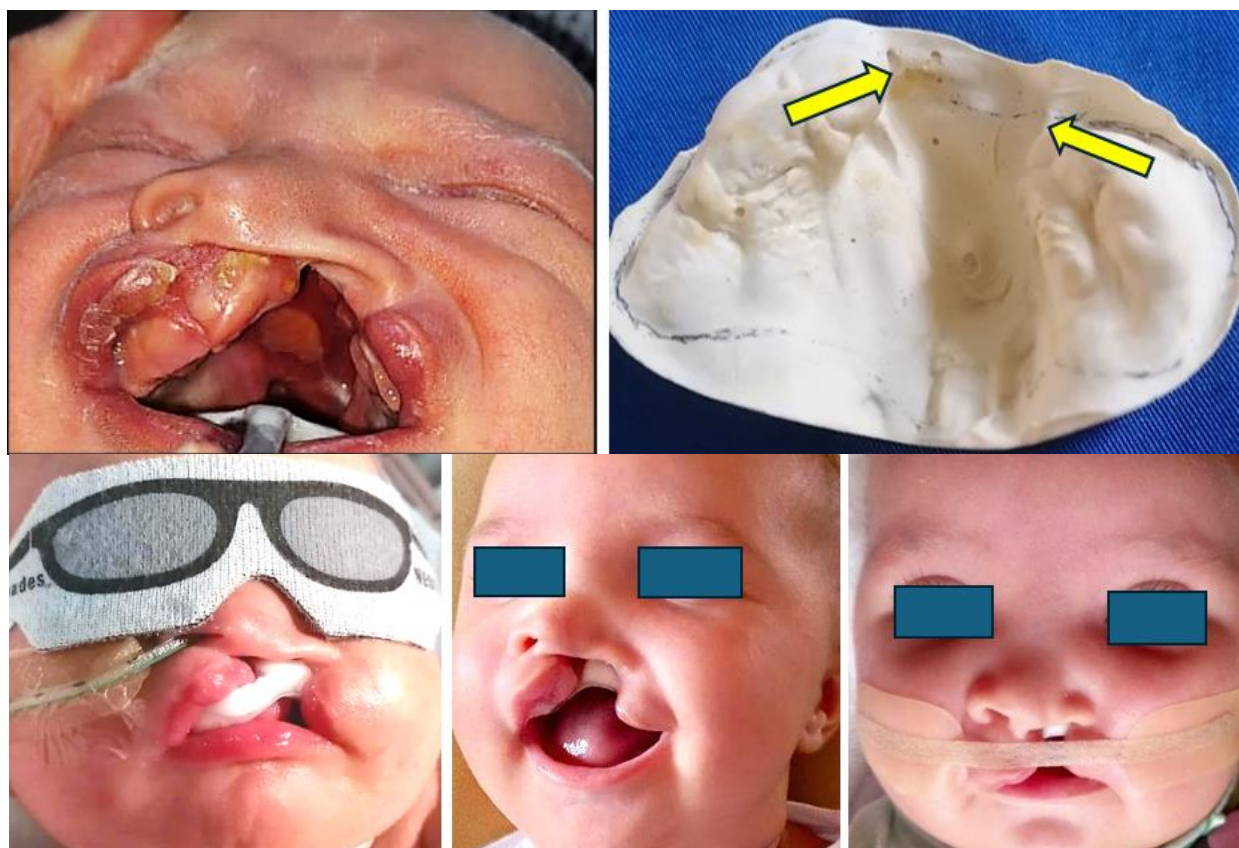


Figure 1: Unilateral CLAP; a: Lip, alveolar and palatal cleft with wide ANF defect; b: Cast model for FJO manufacturing with wide cleft defect; c + d: FJO in situ; e: Lip moulding.

Following birth, the alveolar arch segments adjacent to the cleft mostly exhibit mal-positioning in uCLA/uCLAP patients, with the larger segment rotated anteriorly (outwards) and the smaller segment rotated medially (inwards) [3]. This abnormality presents with an extended deformity at the alveolar arches, as well as in the anterior nasal floor (Fig. 1). In bilateral cleft cases (bCLA/bCLAP), the anterior nasal floor defect is significantly elongated due to protrusive position of the premaxilla. Pre-surgical obturpaedic treatment positively supports midfacial growth modulation in the neonate and infant [2]. As a result, the primary cheiloplasty with the designed lip-red-muco-subdermoid flap result in a less problematic surgical procedure.

