

Review Article

Nasoalveolar molding in cleft lip repair: A literature review

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ABSTRACT:

Cleft lip and palate conditions are congenital anomalies that significantly impact facial aesthetics and functional outcomes in affected individuals. Nasoalveolar molding (NAM) has emerged as a promising approach to improve the surgical outcomes of cleft lip repair. This unstructured abstract provides a concise overview of the existing literature on NAM for both unilateral and bilateral cleft lip repair.

The review begins by summarizing the historical context and evolution of NAM as a preoperative intervention for cleft lip repair. It then explores the underlying principles and mechanisms of NAM, emphasizing its role in reshaping nasal and alveolar structures in preparation for surgical correction. The article discusses various techniques and appliances used in NAM, shedding light on their effectiveness and potential complications.

Additionally, the review critically examines the evidence regarding the timing and duration of NAM treatment, with a focus on the optimal age for initiating therapy and the duration required to achieve desired outcomes. Furthermore, the article highlights the importance of interdisciplinary collaboration involving orthodontists, pediatricians, and surgeons in delivering comprehensive care to cleft lip patients.

The impact of NAM on speech development, feeding difficulties, and psychosocial well-being is addressed to provide a comprehensive understanding of its holistic effects on cleft lip patients. Moreover, the review discusses the current controversies, limitations, and future directions in NAM research and practice, emphasizing the need for standardized protocols and long-term follow-up studies.

In conclusion, this unstructured abstract offers a broad overview of the literature on Nasoalveolar Molding for unilateral and bilateral cleft lip repair, highlighting its potential benefits, challenges, and areas for further investigation. Understanding the current state of NAM research is essential for healthcare professionals involved in the care of cleft lip patients, ultimately aiming to enhance the quality of life for these individuals.

Keywords: Nasoalveolar Molding, Cleft Lip Repair, Unilateral Cleft Lip, Bilateral Cleft Lip, Preoperative Intervention, Orthodontic Treatment, Craniofacial Anomalies, Surgical Outcomes, Interdisciplinary Collaboration, Speech Development, Feeding Difficulties, Psychosocial Well-being, Treatment Timing, Treatment Duration, Complications, Standardized Protocols, Long-term Follow-up, Literature Review.

Received: 05 July, 2023

Accepted: 09 August, 2023

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This article may be cited as: Shadani K, Dolker T, Rathod P, Galhotra V, Parimala, Lepcha J. Nasoalveolar molding in cleft lip repair: A literature review. J Adv Med Dent Scie Res 2023;11(9):19-26.

INTRODUCTION

A. Background and Significance of Cleft Lip Conditions

Cleft lip conditions are congenital craniofacial anomalies that affect millions of individuals worldwide, with a profound impact on their overall well-being. These conditions manifest as a separation or gap in the upper lip, often extending into the nasal structure. The prevalence of cleft lip conditions varies across populations, with estimates ranging from 1 in 1,000 to 1 in 2,500 live births¹. Such conditions can

result in functional issues, including difficulties in feeding, speech development, and dental health, as well as significant psychosocial challenges².

B. Rationale for Nasoalveolar Molding (NAM) as a Preoperative Intervention

The rationale for employing Nasoalveolar Molding (NAM) as a preoperative intervention in the management of cleft lip conditions stems from its potential to mitigate some of the challenges associated with these congenital anomalies. NAM is a non-surgical technique that involves the use of specialized

orthodontic devices to mold and reshape the nasal and alveolar structures before surgical repair. Its primary objectives include achieving better nasal symmetry, enhancing lip and alveolar arch alignment, and improving the overall aesthetics of the affected region.

Existing literature supports the efficacy of NAM in achieving these goals. Grayson et al.³. (2003) conducted a seminal study that demonstrated the positive impact of NAM on nasal and alveolar molding in patients with unilateral cleft lip and palate. They reported improved nasal aesthetics and alignment, which facilitated subsequent surgical correction. Similarly, Zuhaib M et al.⁴. (2016) compared different materials used in NAM and found favorable outcomes, reinforcing NAM's value as a preoperative intervention.

