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Review

Understanding of Speech Production in Cleft Lip/Palate: A Review

Nelvi Yohana[1], *Handoko*[2]

[1]*Faculty of Dentistry, Universitas Andalas, Padang, Indonesia*
[2]*Faculty of Humanities, Universitas Andalas, Padang, Indonesia*

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Correspondence

E-mail: nelvi.yohana@dent.unand.ac.id

A B S T R A C T

A cleft lip is a disorder caused by the incomplete joining of the lips or palate during fetal development. This condition can result in a variety of physical impairments, speech impairments, and even psychological impairments that can affect a person's life. Patients with cleft lip usually suffer from dental problems, speech problems, and breathing and hearing problems. This condition can certainly lead to emotional and social problems that require attention from various parties, including surgeons, dentists, speech therapists, and psychologists, essential. Patients with cleft disorders usually have an inability to produce speech sounds due to the insufficient amount of air pressure passing through the oral cavity. The severity of the disorder depends on various factors such as the intensity of the cleft, age at the surgery, and hearing loss. Early support and treatment can greatly improve patients' quality of life. It is necessary to conduct comprehensive research to address the different issues associated with cleft lip/palate. This involves not only healthcare professionals, such as speech-language pathologists, surgeons, orthodontists, and pediatric dentists, but also communication experts, such as linguists, to develop effective treatments and strategies. This review article discusses the relationship between clefts and speech production, as well as the factors that play a role in improving the quality of life of patients with cleft. The article aims to provide a comprehensive overview of clefts, serving as a reference for dentists, surgeons, linguists, and other professionals who work with cleft patients.

I. INTRODUCTION

Cleft lip and palate (CLP) disorders happen when the upper lip or hard palate does not form completely during fetal development, resulting in a gap or split in the lip/palate. This condition can affect either the hard palate or the soft palate due to incomplete fusion of the tissues that make up the palate (Leal et al., 2020; Vyas et al., 2020). Cleft lip disorder is a common birth abnormality that affects around 700 babies worldwide each year (Mc Goldrick et al., 2023; Muzammil et al., 2021). Studies indicate that more male babies than female babies are born with cleft lip. Moreover, Asian and Native American populations are more vulnerable to this condition than Caucasians (Fritzsche, 2019).

CLP is a congenital disorder that occurs during fetal development. It can cause various physical and functional problems, including dental issues like misaligned teeth, malocclusion, and tooth loss. In addition, cleft disorders can also interfere with functional processes, such as speech, swallowing, eating, and breathing. These conditions can significantly impact patients' quality of life and require specialized medical treatment and therapies (Berrezueta Reyes Eva Estefanía et al., 2023; Handoko & Yohana, 2023). Patients may experience speech impairment due to air escaping from the mouth when speaking, but coming out of the nasal cavity resulting in mispronunciation, nasalisation of sounds, and excessive nasal resonance (hypernasality). In addition, cleft lip can also result in a condition where the muscles at the

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back of the throat do not close completely when speaking, called velopharyngeal insufficiency (VPI). Patients with cleft palate may have difficulty articulating specific sounds due to the lack of air pressure in their oral cavity. This results in them being unable to produce certain sounds, interfering communication and social interaction (Phippen, 2023).

Numerous studies have shown that infants born with CLP experience difficulties in speech input processing compared to infants born without CLP. Therefore, it is necessary to provide early treatment for infants with CLP to anticipate worse conditions. According to Meinusch (2011), early language intervention and speech therapy can improve communication quality in children with cleft lip and palate who have undergone reconstructive surgery. Bessell (2013) also mentioned the important of speech and language therapy interventions for children with cleft palate. Hardin-Jones (2019) highlighted the feedback from speech and language pathologist regarding to the assesment and treatment for CLP patients to improve their communication. Furthermore, Williams (1999) emphasized the importance of speech and language therapy for post surgical patient to provide positive speech outcomes. By analysing various factors, both medical and non-medical, speech and language therapy can improve language and sound production in patients who have received cleft lip and palate surgery (Sand et al., 2022).

This review paper aims to provide an overview of the relationship between medical aspects and non-medical aspects in CLP cases and provide an overview of treatments and interventions that can be done to improve the communication skills of patients with CLP. The aim of this article is to provide information and knowledge to those who are involved in the treatment of cleft lip and palate (CLP) patients, as well as to the general public who may be interested in issues related to CLP and communication disorders in these patients.

