



Review

# Speech Production and Malocclusion: A Review

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## A B S T R A C T

The article focuses on speech production in relation to malocclusion. It investigates how malocclusion could affect sound production and articulating clearly. The article also discusses how orthodontists could fix malocclusion and improve the sound production. Speech production is a complicated process involving several speech organs, including the mouth cavity. Malocclusion can have an adverse effect on pronunciation, especially on specific speech sounds. It can also cause compensatory articulation problems, which can affect pronunciation further. Certain speech sounds, such as /s/, /z/, /t/, /d/, /l/, /r/, /θ /, and /t/, can be affected by malocclusion. Different types and levels of malocclusions may have different effects on pronunciation. It is necessary to speak with an orthodontist to determine the most appropriate therapy for malocclusion. Proper diagnosis and treatment can assist in reducing the impact on pronunciation. Additionally, speech and language therapy may help in the development of speech. The article concludes with an overview of the available treatments for speech production, the potential impacts of malocclusion can be minimized.

## I. INTRODUCTION

Speaking is a complex process that involves coordinating multiple organs and systems, including the lungs, larynx, tongue, lips, and teeth. The organs contribute to speech production by producing sounds and their variation. Due to certain conditions, these organs may impair and affect speech production. The speech problem can result from a variation or impairment in these organs, among others is the Malocclusion in the oral cavity. Many researchers have reported that Malocclusion contributes to speech difficulties, especially sound production.

Malocclusion happens when the teeth are misplaced or inadequately positioned. This condition may occur in adults and children which different types of impairment. People with speech impairment have difficulty articulating sounds, words, or phrases, which affects their communication ability. This speech impairment can occur in various problems, such as stuttering, lisping, or slurring. As mentioned earlier, speech

requires complex processes and involves different systems and organs. Any dysfunction of these systems will affect speech, such as neurological disorders, hearing loss, psychological factors, and physical impairments, including malocclusion.

The relationship between malocclusion and speech impairment has been studied for many decades. Several studies have suggested that malocclusion may affect oral motor control, which leads to speech difficulties (Assaf et al., 2021; Harini et al., 2020; Leavy et al., 2016). People with malocclusion may have difficulty articulating certain sounds and words because of tongue position, lip closure, and airflow problems. Malocclusions may result in changes in the resonant of the oral cavity, which nasalize the sounds. Moreover, several orthodontic problems related to malocclusions, such as missing teeth or misaligned jaws, may also affect the shape and position of the oral cavity. These conditions will affect speech production, especially sound articulation, leading to speech impairment.

## II. DISCUSSION

### Speech Mechanism

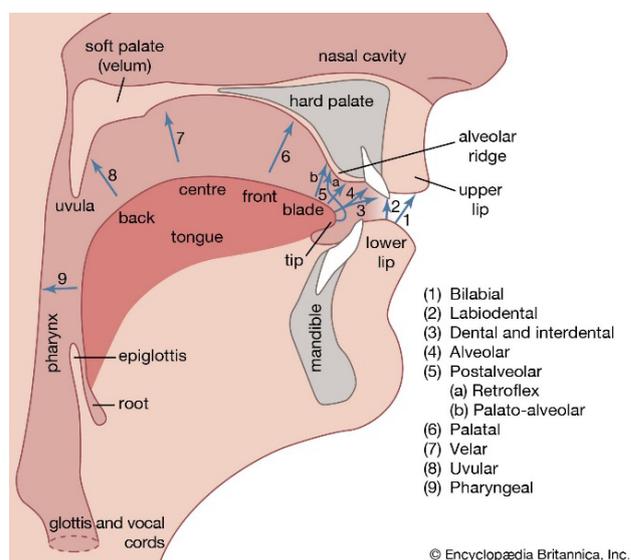
Since speech requires a complex-interrelated system which includes the respiratory system, the larynx, the vocal tract, and the articulators (lips, tongue, teeth, and palate), all have significant parts in speech production (Giegerich, 1992). As a result, humans can produce variations of sounds by elaborating on different processes and mechanisms

of speech organs. The speech mechanism is initiated by the respiratory system, which produces air from the lung and moves up the trachea and into the larynx. The vocal cords vibrate when air passes through them, generating sound in the larynx. During the production of a sound, the tension of the vocal cords and the intensity of air moving through them determine the pitch of the sound. Several changes occur when sound travels through the vocal tract, including the mouth, throat, and nasal cavity. The shape and location of the tongue and lips, as well as the location of the articulators, significantly impact the tone of the voice. Depending on the structure and position of the vocal tract, humans can produce various sounds while speaking. (Giegerich, 1992; Redford, 2015).