C. Purpose and Scope of the Literature Review

The purpose of this literature review is to comprehensively examine the role of Nasoalveolar Molding (NAM) in the context of unilateral and bilateral cleft lip repair. This review aims to provide a consolidated overview of the existing body of literature pertaining to NAM, with a specific focus on its techniques, timing of intervention, outcomes, and associated challenges.

By synthesizing and analyzing the available research, this review intends to offer insights into the effectiveness of NAM in optimizing surgical outcomes and improving the quality of life for individuals with cleft lip conditions. Furthermore, it aims to identify gaps in the literature and areas requiring further investigation, contributing to the ongoing advancement of cleft care.

Prior studies, such as Padovano WM et al's⁵ (2022) systematic review of NAM and gingivoperiosteoplasty outcomes and Koya, Shafees et al.'s⁶ (2018) comprehensive review of Nasoalveolar Molding, have touched upon various aspects of NAM. However, this review seeks to provide a more specific and up-to-date synthesis of literature related to NAM's application in unilateral and bilateral cleft lip repair.

HISTORICAL EVOLUTION OF NASOALVEOLAR MOLDING

A. Early Attempts at Cleft Lip Repair

Early attempts at cleft lip repair can be traced back centuries, reflecting humanity's longstanding recognition of the need to address this congenital condition. Ancient civilizations, such as the Egyptians and the Chinese, documented primitive surgical techniques aimed at correcting cleft lip deformities⁷ (Kling RR, 2014). However, these early approaches were often rudimentary and fraught with high rates of complications.

The historical significance of cleft lip repair lies in the enduring challenge it presented to medical practitioners, inspiring ongoing innovation and refinement of surgical techniques over time. Documentation of these early attempts serves as a

testament to the recognition of the condition's impact on affected individuals.

B. Emergence and Development of Nasoalveolar Molding (NAM)

The emergence of Nasoalveolar Molding (NAM) as a preoperative intervention represents a pivotal moment in the treatment of cleft lip conditions. NAM's development was significantly influenced by advances in orthodontics and craniofacial surgery during the 20th century. The technique was initially introduced by Dr. Barry T. Grayson in the 1950s and gained prominence over subsequent decades.

Dr. Grayson's⁸ pioneering work demonstrated the potential of NAM in preparing cleft lip patients for surgical repair. By applying controlled forces using specialized orthodontic devices, NAM aimed to mold and reposition the nasal and alveolar structures to optimize the surgical outcome. This marked a shift away from traditional surgical correction without preoperative preparation.

The development of NAM marked a paradigm shift in the approach to cleft lip treatment, emphasizing a more comprehensive and multidisciplinary approach. This innovation has since become an integral component of modern cleft care.

C. Evolution of NAM Techniques and Practices

Since its inception, Nasoalveolar Molding (NAM) has seen continuous evolution and refinement in its techniques and practices. Early NAM protocols were relatively basic, but contemporary approaches have incorporated advances in materials, technology, and understanding of craniofacial growth.

One notable development in NAM has been the introduction of 3D digital technology, allowing for more precise treatment planning and monitoring. Additionally, different materials have been explored and compared for their effectiveness in NAM appliances, leading to improved outcomes (Chao et al.⁹, 2016). Collaborative efforts among orthodontists, pediatricians, and surgeons have also contributed to the standardization of NAM protocols.

Ongoing research continues to shape NAM techniques and practices, with a focus on optimizing the balance between achieving desired outcomes and minimizing treatment duration and potential complications.

PRINCIPLES AND MECHANISMS OF NASOALVEOLAR MOLDING

A. The Anatomical Structures Affected by Cleft Lip

To understand the principles of Nasoalveolar Molding (NAM), it's crucial to first appreciate the anatomical structures affected by cleft lip conditions. Cleft lip primarily involves the upper lip and adjacent structures, including the nose and alveolar ridge. In unilateral cleft lip, there is a gap in one side of the lip, often extending into the nostril, while bilateral cleft lip presents gaps on both sides.

The cleft lip condition disrupts the normal alignment and development of these structures, resulting in

varying degrees of asymmetry and malformation. The nasal cartilage, nasal septum, and alveolar bone may also be affected, compounding the complexity of the condition.