II. DISCUSSION

Cleft Lip/Palate

Cleft lip and palate is a complex condition that affects the facial structure of newborns and infants. Although the exact cause of this disorder has yet to be established, several studies have concluded that genetics and environmental factors play an important role. It can also be caused by exposure to substances during pregnancy. Such as drugs and alcohol, or certain genetic mutations that affect the development of facial and oral structures. Despite the various factors that may cause CLP, medical professionals have developed treatments to address CLP problems that allow patients to live a healthier and better life (Martinelli et al., 2020).

Genetic factors have also been reported to contribute to CLP disorders, such as chromosomal abnormalities and family history (Blue, 2012; Askarian, 2022; Ganatra et al., 2021). Certain genetic variants such as TBX22, IRF6, and PVRL1 have also been reported to be associated with CLP risk (Askarian, 2022). Family history of being born with CLP and consanguineous marriage are also strong factors that can trigger the disorder (Jamilian, 2017). Maternal exposure to alcohol, tobacco and drugs during pregnancy is also affect and contributes to CLP in infants. Prenatal exposure to folic acid is also reported in many cases of CLP (Leite, 2002). In fact, direct or indirect exposure to alcohol and tobacco increases the risk of medical and developmental disorders in foetal development, including the risk of CLP (Glantz, 2006). These substances are strongly associated with increased risk of miscarriage, stillbirth, preterm delivery, and sudden infant death syndrome (Bailey, 2011). Consumption and exposure to alcohol and nicotine during pregnancy can exacerbate neurotoxicity and neuroinflammation in the foetus. The risk of CLP has been associated with alcohol and nicotine consumption during pregnancy (Costa, 2023; Regina Altoé et al., 2020). These studies suggest a complex relationship between genetic and environmental factors in the development of CLP.

Lip and palate clefts can occur in the upper lip, palate, or both. This condition can be classified into two types. A cleft lip only or a cleft lip and palate (CLP). The severity of the cleft varies depend on the cleft, and can be categorised as complete or incomplate. In complete CLP, the cleft in the palate opens from the front to the back of the mouth, while in incomplete CLP the cleft tends to be smaller. This condition can cause difficulty in eating, speaking, and hearing, and need surgery to cerrect the structure.

Figure 1 shows the different types and severity of CPL. Cleft palate can be categorised by the location of the cleft where the nasal and oral cavities meet. The first type is known as primary plate clefts

which occur at the front of the incisive foramen. The second type is called secondary clefts which affect the back of the incisive foremen.There is no point of fusion between the maxilla and nasal septum in a bilateral complete cleft of the secondary palate (Zheng et al., 2019). Understanding the location of the cleft is important for proper diagnosis and treatment.

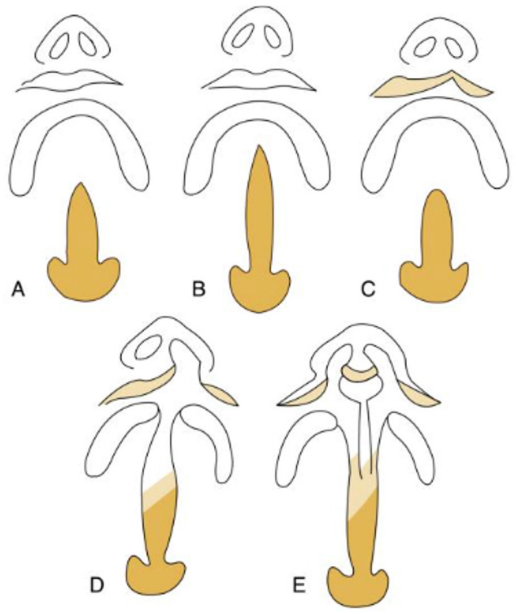

Figure 1. Classification of cleft lip/palate (McCarthy et al, 2021)

Figure 1 illustrates the classification of CLP. Figure A shows a secondary palate cleft, there is a small gap in the palate towards the back. Figure B depicts a complete cleft of the secondary palate, there is a gap that extends all the way to the incisive foramen. Figure C is an incomplete cleft of the primary and secondary palate, there is a gap that extends from the front of the mouth to the back of the mouth, but it does not completely separate the two palates. Figure D is a unilateral complete cleft of the primary and secondary palate, one side of the palate is completely separated from the other side, while the other side is not separated. Figure E is a bilateral complete cleft of the primary and secondary palate, there is a gap that extends across the entire palate, separating the two palates completely.