During this neonatal and infantile obturpaedic treatment period, Lip Moulding appliances are worn continuously to narrow the cleft lip defect. The FJO or NAM1 is adjusted every four weeks to accommodate the rapid oro-facial growth in this period. Consequently the initially abnormal alveolar arches align into a more ideal gothic form (Fig. 2). This process, combined with the presence of a bulky muco-subdermoid flap tissue situated between the Cleft Alveolar Segments (CLAP), further narrows the defect in the secondary hard Palate (shP), reducing the complexity of the total primary cleft reconstruction process [8].

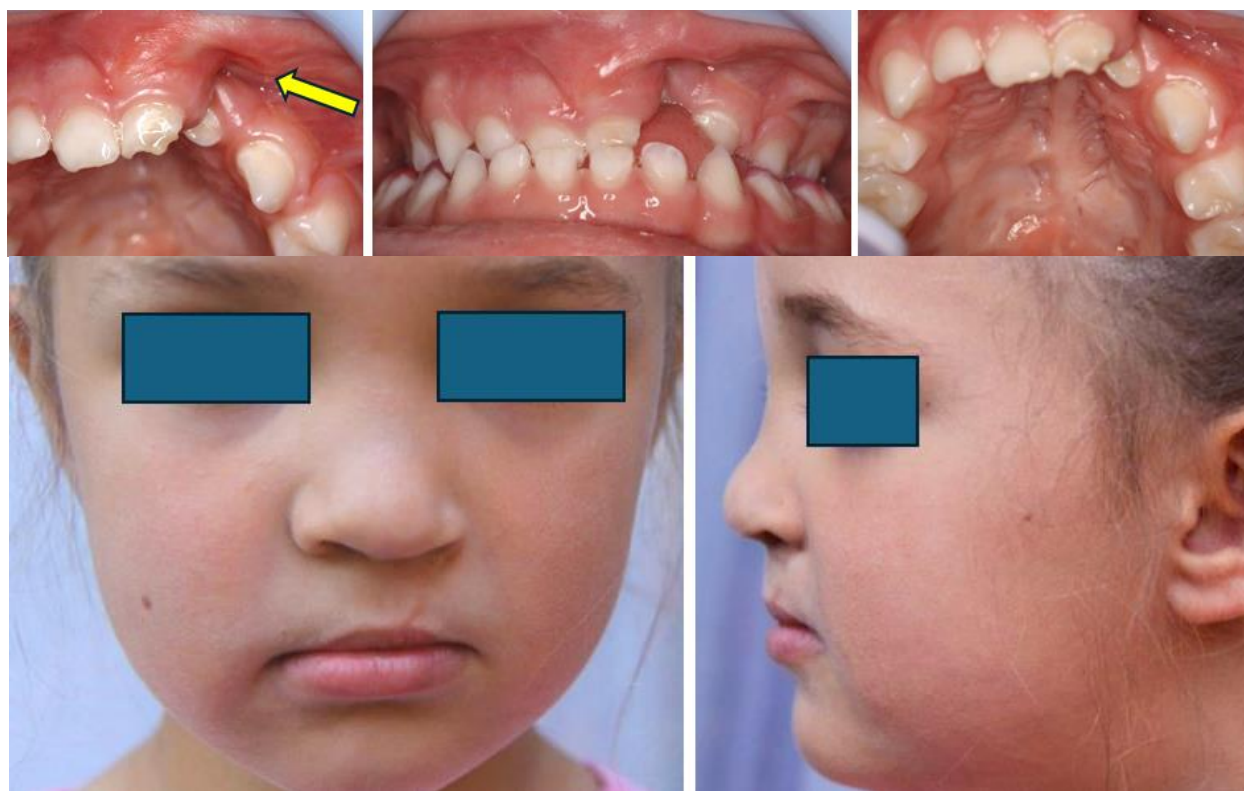


Figure 2: Patient, 3¾ years old, same as in Fig. 3b-e; a: Pedicle of the PNAFF; b: Residual alveolar cleft; c: Repaired cleft of hP (cranially pedicled single-layered vomer flap); d: Front facial view; e: Lateral facial view of cleft side.

Flap Surgery: Diagnosis and Surgery

During primary reconstruction of the unilateral and bilateral cleft-lip-alveolus (u+bCLA) and the unilateral and bilateral cleft-lip-alveolus-palate (u+bCLAP), a critical surgical technique is employed to achieve closure or concealment of the total or extended ANF defect in the primary palate [1,3]. This part of the eANF is an embryological component of the primary palate. In the cleft lip reconstruction (cheiloplasty) design, certain quantities of unusable or superfluous lip tissues are typically discarded. However, in CLA and CLAP cases, these superfluous tissues can be repurposed to create a single-layered muco-subdermoid tissue flap. This flap is pedicled at the buccal-lip-sulcus region and rotated posteriorly to create a superior layer above the cleft alveolar arches, separating the nasal and oral cavities [3,10].