B. How NAM Works to Reshape Nasal and Alveolar Structures

Nasoalveolar Molding (NAM) is a non-surgical technique aimed at gradually reshaping the nasal and alveolar structures in preparation for surgical repair. NAM works by applying controlled forces using specialized orthodontic devices, typically consisting of molded acrylic plates, nasal stents, and elastic bands.

These devices are custom-designed for each patient and are adjusted periodically to direct growth and alignment in the desired direction. **The primary mechanisms involved in NAM include:**

1. **Tissue Stretching:** Elastic forces applied by NAM appliances gently stretch the soft tissues around the cleft site. This helps to close the gap in the lip and guide the alignment of the nasal cartilage.
2. **Alveolar Arch Molding:** NAM devices encourage the proper alignment and approximation of the alveolar arch, improving the shape of the maxillary dental arch.
3. **Nasal Cartilage Remodeling:** The pressure exerted by nasal stents helps reshape the nasal cartilage, promoting more symmetrical nostril development and nasal tip alignment.
4. **Parental Involvement:** NAM requires active participation from parents or caregivers, who are trained to adjust the devices and monitor progress regularly.

C. Mechanisms Underlying Successful NAM Outcomes

Successful outcomes in Nasoalveolar Molding (NAM) are contingent on several key mechanisms and factors. **These include:**

- **Age at Initiation:** NAM is most effective when initiated early, ideally within the first few weeks of life, as the infant's craniofacial structures are still malleable and responsive to molding (Grayson et al¹⁰, 2003).
- **Consistent Device Wear:** Adherence to a strict wear schedule and diligent maintenance of the NAM appliances by parents or caregivers is crucial for achieving desired outcomes.
- **Orthodontic Expertise:** NAM treatment should be overseen by experienced orthodontists who can customize appliances, make necessary adjustments, and monitor progress effectively.
- **Interdisciplinary Collaboration:** Effective communication and collaboration among orthodontists, pediatricians, and surgeons ensure a comprehensive and coordinated approach to cleft care (Grayson et al¹⁰, 2003).
- **Patient-specific Planning:** Tailoring NAM treatment to each patient's unique anatomy and needs is essential for optimizing outcomes.

- **Psychosocial Support:** Recognizing the emotional and psychosocial impact of NAM on parents and caregivers is crucial for maintaining treatment adherence and patient well-being.

NAM TECHNIQUES AND APPLIANCES

A. Overview of Commonly Used NAM Appliances

Nasoalveolar Molding (NAM) employs a variety of appliances and devices designed to reshape the nasal and alveolar structures in patients with cleft lip conditions. **Commonly used NAM appliances include:**

1. **Nasal Stents:** These are devices inserted into the nostrils to support and mold the nasal cartilage. They help in achieving nasal symmetry and alignment.
2. **Molded Acrylic Plates:** These plates are custom-made to fit the infant's palate. They play a crucial role in reshaping the alveolar arch, aligning the cleft segments, and facilitating lip closure.
3. **Elastic Bands:** These are used to apply controlled forces to guide the alignment of the lip and alveolar segments. They help close the gap in the lip and improve alignment.
4. **Taping Techniques:** In some cases, specialized taping techniques may be used to further support lip closure and alignment.

B. Effectiveness and Drawbacks of Different NAM Techniques

The effectiveness of Nasoalveolar Molding techniques can vary based on several factors, including the severity of the cleft condition, the age at which treatment is initiated, and the skill and experience of the healthcare providers. Existing literature discusses the following aspects:

- **Effectiveness:** Studies, such as Grayson et al¹⁰. (2003), have reported positive outcomes with NAM, including improved nasal symmetry, better alveolar arch alignment, and enhanced aesthetics. However, the extent of improvement can vary between individuals.
- **Drawbacks:** Some drawbacks associated with NAM include the need for strict adherence to treatment protocols, potential parental burden in managing appliances, and occasional complications, such as skin irritation or pressure sores.
- **Timing:** Effectiveness is often linked to the timing of NAM initiation. Earlier initiation, ideally within the first few weeks of life, tends to yield better results due to the greater malleability of infant craniofacial structures (Grayson et al¹⁰, 2003).
- **Patient-specific Factors:** Patient-specific factors, including the type and extent of cleft, can influence the choice of NAM techniques and their outcomes.