Diagnosing a baby born with CLP is challenging. This is because the cleft may not be immediately visible and may only become apparent when the baby opens their mouth widely. Doctors usually conduct a comprehensive physical examination of an infant's mouth, nose, and surrounding areas to diagnose cleft lip and palate (CLP). This helps them identify any abnormalities and determine the severity of the clefts. Early diagnosis allows doctors to create an appropriate treatment plan for a better future. To confirm a diagnosis of cleft lip and palate, physicians or pediatricians can perform a physical examination. During pregnancy, an ultrasound scan can also be done to monitor the development of the fetus. Further tests may be recommended by doctors, such as amniocentesis, to detect genetic disorders that could cause CLP (Haj et al., 2020; Mak & Leung, 2019).

Speech therapy is often used to improve the outcomes of surgeries for patients with cleft lip and palate (CLP). Infants born with CLP often experience difficulties in speech, including impairment. However, through speech therapy, patients can improve their pronunciation and reduce communication disorders associated with cleft lip. While surgery can help patients physically, specialised training and treatment are required to improve the function of the speech organs. This will help patients communicate with confidence and interact better with society (Wanchek & Wehby, 2020).

Anatomy and Physiology of Velopharyngeal Mechanism

The undertstanding of anatomy and physiology of Velopharyngeal mechanism is very important to address in this review. It will help people to undertstan how the sounds produces and increase the speech therapy oourcomes.

During the process of speaking, many muscular tissues are involved, known as the velopharyngeal mechanism. This mechanism works in tandem to maintain the separation between the oral and nasal cavities, allowing people to articulate sounds clearly and effectively (Rohde & Friedland, 2022). The structures responsible for organising the various functions of this mechanism are divided into three parts, namely the soft palate (velum), the lateral pharyngeal walls, and the posterior pharyngeal wall, as shown in Figure 2. The soft palate is a covering muscle that extends from the back of the hard palate to the uvula which serves to close the nasopharynx during speech. The lateral pharyngeal which is located on the side of the pharynx is a muscle that functions to stabilise the soft palate and also initiates to close the velopharyngeal. Then the posterior pharyngeal wall helps stabilise the soft palate (Perry, 2011).

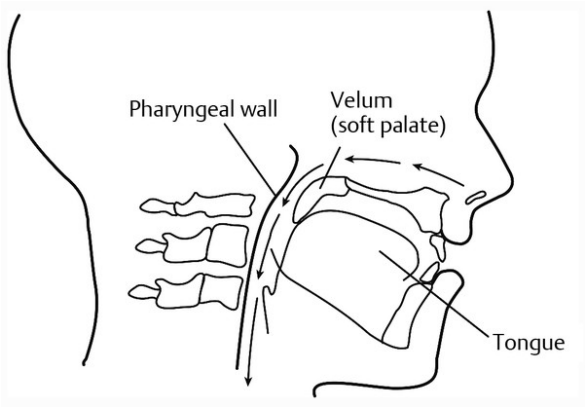

Figure 2. Velopharyngeal valve (Gelany & Abd EL Naeem, 2019)

A set of muscles and tissues help regulate the opening and closing of the nasopharynx, known as the velopharyngeal mechanism. Several muscles contract to move the velopharyngeal mechanism, namely levator veli palatini, tensor veli palatini, palatopharyngeus, and salpingopharyngeus (Figure 3). The inferior surface of the petrous section of the temporal bone and the medial border of the Eustachian tube are the origins of the levator veli palatini. The levator sling, which comprises most of the muscular mass in the palate, is the main muscle responsible for velopharyngeal closure. Its direction and function are critical for normal velopharyngeal function (Gelany & Abd EL Naeem, 2019; Perry, 2011; Raol & Hartnick, 2015).

The lateral margin of the Eustachian tube and the medial pterygoid plate are the sources of the tensor veli palatini. It runs anterior and lateral to the levator and ends. The soft palate is stabilized and tensed by the tensor veli palatini during velopharyngeal closure. The palatoglossus, which is also referred to as the anterior tonsillar pillar, begins its journey into the tongue in the anterior soft palate, where it forms a continuous plane with the contralateral muscle. It then proceeds laterally, inferiorly, and anteriorly. The lateral pharyngeal wall and the soft palate are joined by the palatopharyngeus. It helps to pull the soft palate downward and backward during velopharyngeal closure.

