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A Comprehensive Review of Nasoalveolar Molding: From Origins to Future Advances

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Abstract:- Globally, the most prevalent birth malformations is cleft palate and cleft lip, etiology of cleft is multifactorial and occurrence is as a result of inaccurate tissue fusion. The treatment objective in these patients include restoration of normal anatomy to obtain desired skeletal, cartilaginous and soft tissue relationship. To minimize the severity of cleft before surgery of cleft lip and palate, a nonsurgical methods such as Nasoalveolar molding (NAM) can be used to reshape and align the lip, nostrils, and gingiva. There are various techniques available for Nasoalveolar molding which will be summarized in this article.

Keywords:- *Cleft Lip and Palate (CLCP), Presurgical Nasoalveolar Molding (PNAM), Computer Aided Design NAM (CAD-NAM)*

I. INTRODUCTION

One of the most prevalent head and neck abnormalities is cleft lip and palate (CLP), it has multifactorial etiology (Trimetsuntorn et al., 2020). In India, one in every 781 live births has the CLCP.[1] According to Salari N et al.'s meta-analysis, the prevalence of cleft lip and palate was 0.45 per 1000 live births.[2] The treatment objective in these patients include restoration of normal anatomy to obtain desired soft tissue, skeletal and cartilaginous relationship.[3]

In the evolution of presurgical orthopedic techniques, the surgeon attempt to attain better results by minimizing the severity of the cleft abnormalities prior the primary surgical repair. Numerous presurgical infantile orthopedic methods are reported, including lip taping, lip adhesion, the Latham, and maxillary plates.[7] These appliances aim to retract the premaxilla and expands the posterior alveolar segments. However, none of these have a direct impact on the main nasal deformity associated with cleft lip and palate. Management of cleft lip and palate is a challenge and patient might undergo multiple surgical procedures to improve the nasal form.[8]

A relatively recent modification is Nasoalveolar molding (NAM) that addresses both nasal and alveolar deformity.[9] Concept of NAM therapy is developed based on cartilage plasticity and elevated level of circulating maternal estrogen in infant bloodstream. Improving lip aesthetics and nasal symmetry are the primary objectives of PNAM appliances.

II. HISTORY OF NAM

Present presurgical NAM embarked with McNeil in 1950 where he utilized serial appliance to approximate cleft alveolar segments.[10] These appliances fall into one of two categories: passive or active. Passive appliances do not apply force, they serve as a pivot point for the force generated by surgical lip closure, which shapes and forms the alveolar segments in a predictable fashion. Active appliances help move the alveolar segments in a predetermined manner.

The first nonsurgical approach to repair nasal abnormalities was described by Matsuo et al. in 1989, since the nasal cartilage is developing and reposition can be done in first 6 week after birth.[11] Based on the work by Matsuo et.al Nakajima stated that nasal splints were effective in preserving nostril shape after initial lip closure.[12] Subsequently, Grayson et al. (1993) delineated the first preoperative Nasoalveolar molding appliance, which consists of an intraoral moulding plate with nasal stent, that is used to model the nasal cartilage (NAM) and align the alveolar ridges. This therapeutic approach has greatly increased the interdisciplinary team's

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capacity to maintain and improve the nasolabial aesthetics after primary surgery in patients with cleft lip and palate.[12]

III. TIMING OF NAM

The onset of nasal moulding varies widely in terms of timing, While a few authors advise waiting until the majority of lateromedial correction of larger segment position has been completed, others describe beginning early[13] or when there is reduction of 6mm or below of the alveolar cleft.[14] Theoretically, molding nasal cartilage as soon as possible could be beneficial in order to achieve better durable molding of the plastic immature cartilage and prevent the elastic rebound that would arise from older, more mature, and less plastic cartilage.[15] Shetty V et.al compared the effectiveness of early initiation of Nasoalveolar molding with older infants up to 1 year and concluded that better results were seen in patients who had started treatment before one month of age, than those who presented at 6 months to one year of age.[16] Treatment with Nasoalveolar molding is delayed in case of unique presentation of cleft like severe collapse of alveolar segment as in cleft lip and palate with bilateral involvement which requires molding after the alveolar segments are expanded. Lip taping is done before NAM if the premaxilla is protrusive or in presence of neonatal tooth on cleft margin.[17]