C. Considerations for Choosing the Appropriate NAM Approach

Selecting the appropriate NAM approach involves careful consideration of various factors:

- **Individual Assessment:** Each patient's unique anatomy and cleft presentation require a customized NAM plan. Orthodontists, in collaboration with other healthcare providers, evaluate the specific needs of the patient.
- **Severity of the Cleft:** The severity of the cleft condition and the goals of treatment play a role in determining the appropriate NAM techniques and appliances.
- **Interdisciplinary Collaboration:** Effective communication and collaboration among orthodontists, pediatricians, and surgeons are vital for making informed decisions about NAM approaches (Grayson et al¹⁰, 2003).
- **Parental Education and Support:** Parents or caregivers need to be educated about the chosen NAM approach and supported in managing the appliances and adhering to the treatment plan.
- **Monitoring and Adjustments:** Regular monitoring of progress and adjustments to NAM appliances are essential to ensure that treatment remains on track.

TIMING AND DURATION OF NAM TREATMENT

A. Optimal Age for Initiating NAM Therapy

Determining the optimal age for initiating Nasoalveolar Molding (NAM) therapy is a critical consideration in the treatment of cleft lip conditions. The timing of NAM initiation can significantly impact its effectiveness and overall outcomes. Existing literature and clinical experience provide insights into this aspect:

- **Early Initiation:** Numerous studies emphasize the advantages of initiating NAM therapy as early as possible, ideally within the first few weeks of life. Grayson et al¹⁰. (2003) demonstrated that early NAM initiation in infants with cleft lip and palate led to improved outcomes in terms of nasal symmetry and alveolar arch alignment. The greater malleability of infant craniofacial structures makes early intervention more effective.
- **Age-specific Considerations:** The age at which NAM is initiated may vary based on individual patient factors, such as the extent and severity of the cleft, overall health, and the readiness of the patient and parents to engage in treatment.

B. Duration Required to Achieve Desired Outcomes

The duration of Nasoalveolar Molding (NAM) treatment varies among patients and depends on factors such as the initial severity of the cleft and the goals of treatment. Literature and clinical experience provide insights into the time required to achieve desired outcomes:

- **Treatment Period:** NAM treatment typically spans several months, with regular adjustments to the appliances. The duration varies but can range from 3 to 6 months or longer, depending on the specific case (Chao et al⁹, 2016).
- **Progress Monitoring:** The effectiveness of NAM is assessed through regular monitoring, and adjustments are made as needed to ensure that the treatment progresses toward the desired goals.
- **Patient-specific Factors:** The complexity of the cleft condition, the rate of tissue response to the appliances, and the age at which treatment begins all influence the duration of NAM therapy.

C. Challenges and Considerations in Treatment Timing

While early initiation of NAM is generally favored, several challenges and considerations exist:

- **Diagnosis and Referral:** Timely diagnosis and referral to a specialized cleft care team are essential for initiating NAM promptly.
- **Parental Readiness:** Parents or caregivers must be educated and prepared to actively participate in NAM, which can be demanding, especially if the infant is very young.
- **Clinical Evaluation:** An initial clinical evaluation should consider the specific needs of each patient to determine the most appropriate timing for NAM initiation.
- **Interdisciplinary Coordination:** Effective collaboration among orthodontists, pediatricians, surgeons, and other healthcare providers is crucial to ensure that NAM is initiated at the right time and coordinated with the overall treatment plan (Grayson et al¹⁰, 2003).

INTERDISCIPLINARY COLLABORATION IN CLEFT CARE

A. The Role of Orthodontists, Pediatricians, and Surgeons in NAM

Effective Nasoalveolar Molding (NAM) relies on the collaborative efforts of multiple healthcare professionals who play distinct but complementary roles in the care of cleft lip patients. Existing literature highlights the roles of orthodontists, pediatricians, and surgeons in NAM:

- **Orthodontists:** Orthodontists are central to NAM treatment. They design and customize the NAM appliances, ensure proper fit, and make necessary adjustments throughout the treatment. Their expertise in craniofacial growth and development is instrumental in achieving optimal outcomes (Grayson et al¹⁰, 2003).
- **Pediatricians:** Pediatricians play a crucial role in the overall health and well-being of cleft lip patients. They monitor the patient's growth and development, provide guidance to parents, and collaborate with orthodontists and surgeons to ensure that NAM is integrated into the broader care plan.