The muscle known as the salpingopharyngeus comes from the cartilaginous portion of the auditory tube, specifically from the inferior portion that encloses the nasopharyngeal opening of the tube. It inserts by merging with the palatopharyngeus muscle in the oropharynx as it runs inferiorly. The Eustachian tube and the soft palate are connected

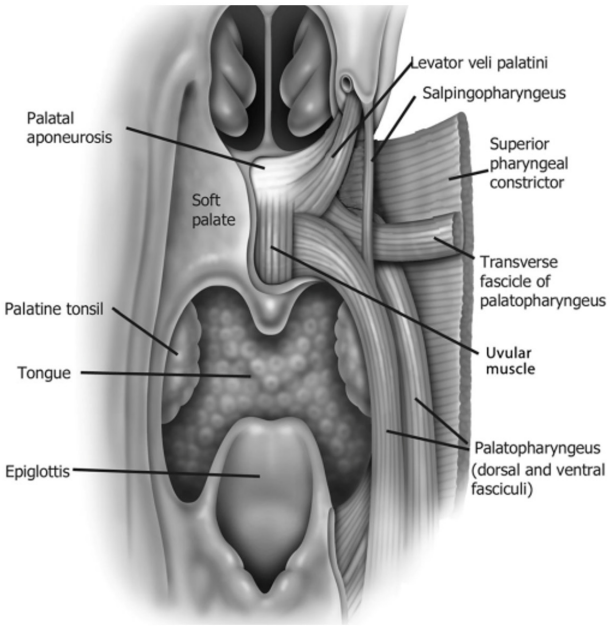

Figure 3. Velopharyngeal mechanism muscles and the nasal surface of the velum in a person with normal anatomy (Olszewska & Woodson, 2019)

by the salpingopharyngeus. It facilitates the opening of the Eustachian tube while swallowing and keeps the soft palate from blocking it during speaking (Gelany & Abd EL Naeem, 2019; Perry, 2011; Raol & Hartnick, 2015).

The velopharyngeal mechanism is responsible for closing the nasopharynx, which forces air to escape the mouth and produce sound when people speak. This process involves various muscles, including the levator veli palatini muscle, which raises the soft palate, and the tensor veli palatini muscle, which tenses it. Additionally, the palatopharyngeus muscle draws the soft palate backward and downward, while the salpingopharyngeus muscle opens the Eustachian tube to equalize air pressure in the middle ear. During swallowing, the velopharyngeal mechanism opens the nasopharynx, allowing food and liquids to enter the esophagus. Once the process is complete, the muscles that make up the velopharyngeal mechanism relax, and the soft palate returns to its resting posture.(Bartha-Doering et al., 2020; Olszewska & Woodson, 2019; Shprintzen, 2013)

Effect of Cleft on Speech Production

People born with CLP usually experience various difficulties in producing sounds, one of which is hypernasality. Hypernasality is a disorder that occurs due to excess air flowing through the nasal cavity when speaking which results in

nasalisation of sounds. Hypernasality can occur due to disruption of the velopharyngeal mechanism caused by underdevelopment of the soft palate. The soft palate is responsible for closing the nasopharynx when speaking. If the soft palate is too short or underdeveloped, it cannot close the nasopharynx and air escapes from the nose (Gart & Gosain, 2014). In other words, if the velopharyngeal mechanism is not working properly, air will flow into the nasal cavity when speaking (Wang et al., 2019). Due to the resonance of sounds, listeners may find it hard to understand the speaker. Nasalization, resulting in impaired articulation due to the escape of air through the nose, is one of the speech problems that can arise from velopharyngeal insufficiency (Pereira & Sell, 2023). It is estimated to occur in 20-40% of children with cleft palate (Ysunza et al., 2015). Hypernasality can be treated with speech therapy or surgery, depending on the severity of the condition (Phippen, 2023).

Regarding sound articulation, there are several classes of articulation mistakes that can occur when a person speaks, namely omissions, substitutions, and distortions. Omissions occur when a person omits certain sounds when speaking. For example, a child with CLP may find it difficult to produce the /b/ sound so they say "ee" instead of "bee". This can be frustrating for both the child and the person they are communicating with. Therefore, people need to be patient when communicate with CLP patiens to understand what they are trying to say. The second common mistake is substitution, which is the changing of sounds. Children with CLP may find it difficult to pronounce some sounds, such as the /ʃ/ sound. For example, when pronouncing the word "shoe" children with CLP will find it difficult and tend to replace it with other sounds such as the /t/ sound. So they will say "too" instead of "shoe". These issues can arise from a number of underlying causes, one of which is related to problems with the soft palate. The soft palate plays a crucial role in the production of speech sounds, and when it is affected by CLP, it can lead to difficulties with speech production (Kummer, 2023; Phippen, 2023).

Children with CLP may have other difficulties related to speech production due to sound resonance and articulation compensation. The soft palate plays an important role in directing sounds when articulated in the oral cavity. However, when the soft palate is unable to function properly, the sound produced from air resonance will be trapped in the nasal cavity. Children with CLP may develop compensatory articulations, which are changes in the way they produce sounds in an effort to overcome their velopharyngeal insufficiency (VPI) or misarticulations. However, these compensatory articulations can further affect their speech comprehension (Fujiki & Thibeault, 2023; Kummer, 2023; Pereira & Sell, 2023).