For unilateral clefts, the flap can be raised from either the lateral or medial cleft lip part. However, due to insufficient length in the medial area, it is harvested from the lateral cleft lip segment, allowing for greater flexibility (Fig. 3). In cases of bilateral cleft, the flap is dissected from both the lateral cleft lip segments to achieve tissue closure around the premaxilla. The design of the flap for the eANF must not adversely impact the aesthetic or functional outcome of the cleft lip cheiloplasty.

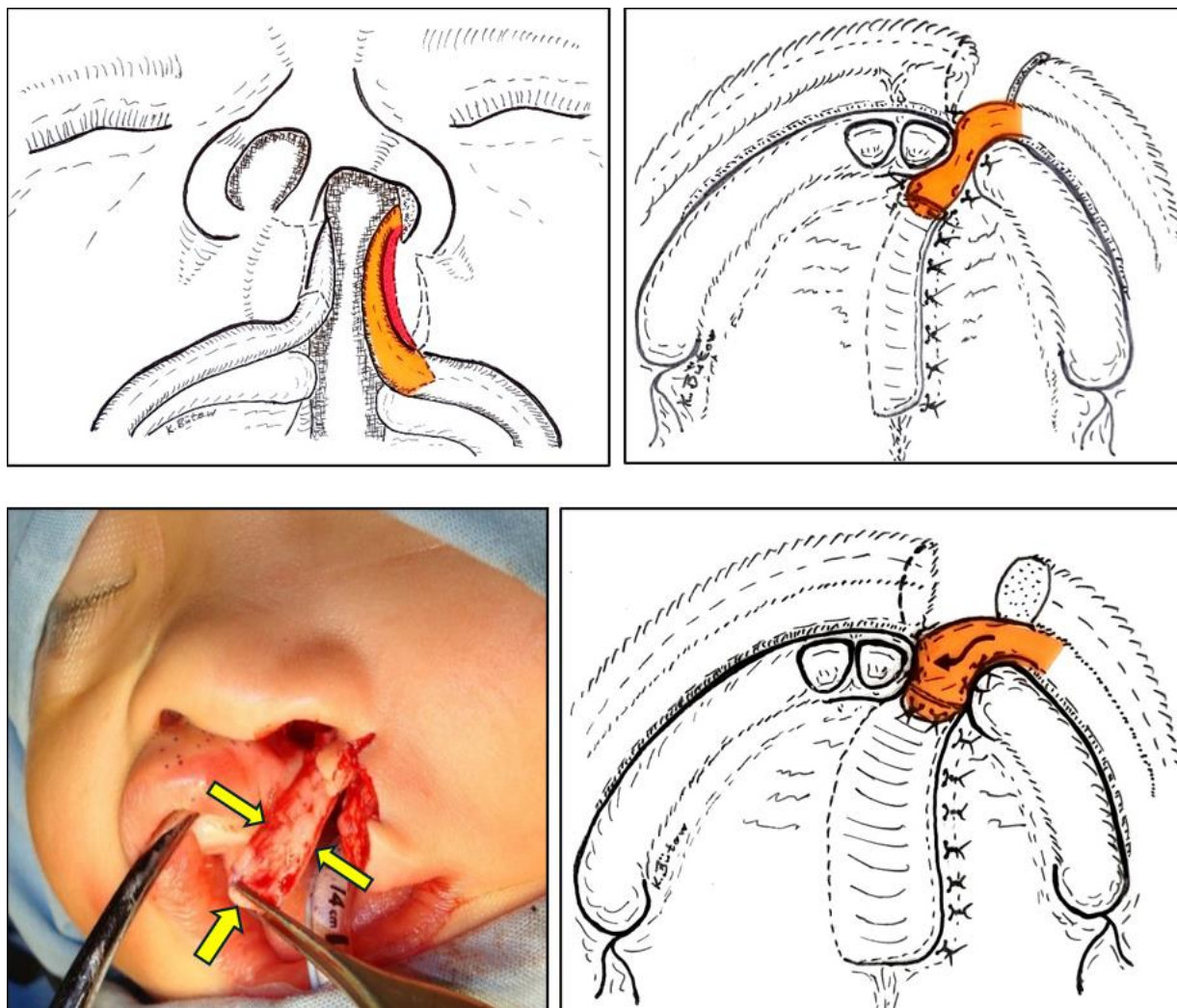


Figure 3: Unilateral CLAP: a: PANFF - red = cutaneous tissue, orange = mucosal tissue; b: Flap overlapping longitudinal a vomerplasty; c: Flap lifted from the lateral cleft lip; d: Wide alveolar cleft with a transversely or diagonally placement of flap at a vomerplasty at shP.