- **Surgeons:** Surgeons are responsible for the primary cleft lip repair surgery, which typically follows NAM treatment. They rely on the preoperative preparation provided by NAM to achieve better surgical outcomes, including improved aesthetics and function.

B. Importance of a Coordinated, Team-Based Approach

Interdisciplinary collaboration is paramount in cleft care, especially when it comes to Nasoalveolar Molding. A coordinated, team-based approach ensures that all aspects of the patient's care are well-integrated. Literature and clinical practice emphasize several key reasons for the importance of such an approach:

- **Comprehensive Care:** Cleft lip conditions involve multiple aspects of health, including aesthetics, speech, and overall well-being. A coordinated team can address these diverse needs effectively.
- **Treatment Planning:** Collaboration among specialists allows for the development of a comprehensive treatment plan that considers the timing of NAM, surgical intervention, and long-term follow-up care.
- **Communication:** Effective communication among team members ensures that everyone is aligned in their approach and that any changes or developments in the patient's condition are promptly addressed.
- **Patient and Family Support:** Interdisciplinary teams provide invaluable support to patients and their families by offering guidance, education, and a unified approach to care.

C. Case Studies Illustrating Successful Collaboration

Case studies serve as powerful examples of the benefits of interdisciplinary collaboration in cleft care. They demonstrate how orthodontists, pediatricians, and surgeons work together to achieve optimal outcomes. While specific case studies may be found in clinical literature, the collaborative successes observed in practice are often documented in multidisciplinary cleft care centers or team-based healthcare settings.

Case studies provide evidence of how NAM, when integrated into a broader care plan, can lead to improved nasal symmetry, alveolar alignment, and overall facial aesthetics, enhancing the quality of life for cleft lip patients.

HOLISTIC IMPACT OF NAM

A. Effects on Speech Development

Nasoalveolar Molding (NAM) not only addresses the aesthetic aspects of cleft lip conditions but also has a significant impact on speech development. Existing literature and clinical observations demonstrate the following effects:

- **Improved Speech Outcomes:** NAM has been shown to contribute to improved speech

outcomes in cleft lip patients. By facilitating better alignment of the alveolar arch and the palate, NAM helps create a more optimal environment for speech sound production (Bajaj et al¹¹, 2011).

- **Early Intervention:** Early initiation of NAM is associated with better speech development outcomes. The molding of nasal and alveolar structures in infancy can positively influence articulation and reduce the risk of compensatory speech patterns (Semb G et al¹², 2005).
- **Multidisciplinary Collaboration:** Effective collaboration among speech-language pathologists, orthodontists, and surgeons is crucial to address speech-related concerns comprehensively.

B. Management of Feeding Difficulties

Feeding difficulties are common challenges faced by infants with cleft lip conditions. NAM plays a role in managing these difficulties:

- **Improved Feeding Skills:** NAM can help improve feeding skills in infants with cleft lips. By narrowing the cleft gap and facilitating better lip closure, infants can achieve more effective suction during breastfeeding or bottle feeding (Esenlik, Elçin et al¹³, 2015).
- **Parental Education:** NAM treatment includes parental education on proper feeding techniques and strategies, empowering parents to provide appropriate support for their infants' nutritional needs.
- **Enhanced Nutritional Intake:** Successful NAM can contribute to better nutritional intake, growth, and overall health in infants with cleft lip conditions.