IV. DESIGN OF NAM APPLIANCE

The NAM appliance is composed of detachable alveolar moulding plate made of orthodontic acrylic or Biocryl, which is derived from the maxillary dental cast of an infant. A 0.032" stainless steel wire with the nasal stent bent at its end is inserted into the anterior part of the alveolar moulding plate. The process of progressively correcting nasal and alveolar abnormalities by making weekly or biweekly modifications to the nasal stent and the intraoral moulding plate is known as "Nasoalveolar moulding".[4] The appliance is held in place using surgical tapes and elastics which are applied to the cheeks and cleft lip segments.

NAM therapy aims to rectify nasal cartilage distortion, retraction and derotation of the premaxilla, nonsurgically extend the columella, enhance alveolar ridge alignment, shorten the distance between cleft lip segments, and facilitate primary surgical repair.[18] Preoperatively reducing the amount of cleft deformity in the osseous and soft tissues significantly lessens the surgical difficulty, leading to better surgical results.[19]

There are two phases in Nasoalveolar Molding Protocol. In the first phase, acrylic moulding plate and lip taping are used to alignment the cleft lip, alveolus, and palate segments followed by attaching nasal stent to the moulding plate for correction of nasal deformity in the second phase. To prevent excessive stretching of the alar rim on the cleft side, the nasal moulding should precede after alveolar moulding.[20]

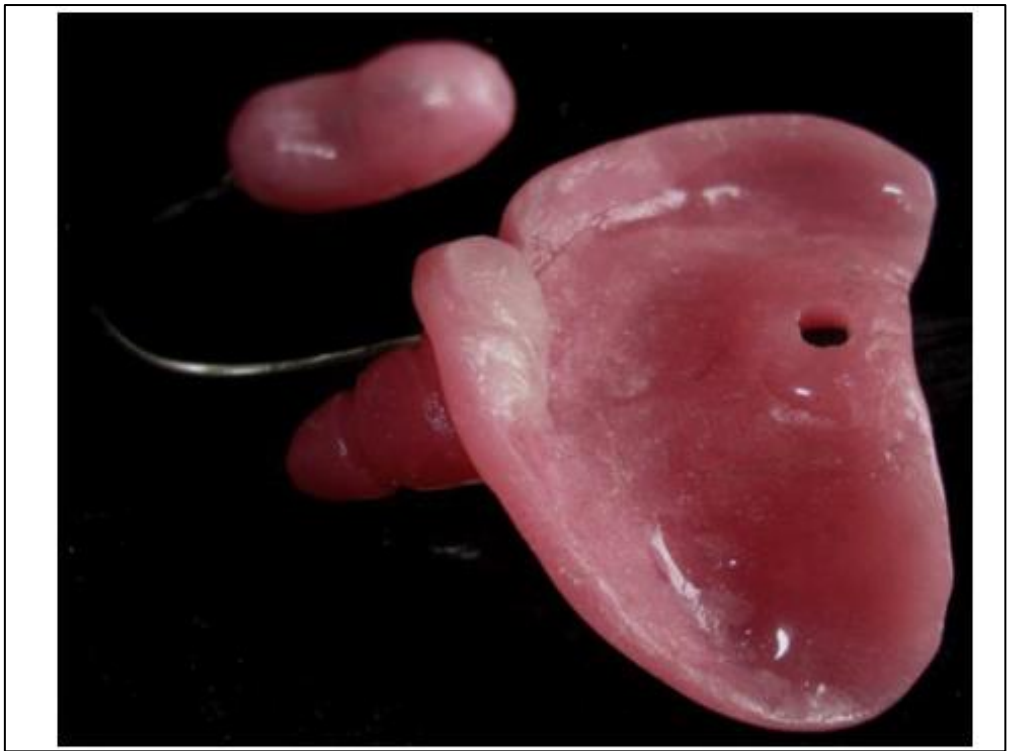

Fig 1: Typical Nasoalveolar Molding Appliance (Shetty, Thakral, and Sreekumar. Nasoalveolar Molding at 1 Year of Age. (J Oral Maxillofac Surg 2015)