Researchers have developed various methods to gain insight into the physical structures involved in speech production, including magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), and X-ray imaging. (Fant, 1971; Gracco et al., 2005; Ramanarayanan et al., 2018; Zhao et al., 2021). Researchers can use these technologies to track sound production in different speech organs. These findings provide insight into the complex interaction between the respiratory system, larynx, vocal tract, and articulators in producing sounds. Furthermore, During speech production, the brain coordinates speech movements and organizes and executes the speaking process (Guenther, 2016; Redford, 2015). Various procedures, including electroencephalography (EEG) and magnetoencephalography (MEG), have been employed to study the speech processes in the brain. (Hixon et al., 2018; Hoit & Weismer, 2016; Weismer & Brown, 2019). In short, imaging and neuroimaging innovations provide insight into how speech processes work. Studying this area is critical to understanding how speech works and discovering treatments for speech problems.

### Speech in Oral Cavity

The dental cavity is one of the main organs in speech production, which includes the tongue, lips, teeth, and palate. In collaborating with the vocal cords, these organs can produce and control sound production. Understanding the complex interaction between these articulators is crucial to the mechanics of speech.



**Figure 1. Human vocal organs and points of articulation** (Source: <https://www.britannica.com/science/phonetics/media/1/457255/3597>)

Among the key articulators in the oral cavity, the tongue is a very flexible muscle with different orientations and forms. As the tongue moves within the mouth, it produces a different sound. Tongue position in a certain area will block airflow during a speech that produces consonants. The place where the tongue pointed and blocks the airflow is called the place of articulation. Figure 1. shows different organs and areas which This will allow people to produce different consonants, such as bilabial, dental, interdental, alveolar, etc. For example, the front of the tongue creates sounds like /t/ and /d/ when it block the airflow in the alveolar ridge area. Meanwhile, the back generates sounds like /k/ and /g/ when it block the airflow in the soft palate (velum). The tongue position also plays an important role in producing vowel sounds. The tongue is arched toward the roof of the mouth when pronouncing a high (close) vowel, such as /i/ and /u/. Unlike high vowels, low (open) vowels, such as /a/, are produced with the tongue relatively flat and low in the mouth.

Lips are also important articulators in the oral cavity. When the mouth is closed, the air

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap		ⱱ		ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Figure 2. Consonant classification

(Source: <https://www.internationalphoneticassociation.org/content/full-ipa-chart>)

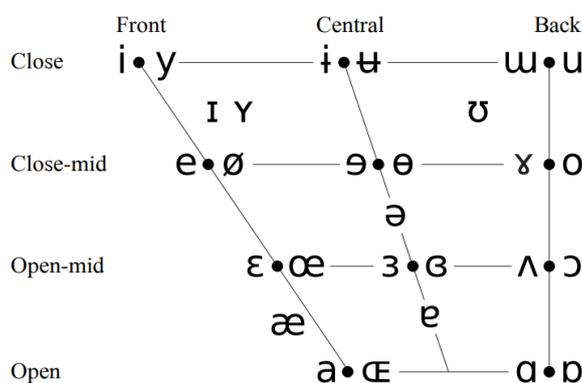


Figure 3. Vowels classification

(Source: <https://www.internationalphoneticassociation.org/content/full-ipa-chart>)

passes through the lips, halted, and then released to produce sounds such as /p/ and /b/. These sounds are known as bilabial sounds. Lip shape and location can also affect the sound produced by the vocal cords, especially the vowel sounds. The lips may be rounded or spread, which is known as labialization, producing the sounds such as /o/ and /w/.

Teeth can also help in speech production. When the upper and lower teeth are brought together, air may pass between them, generating the sounds like /f/ and /v/. Furthermore, the teeth' position can influence the tongue's and other articulators' position, affecting the sound produced by the mouth. The teeth play a significant role in articulating fricative sounds (/s/, /z/, /f/, /v/, /θ/, /ʃ/) and affricate sounds (/tʃ/, /dʒ/).

Several studies have been conducted on speech mechanics in the oral cavity using imaging methods such as MRI and X-ray imaging. These methods have been used to study the tongue and other articulators contribute to speech production. Furthermore, other studies investigate the brain's

role in controlling the speech organs while producing speech. The brain receives sensory input on the placement and movement of the articulators from the articulators and other structures in the mouth cavity. The brain uses this input to monitor and modify speech actions to ensure the correct sound articulation.