Speech difficulties in individuals with CLP can vary based on the type of cleft, age of palate surgery, severity of cleft, and hearing loss. Children with bilateral clefts are likely to face more speech difficulties as compared to those with unilateral clefts. In addition, the age at which a child receives cleft surgery can also affect the severity of the condition. Early treatment can lead to better speech. In certain circumstances, hearing loss may also exacerbate speech production in people with CLP (Shaffer et al., 2020).

Intervention for Speech Production Issues in CLP

Early treatment is essential for people with CLP to achieve better speech production and improve their communication skills. Experts recommend a multidisciplinary approach to address problems related to cleft lip and palate by involving various professionals such as pediatric dentists, surgeons, speech-language pathologists, and orthodontists. With proper treatment, most people with CLP can speak clearly and effectively (Frederick et al., 2022; Lee et al., 2014).

One of the most important interventions is speech and language therapy. Speech and language therapy experts can help people with CLP to improve their articulation skills and learn how to deal with velopharyngeal dysfunction. Treatment through speech and language therapy can begin at a very young age, even before the palate closes. Therapy in newborns may focus on the development of feeding and oral-motor abilities, while therapy in older children may focus on helping them improve their ability to produce sounds and improve communication skills (Sell et al., 2021).

A speech-language pathologist can provide various types of exercises, such as velopharyngeal closure exercises, speech amplification, and articulation therapy (Kotlarek & Krueger, 2023). Articulation therapy is also very important to help children with CLP overcome speech difficulties.

The design of the therapy depends on the individual and is tailored to their condition to improve good speech articulation skills. Many exercises can be done in articulation therapy, such as blowing bubbles, whistling, and playing with toys that involve lip and tongue movement. The therapist should pay attention and identify the sounds that the patient has difficulty pronouncing and then adjust the intervention accordingly. With intensive help and practice, the child can learn to speak clearly and confidently which can certainly improve their quality of life (Hardin-Jones et al., 2020). The muscles involved in velopharyngeal closure should also be strengthened with velopharyngeal closure exercises to maximise velopharyngeal function in producing sounds (Hardin-Jones et al., 2020). Speech amplification tools, such as cochlear implants or hearing aids, can also be used to help children with hearing loss to produce seppech by improving their ability to hear and process speech sounds (Löfkvist et al., 2020).

Medical treatment in the form of surgery can be done to overcome the problem of the gap in the palate and the function of the velopharyngeal valve. The aim is to divide the nasal and oral cavities so that the velve can function properly (Shaw et al., 2019; Shkoukani et al., 2014). Thus, the patients can improve their speech and swallowing ability. To treat infants with hearing loss, further surgery is required. It is recommended to perform surgery between three to six months of age, but it is important that it is done before the baby turns one year old. This is because the first year is an important period for language acquisition in children so early intervention can improve the development of their speech and language ability (Shkoukani et al., 2014).

Furthermore, orthodontic treatment can also be performed on people with CLP to correct dental malocclusion that plays a role in speech production difficulties. Malocclusions such as crowding and spacing can affect the position of the tongue and lips when speaking, making it difficult for the patient to produce certain sounds. After the permanent teeth appear and the palate is closed, dental procedures can be performed. The aim of dental orthodontic treatment is to balance occlusion so that the tongue and lips can produce sounds properly (Mason, 2020; Handoko & Yohana, 2023).

Apart from the interventions already discussed, there are several other methods that are also effective for cleft management. Psychological support is also very important and effective in dealing with the psychological and emotional problems that accompany CLP. Social skill training can help patients to be able to communicate and build interpersonal relationships with others because people with CLP may experience difficulties and challenge in social interaction. In addition, hearing training is equally important, especially for people with CLP. By improving their listening skills, they can get along better and communicate more effectively (Lane et al., 2022; Stock et al., 2020).

III. CONCLUSION

A congenital craniofacial defect known as CLP can affect the production of speech in various ways. Cleft lip/palate may cause problems like hypernasality, velopharyngeal insufficiency (VPI), articulation errors, resonance issues, and voice problems. The severity of speech production issues may vary depending on the type of CLP and the individual. Early identification and intervention are crucial to achieving optimal speech outcomes for children diagnosed with CLP. A comprehensive approach involving multiple disciplines is required for this intervention. Speech-language pathology plays a vital role in addressing the speech production issues caused by CLP.

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