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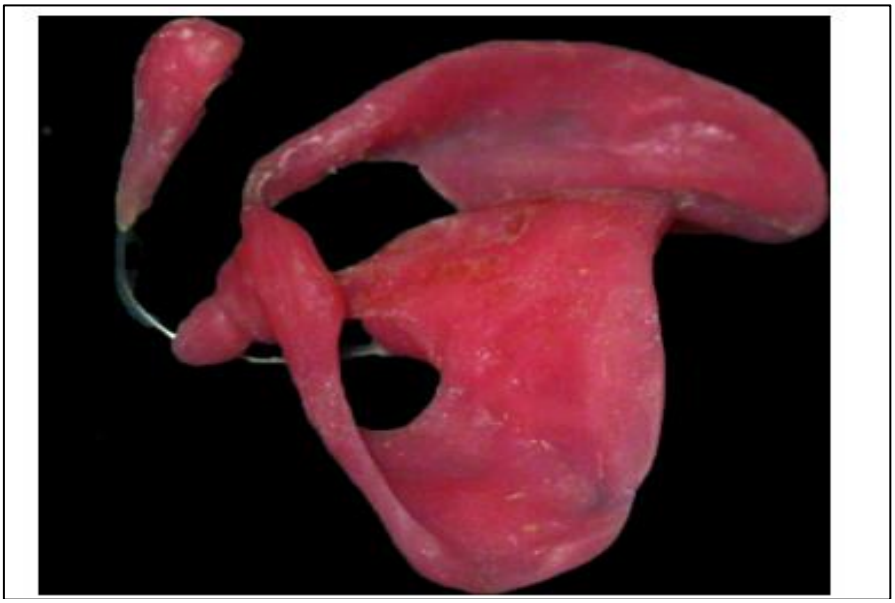

Fig 2: Nasoalveolar Molding Appliance Modified for Tooth Eruption. (Shetty, Thakral, and Sreekumar. Nasoalveolar Molding at 1 Year of Age. (J Oral Maxillofac Surg 2015)

Fig 3:Unilateral Cleft Baby with a NAM Plate Showing the Retention Arm Positioned Approximately 40° Down from the Horizontal to Achieve Proper Activation and to Prevent Unseating of the Appliance from the Palate (Barry H. Grayson, 2020)

Fig 4: Unilateral NAM Plate with a Nasal Stent Showing Lip Taping (Barry H. Grayson, 2020)

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V. TECHNIQUES OF NASOALVEOLAR MOLDING

A. Nasoalveolar Molding Based on Conventional Grayson's Method

Grayson et al. (1993) proposed a method for repairing the alveolus, lip, and nose in newborns with cleft lip and palate.

The primary impression is obtained as soon after the birth using heavybody silicon impression material with infant held upside down. The infant is kept inverted to maintain the tongue forward and to facilitate the drainage of fluids from the oral cavity. The tray is removed once the impression is set, and the oral cavity is examined for any residual impression material. With the acquired impression the cast is poured using dental stone and used for fabrication of molding plate.[21]

Intraoral molding plate constituting the lateral alveolar segments and the premaxilla is fabricated on the wax relieved dental models using hard clear acrylic resin and is lined with a thin layer of soft denture material. Acrylic buttons are added onto molding plate and appliance is secured extraorally to check using elastic tape system and horizontal tape placed on base of the nose. Parents are advised to leave the plate in place full times and to clean it at least once a day. Patients are followed up weekly for appliance adjustment and to check for ulcerations. The fitting surface is ground and soft acrylic resin is added for proper growth and alignment of alveolar segment, once the alveolar gap is reduced to 5mm or less, nasal stent is fixed on to the plate.[14]