C. Influence on Psychosocial Well-being

The psychosocial well-being of individuals with cleft lip conditions is profoundly influenced by their appearance and self-esteem. NAM can positively impact psychosocial outcomes:

- **Enhanced Self-esteem:** Improved facial aesthetics resulting from NAM can enhance self-esteem and body image perception in children and adolescents with cleft lip conditions (Hunt et al¹⁴, 2007).
- **Reduced Stigmatization:** Reduced stigmatization due to improved facial appearance can lead to better psychosocial adjustment and decreased risk of bullying or social isolation (Snyder HT et al¹⁵, 2005).
- **Parental Satisfaction:** Parents of children who undergo NAM often report increased satisfaction with their child's appearance and improved family dynamics (Al-Omari I et al¹⁶, 2005).

D. Assessing the Overall Quality of Life for Cleft Lip Patients Undergoing NAM

Assessing the overall quality of life for cleft lip patients undergoing Nasoalveolar Molding (NAM) involves a comprehensive evaluation of various factors:

- **Health-Related Quality of Life (HRQoL):** Research, such as the study by Al-Omari et al¹⁷. (2013), has utilized standardized HRQoL measures to assess the impact of NAM on various aspects of patients' lives, including physical, emotional, and social well-being.
- **Patient and Parental Perspectives:** Qualitative research and surveys gather insights from patients and their families regarding the holistic impact of NAM, shedding light on their experiences and satisfaction levels.
- **Long-term Follow-up:** Longitudinal studies are essential to understand how NAM's impact on quality of life evolves over time and to identify potential challenges or persistent concerns.
- **Variable Outcomes:** NAM outcomes can vary among patients due to individual factors, such as cleft severity, patient age, and treatment adherence. Managing expectations and communicating potential variability in outcomes is essential (Chao et al⁹, 2016).

C. Areas for Future Research and Improvement

The field of NAM continues to evolve, and there are several areas for future research and improvement:

CONTROVERSIES, LIMITATIONS, AND FUTURE DIRECTIONS

A. Current Debates in the Field of NAM

The field of Nasoalveolar Molding (NAM) is not without its share of debates and ongoing discussions. These controversies reflect the dynamic nature of cleft care and NAM practices. Some of the current debates include:

- **Timing of NAM Initiation:** While early initiation of NAM is generally favored, there is ongoing debate about the precise age at which it should commence. Some argue for immediate initiation within the first weeks of life, while others suggest waiting for anatomical stability (Grollemund B et al¹⁸, 2018).
- **Efficacy vs. Complications:** Balancing the potential benefits of NAM with the risk of complications, such as skin irritation or pressure sores, remains a subject of debate. Determining the threshold for intervention-related complications is an ongoing discussion (Chao et al⁹, 2016).
- **Standardization of Protocols:** There is debate about the need for standardized NAM protocols versus individualized approaches tailored to each patient's unique needs. Striking the right balance between consistency and customization is a point of contention (Chao et al⁹, 2016).

B. Common Limitations and Challenges in NAM Practice

Despite its many benefits, Nasoalveolar Molding (NAM) faces certain limitations and challenges:

- **Treatment Adherence:** Ensuring that parents or caregivers consistently adhere to the NAM treatment plan, including appliance wear and adjustments, can be challenging. Maintaining motivation and compliance over the entire treatment duration is critical (Hoek IH et al¹⁹, 2009).
- **Resource Constraints:** NAM may not be readily accessible in all regions, and the cost of treatment can be a barrier for some families. Addressing resource disparities and expanding access to care remain ongoing challenges (Tao et al²⁰, 2019).

- **Long-term Outcomes:** Longitudinal studies are needed to assess the enduring impact of NAM on facial growth, speech development, and psychosocial well-being. Research that follows patients into adolescence and adulthood can provide valuable insights (Grollemund B et al¹⁸, 2018).

- **Standardization and Guidelines:** Developing standardized protocols and clinical guidelines for NAM, while allowing for individualization where necessary, can improve consistency and outcomes in NAM practice (Chao et al⁹, 2016).

- **Advanced Materials and Technology:** Research into innovative materials and technology for NAM appliances can lead to improved comfort, reduced complications, and enhanced treatment outcomes (Hoek IH et al¹⁹, 2009).

- **Psychosocial Impact:** Further exploration of the long-term psychosocial impact of NAM on patients and their families can inform support strategies and interventions (Stock et al²¹, 2003).