The Primary Anterior Nasal Floor Flap (PANFF) consists of lip mucosa, red-lip-dry, red-lip-wet and subdermoid tissue, while a narrow strip of cutaneous tissue is eliminated (Fig. 3). This approach results in a relatively bulky flap. During cheiloplasty, no essential cutaneous, mucosal or muscular tissue of the lip is sacrificed to create the PANFF. This flap functions as a rotational-longitudinal-advancement flap, rotating from vertical to horizontal and placed longitudinally between the alveolar segments towards the anterior part of the hard palate, which is embryologically referred to as the secondary palate (shP). Following the design and the dissection of the cleft lip for the cheiloplasty, the cleft lip shall surgically be sutured only after the PANFF is placed and sutured at the ANF. The flap needs to overlap nasally at shP edge (CLA) or the reconstructed shP flap (CLAP).

In bilateral CLA and CLAP cases, the PANFF surrounds the premaxilla and connects to the shP, avoiding openings in the ANF (Fig. 4). Small incisions are made at the border of the nasal cavity and at the alveolar arch segments, therefore at the medial and lateral sides of the nasal floor, raising a minute mucoperiosteum edge of approximately 0,5 to 1,0 mm. The lateral flap edges of the flap are sutured at these small incisions to secure a tight closure. In wide clefts, previous extensive obturpaedic arch modulation, the flap can be placed transversely into the eANF (Fig.3d), with one lateral side of the flap margin overlapping the reconstructed cleft hard palate (CLAP) (Fig.3d). With secure attachment, this flap provides a continuous layer from lip, lip-sulcus or vestibule, alongside the cleft alveolar arches and overlaps the anterior part of shP.

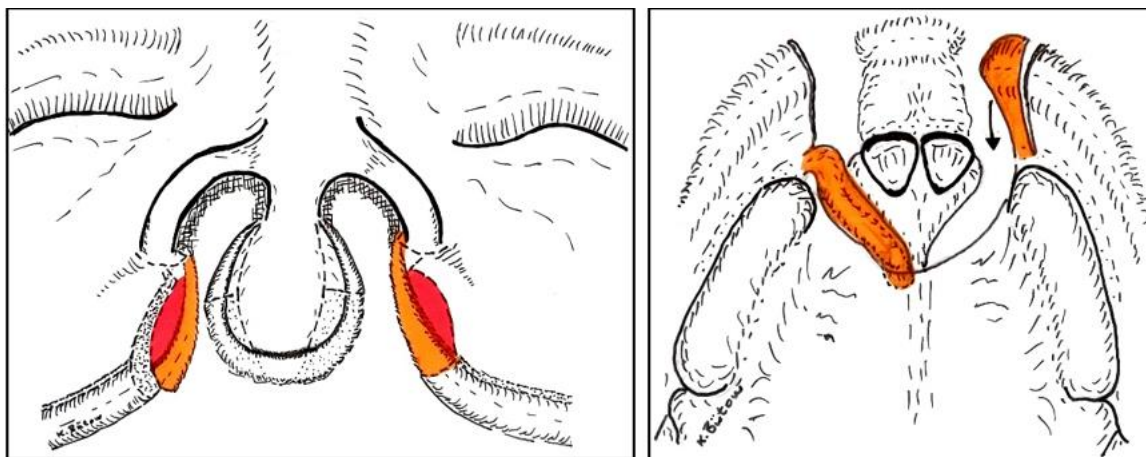


Figure 4: Bilateral CLA: a: Outline of PANFF, red = cutaneous tissue, orange = mucosal tissue; b: Bilateral cleft - flap surrounds longitudinal the premaxilla and attached at the hard palate.

To support long-term outcomes, the raw surface of the PANFF may be covered with a resorbable Poly-d,l-lactic acid (PdLALLA) plate or a gelatine plug. Such coverage may induct and facilitate appositional bone growth adjacent to the alveolar arch narrowing and stabilizing the alveolar segments [3]. However, long-term results have not yet been fully accessed.

