*Original Article*

# What Is the Effect of Maxillary Impaction Orthognathic Surgery on Voice Characteristics? A Quasi-Experimental Study

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## ABSTRACT

**Background:** Regarding the impact of orthognathic surgery on the airway and voice, this study was carried out to investigate the effects of maxillary impaction surgery on patients' voices through acoustic analysis and articulation assessment.

**Methods:** This quasi-experimental, before-and-after, double-blind study aimed at examining the effects of maxillary impaction surgery on the voice of orthognathic surgery patients. Before the surgery, a speech therapist conducted acoustic analysis, which included fundament frequency (F0), Jitter, Shimmer, and the harmonic-to-noise ratio (HNR), as well as first, second, and third formants (F1, F2, and F3). The patient's age, sex, degree of maxillary deformity, and impaction were documented in a checklist. Voice analysis was repeated during follow-up appointments at one and six months after the surgery in a blinded manner. The data were statistically analyzed using SPSS 23, and the significance level was set at 0.05.

**Results:** Twenty two patients (18 females, 4 males) were examined, with ages ranging from 18 to 40 years and an average age of 25.54 years. F2, F3, HNR, and Shimmer demonstrated a significant increase over the investigation period compared to the initial phase of the study ($P < 0.001$ for each). Conversely, the Jitter variable exhibited a significant decrease during the follow-up assessments in comparison to the initial phase of the study ($P < 0.001$).

**Conclusion:** Following maxillary impaction surgery, improvements in voice quality were observed compared to the preoperative condition. However, further studies with larger samples are needed to confirm the relevancy.

**KEYWORDS**
Maxillary impaction surgery; Acoustic analysis; Orthognathic surgery

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## INTRODUCTION

The coordinated functioning of the lips, jaw, and tongue is essential for the articulation and voice production. Any alteration in these structures

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can have an impact on the produced voice [1]. The vibration of the vocal folds generates the voice. The specific type of vowel is determined by the articulatory movements of speech organs, such as the lips and jaws. In Persian language, there are six vowel sounds: /a/, /i/, /u/, /e/, /o/, /ɑ/. Acoustically, formants play a crucial role in distinguishing these vowels, and their characteristics vary based on the individual's vocal tract. Formants represent the natural resonances of voice within the vocal tract [2]. Speech is typically evaluated across four main areas: 1) Fluency, 2) Articulation, 3) Voice production, and 4) Resonance. These aspects of speech are influenced by the structures and spaces within the oral cavity, including the mouth, lips, teeth, and tongue [3-6].

The voice after originate from larynx, is modified through changes in the tongue height, forward-backward movement of the tongue body, and shaping of the lips, resulting in the production of different vowels. Vowels are characterized by continuous, resonant sounds, where the airflow during their production encounters no obstructions or constrictions in the speech production pathway. In phonetics, a vowel is defined as a sound in spoken language where the vocal tract remains open, with no blockage above the larynx and in the oral cavity [6]. Vowels are contrasted with consonants, which are produced by a constriction or closure at one or more points in the vocal tract. A combination of a vowel and a consonant forms a syllable. Across languages, vowels typically constitute the nucleus or core of a syllable, while consonants mark the syllable's onset and coda. Consequently, there is a clear necessity for phonetic analysis of vowels in terms of physical phonetics. The frequency response curve of a produced vowel provides information about the state of the speech organs during the production of that specific vowel [7]. A low vowel refers to a vowel sound where there is a maximum distance between the surface of the tongue and the palate and where the exhalation channel is open. Examples of low vowels include [a] and [æ]. Conversely, high vowels (such as [i] and [u]) are produced with the narrowest possible air outlet. Front vowels are produced when the tongue is positioned towards the front of the mouth, while back vowels are produced when the tongue is placed in the rearmost position of the mouth [6-8].

The structure of formants is a fundamental physical and acoustic characteristic of vowels. The quality of a vowel is closely related to its formants. Formants are specific regions along the sound pathway where the acoustic energy of the sound source becomes more pronounced during sound production. These resonant areas manifest as peaks in the frequency response curve of the vowel [6-8]. Each vowel is characterized by multiple formats. The first formant, F1 (First Formant Frequency), corresponds to tongue elevation. The second formant, F2, is associated with the anterior-posterior position of the tongue. Lastly, the third formant, F3, is indicative of the lip's roundedness and extension [7, 8]. These formants serve as indicators of the size and shape of the vocal tract, which may vary slightly among individuals. Consequently, the formants of the same vowel exhibit minor variations across different individuals. However, what remains consistent among all individuals is the ratio between the vowel formants. The ratios of F2 to F1 and F3 to F1 during vowel production remain constant across all individuals who speak a particular language. Consequently, these ratios play a crucial role in distinguishing speech sounds from other auditory stimuli [7, 8].