When treating bilateral cleft lip and palate, two retention arms and nasal stents are required, once the nasal stents are added, attention is focused on nonsurgical lengthening of the columella, to achieve this a horizontal band of soft denture material is added to join the left and right lower lobes of the nasal stents, spanning the base of the columella. After the vertical prolabial tape is in place, the horizontal lip tape is applied.[21]

Primary surgical closure of the lip and nose is done between the ages of three to five months since the alveolar segments are approximating and gingivoperiosteoplasty (GPP) can be performed to avoided extensive dissection with limited effect on growth of the midface.[22,23]

One way to modify this method is to replace the traditional stainless-steel wire used in Grayson's method with a titanium molybdenum alloy (TMA) nasal stent with a single loop design.[3]

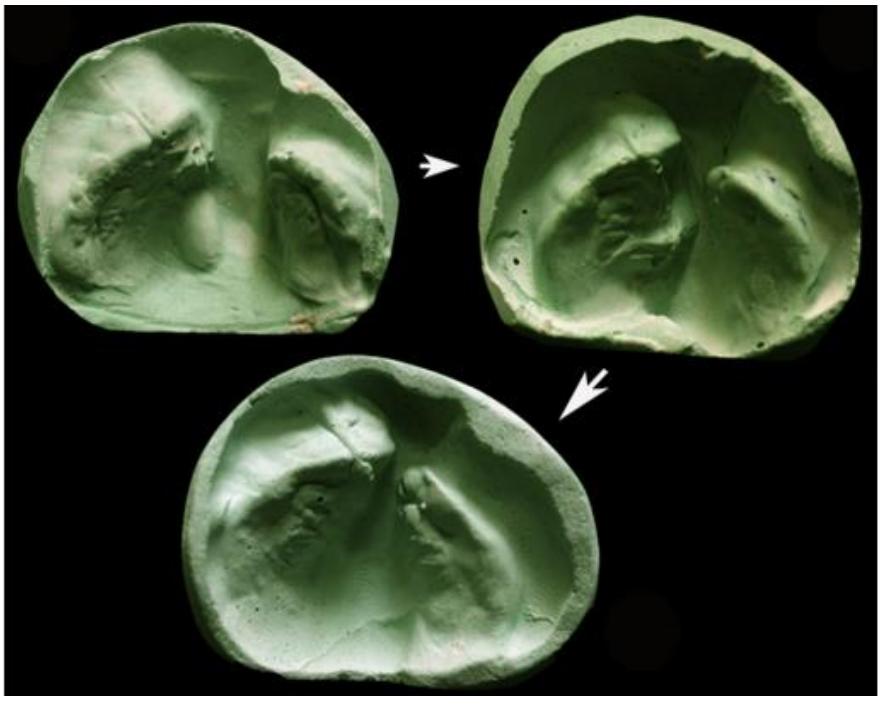

Fig 5: Weekly Modification of Molding Plate to Correct Alveolar Arch Symmetry Gradually Along with Closure of Alveolar Cleft.(Shetty, Thakral, and Sreekumar. Nasoalveolar Molding at 1 Year of Age. (J Oral Maxillofac Surg 2015)

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Fig 6: Bilateral Nasoalveolar Moulding Plate with Retention Buttons Fabricated Using Self-Cure Acrylic Resin (Barry H. Grayson, 2020)