Many dental problems, such as cleft lip and palate, tongue-tie (Ankyloglossia), mouth breathing, and tongue-thrusting habit, can cause speech deficits because they impact the positioning and movement of the tongue, lips, and teeth. (Alhazmi, 2022; Chandrashekhara et al., 2020; Hitos et al., 2013). Other researchers have also suggested that dental conditions such as missing teeth, dental caries, dental trauma, and malocclusion can cause speech impairment. (Alhammedi et al., 2018; Assaf et al., 2021; Harini et al., 2020; Lam, 2016; Leck et al., 2022)

**Malocclusion**

Malocclusion is a common dental condition characterized by a misalignment of teeth and jaws. An individual with this condition may experience

various problems, including difficulties eating, speaking, discomfort, and pain. Malocclusion can be caused by several factors, including genetic and developmental factors. Several genetic factors, such as the size of the teeth and jaws and the location of the teeth and jaws, can cause a malocclusion. Besides genetic factors, malocclusion can also result from acquired factors, including thumb sucking, sticking out the tongue, and constant use of pacifiers and bottles that may cause. (Bourzgui, 2015; Inglehart & Bagramian, 2002; Kharbanda, 2019).

Different types of malocclusion can occur based on the position of the teeth, including overbite, underbite, crossbite, and open bite. Overbite can be described as the overlap or gap between the top front teeth and the bottom front teeth. This condition occurs when lower jaw teeth are too far behind upper jaw teeth. In contrast, the underbite occurs when the lower teeth are located further forward than the upper teeth. Crossbite is the condition in which your teeth do not fit over one another when your mouth is closed. Depending on the location of the misalignment, it may appear in the front of the mouth or on the sides of the mouth. Open bite is characterized by the top and bottom teeth not touching each other when the mouth is fully closed, resulting in an opening between the top and bottom teeth. Some of the factors contributing to these conditions include thumb sucking, pushing

teeth with the tongue (tongue-thrusting), using pacifiers after the third birthday, and continuing to use a bottle after the infant years. It is important to note that these conditions have a significant impact on oral health and quality of life. Malocclusions make it difficult for individuals to maintain proper oral hygiene, which can lead to tooth decay and periodontal disease. Furthermore, these conditions may also lead to speech disorders as they affect the ability to produce certain sounds.

Different dental procedures can be applied depending on the type of malocclusion. Using orthodontic treatment, such as braces or transparent aligners, teeth can be gradually realigned. Orthodontic treatment also can help improve chewing ability and decrease the possibility of dental problems in the future. Surgical intervention, such as jawbone repositioning, may be used to enhance biting alignment. However, It is usually only recommended to perform surgery in the case of severe malocclusions. In certain instances, however, surgery may be harmful (Kharbanda, 2019). The potential for malocclusion can be reduced by preventive actions, such as avoiding using pacifiers or bottles for a long time, avoiding thumb-sucking, and promoting dental hygiene practices. Furthermore, regular dental exams can be an early detection and treatment of malocclusions. (Anant et al., 2022; Granath & McHugh, 2021; Hiremath, 2011).