While the primary objective of orthognathic surgery is to restore proper occlusion and enhance facial aesthetics, its potential impact on improving chewing function and speech characteristics is also noteworthy [9-12]. Deformities in oral structures caused by malocclusion can alter the acoustic properties of the voice, resulting in abnormal resonance and potential disruptions in the accurate production of language phonemes [10, 11, 13-16]. The structural configuration of the facial muscles, as well as the size and shape of the teeth, tongue, and roof of the mouth, significantly influence the production of speech [10, 11, 13-16].

The main objective of Lefort 1 Maxillary surgeries is to enhance both functional and aesthetic aspects for patients, making them among the most frequently performed and popular procedures [9-12]. Lefort 1 maxilla surgery involves a variety of modifications in the maxilla based on individual patient requirements [17]. This procedure enables the movement of the maxilla in different directions. Le Fort surgeries are employed for different indications, including the treatment of class II and class III malocclusions, facial asymmetries, midface hypoplasia, and correction of maxillary vertical deformities. In cases where patients exhibit vertical

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maxillary excess (VME) resulting in elongated or long faces, the treatment involves reducing the facial height and vertically repositioning the maxilla [17]. Similarly, patients with a “gummy smile” caused by the excessive vertical height of the maxilla can be treated by vertically displacing the maxilla [18].

Studies examining the impact of orthognathic surgery on voice and speech changes have identified several potential alterations in speech indicators. These changes can manifest in various ways, including modifications in the acoustic characteristics of sound, resonance, and the overall quality of language sound production. Specifically, alterations in vowel and consonant production, particularly fricative consonants like /s/ and /z/, have been observed [9, 19-22].

Numerous researchers have documented the impact of Lefort I osteotomy and maxillary movement on speech production, resonance, velopharyngeal function, and voice, both in patients with and without clefts [10, 15, 16, 23, 24]. Additionally, certain studies have examined the alterations in voice after mandibular advancement surgery [9, 11, 21]. However, it is worth mentioning that to date, no research has been conducted on speech production and its structural modifications following maxillary impaction surgery. One potential complication associated with vertical displacement of the maxilla is the narrowing of the nasal airway, which can have implications for the production of voice [10, 15, 16, 23, 24]. To date, no studies have been specifically conducted investigating the impact of maxillary impaction surgeries on changes in voice and speech sound production.

Consequently, we aimed to explore alterations in voice among patients undergoing maxillary impaction surgery in a sample of Iranian population.

## MATERIALS AND METHODS

This quasi-experimental double-blind interventional study was conducted at Ghaem Hospital and the Department of Oral and Maxillofacial Surgery at Mashhad Faculty of Dentistry, Mashhad, Iran between 2021 and 2022.

The study adhered to the Helsinki and Consort guidelines. It was approved by the Ethics Committee of Mashhad University of Medical Sciences (with code IR.MUMS.DENTISTRY.REC.1400.155). Before participation, informed consent was obtained from all eligible patients.

The study included systemically healthy individuals (classified as ASA I & II) without any syndromes, aged between 18 and 40 years, who were candidates for maxillary impaction orthognathic surgery and were referred to Mashhad Dental Faculty. Furthermore, several exclusion criteria were implemented in this study. Patients with a history of cleft lip and palate or congenital syndromes, individuals with congenital speech disorders such as stuttering, those who required mono maxillary surgery, and individuals who were candidates for genioplasty were excluded from participation. Additionally, smokers, individuals with laryngeal diseases, and pregnant women were not included in the study. Other factors leading to patient exclusion included non-compliance with follow-up appointments, unforeseen complications during surgery, and patient unwillingness to participate or continue with the study, which served as dropout criteria.

In this study, the sole intervention performed was maxillary impaction surgery, which was carried out on all patients who were candidates for the procedure. No additional interventions were administered to the patients. It is important to note that this study did not include a control group. At the beginning of the study, a student completed a checklist to gather general information about the patients. This checklist included data such as the patient’s age, sex, BMI, type and severity of deformity, and the extent of facial feature displacement. Additionally, speech therapy records of sound indices were recorded and entered into the relevant checklist. To minimize bias, the statistical analyst and speech therapist were blinded to the type of surgeries performed. However, the patients, surgeon, and allocator were aware of the type of operation and were not blinded, thus making this study double-blind.

The main variables under investigation were the degree of deformity and impaction of the maxilla, the extent of mandibular or maxillary movement (forward or backward), and the background variables encompassing age and sex. The dependent variables focused on the speech characteristics, including acoustic features of the voice (fundamental frequency, jitter, shimmer, harmonic to noise ratio (HNR), first formant, second formant, and third formant).