- **Global Accessibility:** Efforts to increase the accessibility of NAM in underserved regions and reduce treatment costs are crucial for ensuring that all cleft lip patients have access to optimal care (Tao et al²⁰, 2019).

CONCLUSION

A. Summary of Key Findings from the Literature Review

In this comprehensive literature review, we have explored the multifaceted landscape of Nasoalveolar Molding (NAM) for unilateral and bilateral cleft lip repair. Key findings from the review include:

- **Historical Evolution:** NAM has evolved as a significant preoperative intervention, transitioning from rudimentary cleft lip repair attempts in ancient civilizations to a modern, multidisciplinary approach pioneered by Dr. Barry T. Grayson (Grayson et al¹⁰, 2003).
- **Mechanisms and Principles:** NAM devices and techniques work by applying controlled forces to reshape the nasal and alveolar structures. It involves tissue stretching, alveolar arch molding, nasal cartilage remodeling, and requires active parental involvement (Grayson et al¹⁰, 2003).
- **Interdisciplinary Collaboration:** Successful NAM treatment relies on the collaborative efforts of orthodontists, pediatricians, and surgeons, emphasizing the importance of a coordinated, team-based approach (Grayson et al¹⁰, 2003).

- **Holistic Impact:** NAM not only improves aesthetics but also positively influences speech development, the management of feeding difficulties, and psychosocial well-being in cleft lip patients. It contributes to better quality of life outcomes (Hunt et al¹⁴., 2007; Stock et al²¹., 2003).
- **Challenges and Controversies:** NAM practice faces challenges related to treatment adherence, resource disparities, and variability in outcomes. Ongoing debates include the optimal timing of NAM initiation and the balance between standardization and customization (Chao et al⁹., 2016; Grollemund B et al¹⁸., 2018).
- **Future Directions:** Future research should focus on long-term outcomes, standardization of protocols, advanced materials and technology, and improving global accessibility to NAM (Hoek IH et al¹⁹., 2009; Tao et al²⁰., 2019).

B. The Significance of NAM in Improving Cleft Lip Repair Outcomes

Nasoalveolar Molding (NAM) holds profound significance in the field of cleft lip repair. Its impact extends beyond the cosmetic realm, addressing functional and psychosocial aspects. NAM's significance lies in:

- **Enhanced Surgical Outcomes:** By preparing the nasal and alveolar structures, NAM sets the stage for improved surgical outcomes. Surgeons can achieve better lip closure, nasal symmetry, and overall facial aesthetics (Grayson et al¹⁰., 2003).
- **Optimized Speech Development:** NAM contributes to improved speech development by aligning the alveolar arch and creating a more favorable environment for speech sound production (Bajaj et al¹¹., 2011).
- **Improved Feeding Skills:** NAM aids in managing feeding difficulties, ensuring better nutritional intake and overall health in infants with cleft lip conditions (Esenlik, Elçin et al¹³., 2015).
- **Enhanced Psychosocial Well-being:** NAM positively influences psychosocial well-being by enhancing self-esteem, reducing stigmatization, and improving overall quality of life (Hunt et al¹⁴., 2007; Stock et al²¹., 2003).

C. Implications for Healthcare Professionals and Further Research

The findings of this literature review have several implications for healthcare professionals and future research:

- **Healthcare Professionals:** Healthcare providers, including orthodontists, pediatricians, surgeons, and speech-language pathologists, should recognize the importance of interdisciplinary collaboration in cleft care. They should also stay informed about evolving NAM techniques and practices.
- **Parents and Caregivers:** Parents and caregivers of cleft lip patients should be educated about

NAM, its potential benefits, and the importance of treatment adherence.

- **Further Research:** Future research should focus on longitudinal studies to assess long-term NAM outcomes, the development of standardized NAM protocols, and efforts to increase global accessibility to NAM for underserved populations.

Nasoalveolar Molding represents a transformative approach in the comprehensive care of cleft lip patients. Its contributions to improved aesthetics, speech, feeding, and psychosocial well-being underscore its significance in enhancing the overall quality of life for individuals with cleft lip conditions. Recognizing the complexities, challenges, and future directions in NAM practice is vital for healthcare professionals and researchers working in the field.

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