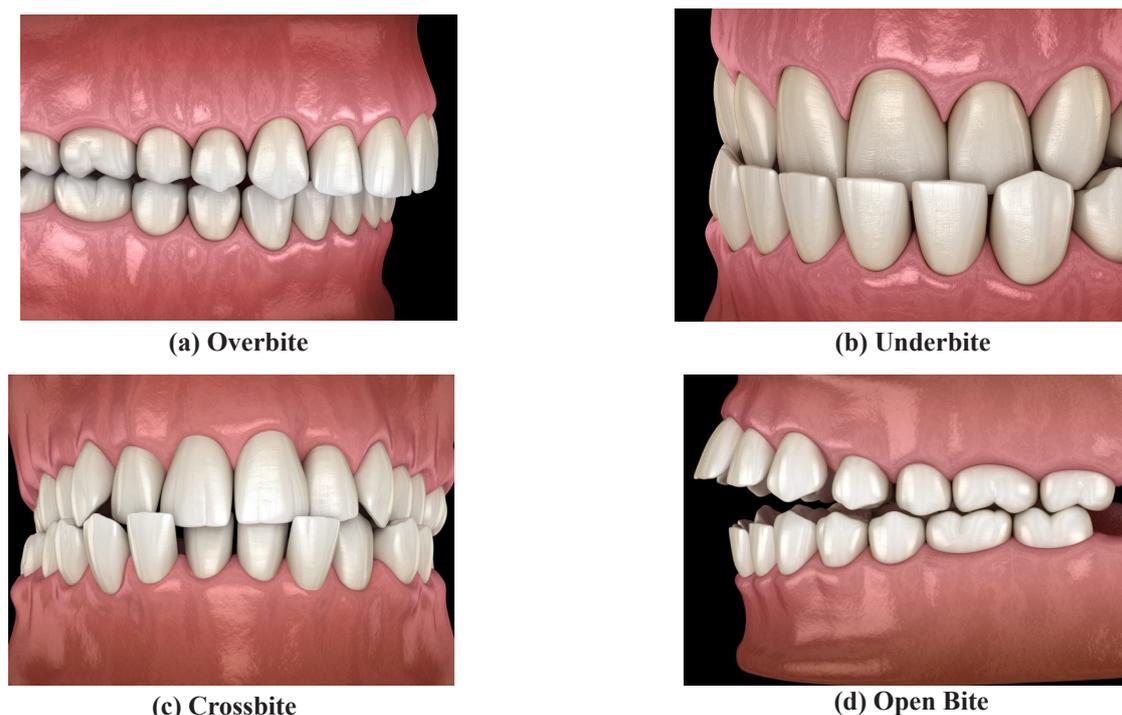


Figure 4. Types of Malocclusion

Regarding the severity level, malocclusion can be categorized into three major classes. Malocclusion class I is the most common condition which occurs when the upper teeth slightly overlap the lower teeth. In this type of malocclusion, both upper and lower molars are in the proper position, but other teeth may be misaligned. As a result of this condition, the people with malocclusion class I suffers from difficulty speaking, chewing, and appearing. Orthodontic appliances such as braces or clear aligners are the most common treatment for this condition.

Class II malocclusions are characterized by severe overbite. This type is characterized by a significant overlap between the upper and lower teeth. The symptoms of this condition include difficulties speaking, chewing, and gazing as well as jaw discomfort, migraines, and other issues. The use of braces, retainers, and/or headgear may also be helpful in treating class II malocclusions. In the case of younger patients with immature jawbones, retainers may be recommended. Children between the ages of six and twelve may also benefit from wearing headgear to support normal jaw growth and alignment.

Class III malocclusion is characterized by prognathism when the lower teeth protrude beyond the upper teeth. Class III malocclusions can cause a number of serious problems, such as difficulty chewing or premature wear of teeth. There are several treatment options available, depending on

the type and severity of the condition. Some options include palate expanders, braces, and surgery. Early intervention is essential for preventing the problem from worsening.

Malocclusions are common dental problems that can have a negative impact on a person's ability to communicate, eat, and chew. The cause of malocclusion can be genetic or acquired, including thumb sucking, prolonged use of pacifiers, cleft palates and lips, poor oral hygiene, trauma and injuries, and mouth tumours. As a result of this condition, you may experience speech difficulties, misaligned teeth, chewing and biting difficulties, mouth breathing problems, biting your cheeks and tongue, and changes to your facial appearance. A number of treatments are available to treat malocclusion, including orthodontic treatment and surgical surgery. Malocclusions should be treated as soon as possible to prevent further dental conditions such as tooth decay, gum disease, and temporomandibular joint dysfunction (Araujo & Buschang, 2016; Bourzgui, 2015; Kharbanda, 2019).

### Malocclusion and Speech Difficulties

Malocclusion is an orthodontic problem that impacts the alignment of teeth, the way they fit together, and how they sound. It can have an impact on their dental health and quality of life, as well as their ability to articulate words. A majority of the studies indicated that malocclusion can