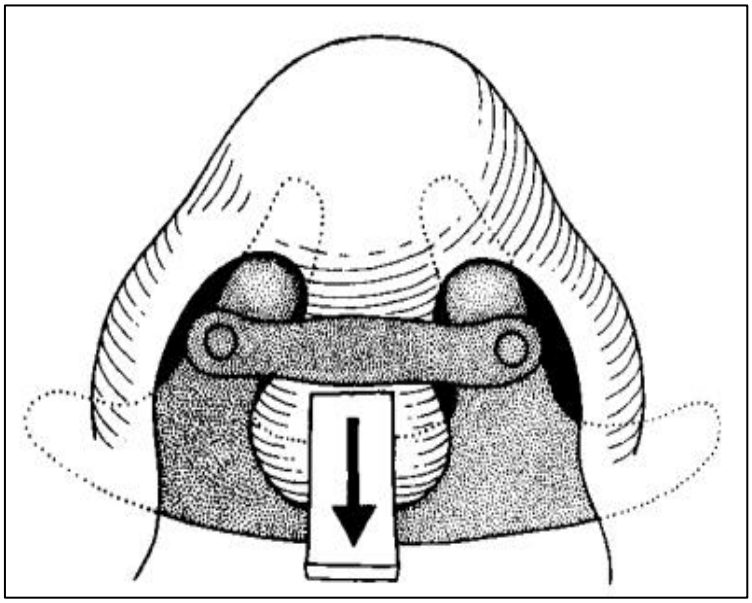

Fig7: Diagram Shows Front View of Molding Plate with Nasal Stent. The Nasal Stent Elevates The Nasal Cartilage While Providing Resistance to Downward Pull of Tape on Prolabium. The Horizontal Prolabial Band Pulls Down On the Base of the Columella at the Nasolabial Fold (Grayson BH 1999)

B. Figueroa And Polley's Method

Another method for Nasoalveolar molding was presented by Figueroa and Polley in 2006. This method involves the use of an intraoral plate composed of light-cured acrylic resin. This intraoral plate has a nasal stent attached to it consisting of a loop for future adjustments. Since extraoral tapes or elastics were not used in this technique, the acrylic button on the intraoral plate is removed. Denture adhesives were used for the retention of appliance and tapes are used only in severe cases.[25] In comparison between 2 techniques (Grayson's and Figueroa's), Chang et.al found no difference in his randomized clinical trial.[26]

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Fig 8: Left side Figueroa Nasoalveolar molding. Right side Grayson molding (Chang CS 2014)

In the era of digital orthodontics, In 2011, Yu et.al presented the concept of "computer-aided design/Nasoalveolar moulding" (CAD/ NAM) for the digital activation of NAM equipment.[27] This method saves time and labor by using software to create a sequence of 3D printed models that mimic the activation processes. Using computers and rapid prototyping virtual planning and sequential Nasoalveolar moulding devices can be manufactured.[28]

Initially digital models were produced by scanning the plaster cast and later by scanning the impression directly, but now with the availability of intraoral scanners this can be replaced. As a result, traditional plaster models may eventually be replaced with three-dimensional (3D) computer models.[29]

- TRIOS acquiring 3D image data
- Separating alveolar segments
- Virtual alignment by computer
- 3D design of NAM appliance
- Direct 3D printing appliances

Digital workflow of the process of designing and manufacturing of NAM appliances (Gong X 2020)

Different software's can be used to digitally manipulate and reposition the alveolar segments inorder to achieve series of models, these are referred to as CAD-NAM. The 3D printed models facilitate the production of a range of NAM appliances.[30]

C. NAM Designed with Rapid Prototyping and Computer-Aided Reverse Engineering

The plaster cast is made from the silicone impression and three-dimensional laser scanning. Once the initial digital study model is ready a series of continuous digital models of maxilla movement is virtually designed with reverse engineering software and the solid models is printed with rapid prototyping system.[31]

The design of the appliance consist of, digital model of maxillary denture which is divided into multiple sections, each of which represents the movement of the alveolar segments throughout NAM therapy.[32]

The digital geometrical data is exported to print a scale model with rapid prototyping system when the treatment design is formulated and a series of appliances is created according to the scale models. A retentive button and a dental plate with a thickness of 2 mm comprise each pair of NAM devices. 1 set of appliances is changed every week by the parent, followed by recall every month for examination and adjustment.[32]

