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Biodegradable Polycaprolactone Bone Scaffold for Rhinoplasty in Bilateral Cleft Repair: A Case Report

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ABSTRACT
Cleft nasal deformities are commonly observed in patients with unilateral or bilateral cleft lip, presenting various degrees of severity. Correcting nasal deformities, particularly in bilateral cleft lip patients, remains a complex challenge due to underlying anatomical abnormalities and the scarring from previous surgeries. This research aims to evaluate the effectiveness of secondary cleft rhinoplasty, focusing on addressing the hypoplastic and depressed bony structures critical to nasal projection. In many cases, autologous grafts, such as cartilage from the septum, ear, or rib, are traditionally used for nasal reconstruction. However, these materials present challenges, including donor site morbidity and tissue resorption. In this study, we explore the use of Osteopore™, a biodegradable polycaprolactone scaffold, as a bone substitute for nasal reconstruction. The results indicate that Osteopore™ offers a promising alternative with reduced morbidity and stable long-term outcomes. This method provides new insights into the materials and techniques for addressing cleft nasal deformities in bilateral cleft lip patients, potentially improving both aesthetic and functional outcomes.

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INTRODUCTION

The cleft nasal deformity affects the skin, cartilage, mucosa, and skeletal structure. In patients with bilateral cleft lip, the columella may be short or almost absent, with reduced soft tissue between the nasal tip and the vermillion border of the lip (Schliephake & Hausamen, 2023). The lower lateral cartilages exhibit an increased interdomain distance due to abnormal muscular insertions, leading to diminished projection and tip definition. The septum may remain midline in cases of incomplete clefts, but in complete clefts, it is often displaced and obstructive (Alhusainan, Bartlett, & Gilardino, 2022).

Bilateral deformity requires the repositioning of the second lower lateral cartilage (LLC) with reshaping techniques as well as suture techniques at the tip of the nose. Removal of fibrofatty tissue after LLC is separated helps define the shape of the tip of the nose (Lavernia, Brown, Wong, Hu, & Athanasiou, 2019). If the lower lateral cartilage is not strong enough to support proper projection, the use of columella strut and onlay grafts can be beneficial. The goal of bilateral deformity treatment is to

reduce the angle of divergence between the domal points of the LLC and provide a strong columella framework for the projection of the tip of the nose.

The preferred graft material for nasal reconstruction has traditionally been autologous tissue, including cartilage from the septum, ear, or rib, or bone from the rib, iliac crest, or skull (Hahn, 2017). However, using autografts can lead to complications at the donor site and create challenging postoperative experiences. Additionally, there is a risk of resorption, potentially requiring multiple rhinoplasty revisions. Given these factors, alloplastic materials offer a safer alternative.

In this case, Osteopore, a biodegradable polycaprolactone bone scaffold, was selected as a bone substitute for nasal reconstruction in patients with bilateral cleft lip (Oliver et al., 2021). A biodegradable polycaprolactone scaffold was considered because the nose continues to grow until around 15 to 18 years of age in boys. With this in mind, the use of biodegradable polycaprolactone has a minimal adverse effect on craniofacial growth. The implant is employed to correct the aesthetic shape of the nasal dome and tip, along with columellar lengthening reconstruction (Cho et al., 2021).

Osteopore, a bioresorbable implant, utilizes the body's regenerative capacity to restore lost tissue by guiding the natural healing process at the site of the defect (Mulchandani, Prasad, & Katiyar, 2019). The implant completely degrades over 18 to 24 months through hydrolysis. As tissue regeneration occurs through natural healing, the implant is gradually replaced by the patient's tissue and bone. The Osteopore™ 3D printing technique, combined with the use of polycaprolactone (PCL), allows the implant to achieve a structural stiffness similar to that of cancellous bone, providing necessary support during the regenerative phase. PCL is a synthetic biodegradable aliphatic polyester that undergoes hydrolytic degradation in humans. The degradation products of PCL do not contain harmful elements such as boron or chlorine (Dogan, Dogan, Savas, Ozcelik, & Tayfun, 2021). Therefore, PCL has been approved by the United States Food and Drug Administration for use in humans due to its high biocompatibility and safety.