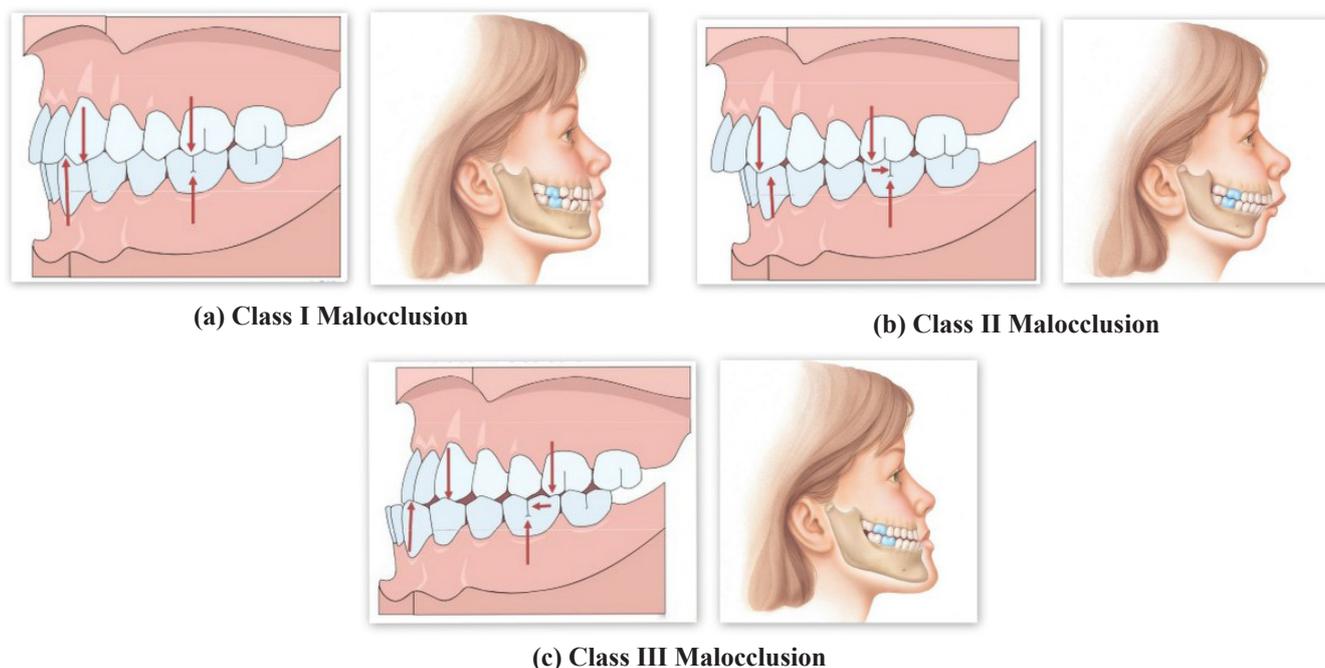


Figure 5. Malocclusion Classes

affect pronunciation. (Assaf et al., 2021; Harini et al., 2020; Leavy et al., 2016). Malocclusion, in particular, has been proven to affect the production of specific speech sounds, such as /s/, /z/, /t/, /d/, /l/, /r/, /f/, and /tʃ/ (Leavy et al., 2016; Vallino & Tompson, 1993). Several studies have also discovered that malocclusion may lead to compensatory articulation errors, such as tongue thrusting when producing certain sounds. Malocclusions, which vary in level and type, can lead to difficulties with speaking. (Gurudatta et al., 2021; Harini et al., 2020).

According to the results of this comprehensive research, malocclusion can have a harmful effect on pronunciation, particularly when producing particular speech sounds. Different types of malocclusion can have effects on the production of several different sounds. Class I malocclusion causes no significant speech issues, although misaligned teeth can impact the tongue and lips, causing difficulties with certain pronunciations, specifically /s/ and /z/. Overbite creates problems with some speech sounds in class II malocclusion, including /s/, /z/, /f/, and /tʃ/. Furthermore, underbites in class III malocclusion can affect the production of a variety of sounds, including /t/, /d/, /l/, and /r/.

Other problems, such as tongue-tie, hearing loss, or developmental delays, may also contribute to speech difficulties in addition to malocclusion. Discussion with a speech-language pathologist or dentist can help people to identify the primary cause of speech problems and design a suitable treatment plan. (Assaf et al., 2021; Chen et al.,

2018; Gurudatta et al., 2021; Kaya & Taner, 2011; Khattab et al., 2013; Lathrop-Marshall et al., 2022; Mogren et al., 2022).

Several studies found that orthodontic treatment can improve pronunciation in individuals with malocclusion (Baghbadorani & Roohani, 2014; Damasceno Melo et al., 2021; Eslamian & Leilazpour, 2006; Karacay et al., 2013; Papageorgiou et al., 2016; Yamaguchi et al., 1994). For example, several studies found that people who received orthodontic treatment had improved speech intelligibility compared to people who did not receive treatment (Brzezińska-Zajac et al., 2023; A. K. Rai et al., 2014). However, orthodontic treatment may lead to temporary pronunciation difficulties, particularly in the initial stages of treatment (De Felipe et al., 2010; Doshi & Bhad-Patil, 2011; Long et al., 2013; Paley et al., 2016; A. Rai et al., 2013).

### III. CONCLUSION

Malocclusion can have a negative impact on pronunciation, particularly regarding the production of certain speech sounds. Malocclusion can also lead to compensatory articulation errors, which may further impact pronunciation. Orthodontic treatment may improve pronunciation in individuals with malocclusion, although temporary pronunciation difficulties may occur during treatment. Further research is needed to understand the impact of malocclusion on pronunciation better. Clinicians should be aware of the potential impact of malocclusion on pronunciation and consider this when evaluating and treating patients.

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