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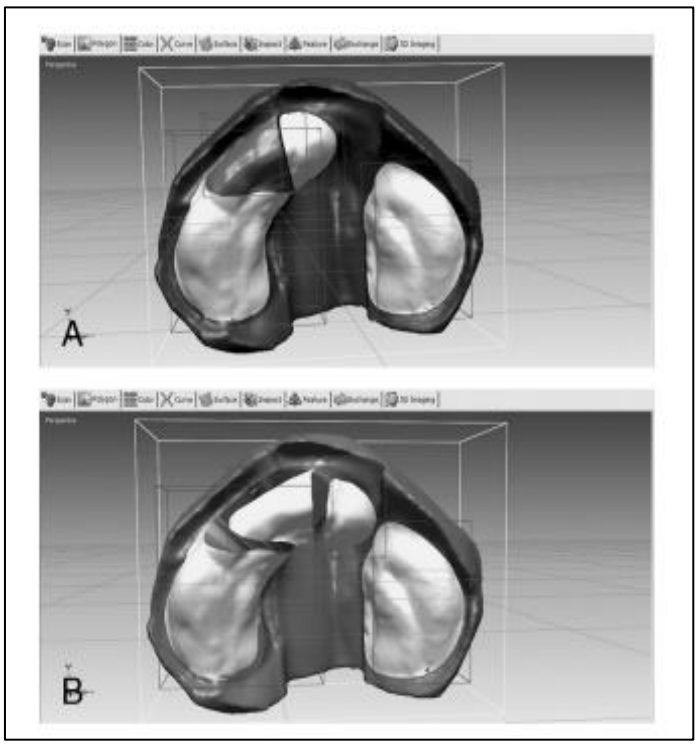

Fig 9: A Digital Three-Dimensional Model of the Upper Alveolar was Constructed in Reverse Engineering Software. B, The Model was Split Into Several Regions, Which were Regarded as the Movement Alveolar Segments in NAM Treatment (Yu Q 2011)

D. Rapid NAM Approach

An alternate digital workflow for NAM therapy is the digital design of a corresponding sequence of appliances made using computer-aided manufacturing technology, like 3D printing, after virtual treatment planning. In terms of additive manufacturing, RapidNAM entails digitizing plaster casts, virtualizing the models, and creating a number of NAM devices via CAD/CAM.[30] The concept involves the prediction of three trajectories that envelope the fragmented alveolar segments with the goal to mimic a harmonic arch, developing NAM with ventilation hole, fixation pin, and fixation points for the nasal stents. The extrusion from the larger toward the smaller alveolar segment along the envelope curves toward the harmonic upper alveolar arch.[33]

E. Clear Aligner And 3D Printing Workflow In NAM / NAM Aligners

Compared to traditional approach NAM aligners provides similar benefits. The computerized process used in the design and manufacturing of NAM aligners consists of: retrieving the model using traditional technique or intraoral scanning, digitalization of model and alveolar segmentation using the software, Vacuform machine is used to fabricate an aligner for each stage, the nose piece is added to the aligner at the desired stage with a 0.030-in orthodontic wire and Triad is added for nasal support.[34]

In a comparison between 3D NAM and standard NAM, Ritschl et.al found that both approaches were equally effective.[35]

El-Ashmawi NA et.al compared the effectiveness of Nasoalveolar Molding (NAM) Using Grayson Method Versus Computer-Aided Design NAM (CAD/NAM) in Infants with Bilateral Cleft Lip and Palate and concluded that both the interventions were effective but the CAD/NAM required less chair side time compared to the NAM treatment.

The effectiveness of computer-aided design NAM (CAD/NAM) and Nasoalveolar Moulding (NAM) using the Grayson method was compared for infants with bilateral cleft lip and palate by El-Ashmawi NA et al. and found that while both interventions were effective, CAD/NAM required less chair side time.36

VI. CONCLUSION

The most prevalent congenital abnormality observed globally is cleft lip and palate, the incidence varies among population. Early diagnosis of cleft lip and palate helps in growth and development of maxilla in particular which is mainly done with Nasoalveolar molding. This review has given a detailed description of various recent modifications in the Nasoalveolar molding which is helpful for the proper approximation of the maxilla prior to surgical procedures.

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