Fusion - Primary Palate Attached at Secondary Palate

For a successful, full-length reconstruction of the cleft defect in the primary palate, the PANFF needs to be securely connected to the shP (CLA) or to the reconstructed cleft of the shP (CLAP). To minimise long-term dysgnathial effects on the midface as a brevi-retrognathia and/or arch collapsing of the maxilla. The conjointly fusion of the PANFF and a vomer-flap procedure in the shP, evades mucoperiosteal stripping of the posterior part of the primary palate and shP. This procedure is particularly recommended for infants and young children to prevent dysgnathial influence [3,8].

Three primary vomerplasty techniques have been published: a single-layered, cranially-pediced vomer-flap with raw surface coverage, a caudally-pediced vomer-flap and a double-layered vomer-flap [3,8,11-14]. The mucosal overlapping at the hP in the cranially-pediced single-layered and double-layered vomer-flaps are a mucosal-to-raw surface connection, with no reported fusional-healing dehiscence. In contrast, a caudally-pediced single-layered flap the mucosal overlap is a raw-to-raw surface connection. This vomerplasty is associated with adverse long-term contracted groove formation in the hP. The latter method is generally avoided except in cases involving exceptionally wide cleft in the shP. Alternatively, the surgical closure of the shP may be delayed until approximately 12 years of age, involving then a procedure with muco-periosteal stripping; however, this approach is associated with long-term palatal oro-nasal opening with adverse problems and should be considered carefully [8]. Long-term oro-nasal opening between or in the primary palate-shP requires extremely difficult secondary reconstruction during and beyond the orthopaedodontic treatment phase. Quite often it is assumed this secondary reconstruction is been part of secondary osteoplasty-oronasal fistula combination reconstruction with no guaranteed success at the posterior part of the primary palate. Various mucosal and cutaneous flaps for such an extensive secondary repair at the primary palate are previously been published deriving from buccal, cheek, premaxillary-reverse, turbinate, tongue, lip-scar, alar-island, subcutaneous nasolabial or nasal septum regions, with frequently non-assured healing success [15].

Discussion

Presurgical obturpaedic intervention is vital to modulate the eANF [2,4-7,16,17]. While patient compliance and the timing of obturpaedic device use are key variables. The benefits of this intervention generally outweigh any drawbacks, such as material reaction or oral hygiene deterioration due to possible milk products or liquid food residue stuck between the oral mucosa and artificial plate. A key positive outcome is the extensive reshaping of deformed oral and nasal structures. The growth forces during neonatal and infantile phases influence the applied rotational and alignment of the alveolar segments, which leads to effective narrowing of the cleft lip, reduction of nasal sill flaring and narrowing of the cleft between the alveolar segments. This positive progression is well-documented [5-7,16,17,19]. The width of the cleft at the alveolar segments directly affects the width of eANF with narrower defects requiring less flap width but necessitating a thicker or bulkier pedicle for a successful closure [3,20].

Devices such as the FJO or a NAM1 provides a protective barrier covering the surgical sites during the neonatal/infantile obturpaedic phase [2,4-7,16-18,21]. These devices safeguard against abrasive lesions and reduce the risk of infections or complications. The effect of the obturpaedic intervention is crucial in positively enhancing the structural integrity and growth at the nasal floor and facilitates a more acceptable anatomical configuration.

Various approaches to partial ANF reconstruction have been published, describing different flap designs. Early techniques, such as the Burian flap were designed as a double layer to close a gap between the alveolar segments [22,23]. Later adaptations, such as the L-flap, employing a small lateral lip mucosal flap are documented but also lack sufficient length to achieve connection to the shP [24,25]. Over time, several forms of partial anterior nasal floor reconstruction using lip-mucosal, buccal-mucosal, nasal-mucoperiosteal flaps or in any of these combinations have been described [20,23,24-26]. However, all these approaches often lack the required length to connect with the shP adequately. Similarly, the M- and L-flaps, although widely documented, often fail to provide sufficient tissue thickness or length [10] for an eANF construction. As a result, these techniques lead to persistent oro-nasal fistulae, in particularly in the alveolar-incisival region of the primary palate. Alternative approaches, such as a double-layered periosteal flap collected from the maxillary sinus wall, have been used for only a partial ANF closure, but have not adequately addressed the effects on the midfacial dysgnathia or the fusion to the shP [27].