This study aims to evaluate the effectiveness of Osteopore™ as a biodegradable bone scaffold for nasal reconstruction in patients with bilateral cleft lip, focusing on its impact on nasal aesthetics, structural integrity, and postoperative outcomes. Another objective is to assess polycaprolactone's long-term biocompatibility and safety (PCL) in pediatric patients, considering its effects on nasal growth and craniofacial development.

The findings of this research will provide valuable insights into the use of bioresorbable materials for nasal reconstruction, potentially offering a safer and more effective alternative to traditional autografts (Vasile et al., 2022). This could improve aesthetic outcomes, reduce postoperative complications, and result in fewer revision surgeries for patients with cleft nasal deformities. Additionally, the study will contribute to the broader understanding of biodegradable scaffolds in craniofacial reconstruction, informing clinical practices and material selection for future cases (Liu et al., 2021).

This study employs a case report research method, focusing on a patient with bilateral cleft lip undergoing nasal reconstruction. The patient was treated using the Osteopore™ bioresorbable implant in place of traditional autologous grafts. Data collection included preoperative and postoperative assessments of nasal structure, projection, and aesthetic outcomes. Additionally, postoperative follow-ups were conducted over a 24-month period to monitor the degradation of the scaffold and the patient’s natural tissue regeneration. This method allows for an in-depth analysis of the clinical application and outcomes associated with the use of biodegradable polycaprolactone scaffolds in nasal reconstruction (Maroulakos, Kamperos, Tayebi, Halazonetis, & Ren, 2019).

RESULT AND DISCUSSION

A 9-year-old male came to the plastic reconstructive and aesthetic surgery outpatient clinic with a chief complaint being a lack of nasal symmetry from the previous procedure (Milothridis, 2020). Past surgical history revealed that he had undergone cleft lip repair at the age of 3 months and cleft palate repair at the age of 1,5 years.

The preoperative examination findings were wide nasal dorsum, nasal pyramid was slightly slanted to the left side of patient, absent nasal tip projection, the columella was short, widened nostrils, and hypertrophic scarring throughout the philtrum. (Figure 1).

Figure 1.
Patients' preoperative profile view

Open rhinoplasty was performed for the cleft nasal deformity. The surgery was carried out under general anesthesia (Yue, Piao, Cao, Chen, & Huang, 2023). An inverted-V transcolumellar incision with a bilateral marginal incision was made (Figure 2), and dissection was done until the lower lateral cartilage and septal cartilage were exposed. Columellar lengthening was done, and nasal reconstruction using a biodegradable polycaprolactone bone scaffold as a columellar strut graft (Figure 3).

Figure 2.

Inverted-V transcolumellar incision with bilateral marginal incision

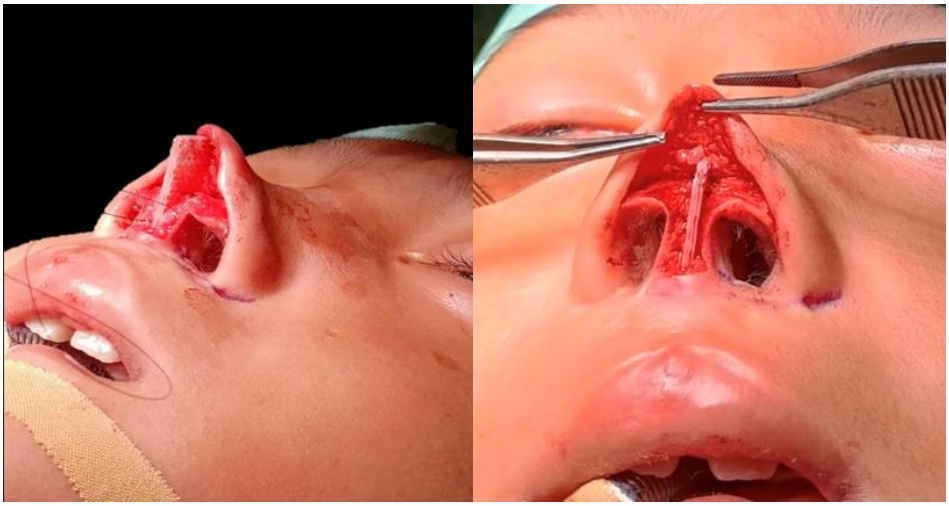

Figure 3.
Biodegradable polycaprolactone bone scaffold as a columellar strut graft

Figure 4.
Patients' postoperative profile view

Postoperatively, the healing was satisfactory, with no signs of infection or wound dehiscence (Adogwa et al., 2014). The symmetry of the nasal tip was corrected, and both nostrils were similar in size. There was a good projection of the nasal dorsum and nasal tip postoperatively (Figure 5). The results were stable, with no evidence of relapse, with a period of follow-up of 6 months.

Figure 5.
(a) One-month postoperative photograph of frontal and lateral view. (b) Three months postoperative photograph frontal and lateral view. (c) Six months postoperative photograph frontal and side view.

Cleft nasal deformity remains a complex issue, particularly in bilateral cleft lip patients. The difficulty lies not only in the primary anatomic defects but also in the challenges created by scar tissue

from previous surgical repairs. This case highlights the significance of addressing both soft tissue and the underlying bony structure during secondary cleft rhinoplasty (Yuan & An, 2024a). The hypoplastic and weakened nasal framework, particularly in the bony and cartilaginous structures, demands special attention to ensure proper nasal projection and symmetry, which are crucial for both functional and aesthetic outcomes (Carro & Tokgöz, 2023).

In this case, using autologous grafts such as cartilage for nasal reconstruction was weighed against potential complications (Yuan & An, 2024b). While autografts provide structural support and have been the gold standard, they have disadvantages. Donor site morbidity and the possibility of graft resorption can complicate long-term outcomes and patient satisfaction (Putters et al., 2018).

The decision to use a biodegradable polycaprolactone bone scaffold was based on the need for both structural support and minimized patient morbidity (Alonzo et al., 2021). At the age of 15 to 18 years in boys, the nose continues to grow, and the use of biodegradable scaffold only has a lesser adverse effect on craniofacial growth. However, the long-term success of this technique will require careful monitoring, as the balance between resorption and tissue integration remains a crucial factor in the outcome of the reconstruction (Zizzari et al., 2016).

This approach aligns with emerging trends in cleft rhinoplasty, where emphasis is increasingly placed on minimizing patient morbidity while optimizing structural and aesthetic outcomes (Nikparto et al., 2024). Further research is needed to fully assess the long-term outcomes of biodegradable scaffolds in cleft nasal deformity, particularly in bilateral cases where the anatomical challenges are greater (Sharif, Ur Rehman, Muhammad, & MacNeil, 2016).

Ultimately, this case highlights the importance of personalized treatment plans for cleft patients, taking into account the specific anatomical challenges and patient needs (Haj et al., 2024). The incorporation of newer materials like biodegradable polycaprolactone bone scaffold into cleft nasal reconstruction offers exciting possibilities for improving outcomes while reducing the complications associated with autologous grafts (Tollemar et al., 2016).

CONCLUSION

The cleft nasal deformity presents a persistent challenge to surgeons, and addressing this issue requires both an in-depth understanding of the cleft anatomy and a comprehensive assessment of its aesthetic and functional impacts. This study contributes to the field by underscoring the importance of individualized treatment plans that factor in these complex variables. The findings suggest that an open external approach to rhinoplasty offers optimal exposure for structural graft placement, enhancing tip projection, definition, support, and overall function. Furthermore, the use of a biodegradable polycaprolactone bone scaffold for nasal reconstruction in patients under 18 with bilateral cleft lip demonstrates a significant advancement. This approach minimizes the risk of donor site morbidity and mitigates distressing postoperative experiences, thereby contributing to improved patient outcomes and advancing surgical techniques in cleft nasal reconstruction.

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