Selecting an appropriate cheiloplasty technique remains a challenge in eANF reconstruction, especially when aiming to preserve sufficient tissue for a secure nasal floor flap [3,8,28]. In bCLAP reconstruction, the choice between the Broadbent-Woolf and Noordhoff-Trott techniques, each with distinct lip design, influences the most effective approach for accommodating a PANFF [3]. While a relatively simple surgery in concept, the extended primary anterior nasal floor reconstruction requires strict adherence to flap surgery principles to ensure successful closure and overlap with lateral adjacent areas [3]. In Cleft Lip cheiloplasty (CL), the three tissue layers - cutaneous, mucosal and muscular - must be adequately designed and sutured to achieve both aesthetical and functional results [3,8]. Discarding superfluous lip tissues, particularly for the CLA and CLAP cases is common practice but may result in the loss of opportunity for naso-palatal closure in the primary palate and extended as a connection to the shP [28]. The PANFF, as a bulky single-layered muco-subdermoid tissue flap, minimises contraction and remains securely in place when attached to the repaired shP. Avoiding extensive mucoperiosteal dissection in the walls of the ANF between the cleft alveolar segments minimises midfacial dysgnathial influences. The PANFF intervention eliminates oro-nasal fistulae in key areas such as buccal sulcus, alveolar-intersegmental and it particular at the alveolar-incisival or posterior primary palate. It provides a stable nasal layer for future procedures, such as alveolar bone grafting. Failure to close the eANF often results in oro-nasal openings, with persistent adverse otorhinolaryngologic sequelae at the alveolar-incisival primary palate region [15,29]. These becomes secondary or even tertiary surgical challenges due to the presence of teeth, alveolar bone shape and thin mucosal linings.

In the long-term, significant benefits are noted during subsequent orthopaeddontic intervention phase as this treatment becomes less invasive and require less force [8,9]. The absence of an anterior oro-nasal opening effectively minimises the risk of food particles or cement becoming trapped or entering the nasal cavity. Additionally, oral hygiene can be maintained at a higher standard, as cleaning agents, toothpaste and other materials will not penetrate and irritate the mucosal lining in the nasal cavity. This facilitates easier cleaning of appliances and adjacent deciduous teeth, which is more manageable for both the paediatric patients and their caregivers. The additional bulk tissue between the alveolar segments also serves as a protective barrier in the alveolar cleft, simplifying the orthopaeddontist treatment during this psychologically sensitive period. An otherwise uncomfortable water-air-spray application experience at the cleft region- often accompanied by echoing or reverberation in the ANF defect, nose and sinus cavities becomes more tolerable [9]. During orthognathic-orthopaeddontic treatment, involving expansion of the alveolar cleft, the integrity of the flap tissue remains unaffected. While orthopaeddontic appliances can influence speech. A tight closure of the ANF significantly mitigates the issue when appliances are located at the alveolar cleft region.

In a cycle of treatment sequela of Obturpaedics, Primary Surgery, Orthopaeddontics and Secondary Surgery. the advantages of the presurgical primary treatment far outweigh any disadvantages. Without presurgical obturpaedic, subsequent orthopaeddontic interventions and surgical construction of the eANF, both primary and secondary surgeries would be considerably more complex, as alveolar segments would likely remain misaligned and available tissue for reconstruction would be insufficient [2,9].

Conclusion

The importance of early obturpaedic intervention during the first months of rapid neonatal and infantile growth cannot be overstated. This phase is crucial for the alignment of the cleft alveolar segments, facilitating more precise arch formation and ensuring substantial narrowing of the eANF for a PANFF placement. The successful primary cleft surgical construction of the eANF in the primary palatal pivots on several critical factors: firstly on the design of the cheiloplasty and with it the design of the PANFF in terms of length, width and bulk; secondly on outcome of the presurgical obturpaedic alveolar arch alignments. The strategic use of superfluous tissue of a tactically chosen cheiloplasty can significantly contribute to the closure of its entire length of the primary palate of the ANF with a secured fusion to a reconstructed shP. Furthermore, it is essential to emphasise the inter-disciplinary approach combining obturpaedics and surgery to achieve optimal results. This synergy profoundly impacts both the functionality and aesthetics of the reconstructed eANF, significantly simplifying the orthopaeddontic treatment and contributing to better long-term outcomes for adolescents born with cleft anomalies. Early intervention during the neonate-infantile sets the foundation for the substantial improvement of overall treatment trajectory and quality of life of patient.

Conflict of Interest

All authors declare that they have no conflicts of interest.

Author Contributions

All authors contributed equally for this paper.

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