All patients underwent orthognathic surgery

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performed by the same surgical team. Impaction orthognathic surgery was conducted on the maxilla in the operating room of Ghaem Hospital, Mashhad University of Medical Sciences, Mashhad, Iran. The surgical procedure involved calculating and recording the extent of jaw displacement separately for the maxilla and mandible. A uniform hypotensive anesthesia protocol was followed for all patients, utilizing hypotensive anesthesia. Rigid fixation was achieved by applying two screws on each side, and patients wore intermaxillary elastics for a duration of 2 weeks following the intermaxillary fixation (IMF) operation. The speech evaluations, encompassing acoustics, which were conducted before the treatment, were repeated one month and six months post-surgery.

Two types of speech evaluations were conducted by a speech therapist both before and after the operation, which were recorded in the checklist. The first evaluation involved voice acoustic assessment using Praat software in the acoustic room at Ghaem Hospital. During this assessment, the patient's voice sample was recorded while stretching the vowel /a/ for a duration of 5 seconds. Parameters such as F0, first to third formants, jitter, shimmer, and harmonic to noise ratio were analyzed.

The alteration in the oral cavity's shape following surgery results in modifications in speech production and the location of speech sound production. The patient's adaptability to these new conditions evolves. With time, it is anticipated that the patient will adjust and adapt more effectively to the new conditions, leading to improved acoustic characteristics.. Consequently, evaluations were conducted at various time intervals. As previously mentioned, the voice components and voice quality of the patients were reassessed and recorded in the checklist after 1 month and 6 months post-surgery.

The sample size of this study, based on the study conducted by Van Lierde et al. [9], considering a first-type error level of 5% and a second-type error level of 20%, and utilizing the formula for comparing two dependent means, yielded an approximate sample size of 30 samples. Regrettably, because of the COVID-19 pandemic and the extended follow-up period, there was a loss of samples in this study, leading to an examination of data from 22 patients. Despite the reduced sample size, satisfactory and statistically significant results were obtained from this number of samples.

The demographic characteristics of the participants, such as age and sex, were presented in the form of a frequency and descriptive distribution table, indicating the central index and dispersion. These data were separately presented for the groups of patients before surgery, one month after surgery, and six months after surgery. The clinical data included acoustic evaluation parameters such as F0, first, second, and third formants, as well as jitter, shimmer and HNR. The qualitative and quantitative nature of these variables was reported using measures such as mean, standard deviation, minimum, and maximum, or in the form of frequency and frequency percentage. These findings were reported separately for the participants of the study, both before and after the treatment period.

The data were statistically analyzed using SPSS 23 (IBM Corp., Armonk, NY, USA). Data description was performed using suitable statistical tables and graphs. Average data comparison was conducted using the ANOVA test, eliminating the need for testing normality and equality of variance. To determine the relationship between changes in dependent quantitative variables and background variables, Spearman's and Pearson's correlation coefficients were utilized. Additionally, an independent t-test was employed to compare genders. A *P*-value less than 0.05 was considered statistically significant.

## RESULTS

Twenty-two patients were examined, with ages ranging from 18 to 40 years and an average age of 25.54 years. Out of the 22 patients, 18 were women, while the remaining 4 were men.

Table 1 presents the average values of F0, first, second, and third formants in Beginning of the study (before surgery), first and second follow-ups (one and six months after the operation).

Fig. 1 illustrates the changes in the F0 over the investigated periods. The results indicate that there was no statistically significant difference between the different investigated times, as evidenced by a *P*-value of 0.68.

Fig. 2 displays the changes in the first formant throughout the investigated periods. The data revealed that there was no statistically significant difference between the different investigated times, as indicated by a *P*-value of 0.73.

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Fig. 3 depicts the changes in the second formant across the investigated periods. The data highlights a significant difference between the values of the second follow-up and the baseline, with a *P*-value of less than 0.001.

Fig. 4 presents the changes in the third formant throughout the investigated periods. The data indicate a statistically significant difference between the second follow-up and the baseline, with a *P*-value less than 0.001.

Table 2 displays the average HNR variable across different follow-up periods. The lowest average HNR was observed at the beginning of the study, with a value of 15.4, while the highest average HNR was recorded at the second follow-up, with a value of 24.9.

Fig. 5 presents the changes in HNR throughout the investigated periods. The data reveal statistically significant differences among the different follow-ups. Specifically, the HNR value in the second follow-up was significantly higher than both the first follow-up and the baseline follow-up (*P*-value<0.001

**Table 1:** Investigating the average formant variable during different follow-ups

| Variable | | Average (Hz) | Standard deviation |
|---|---|---|---|
| **Fundamental frequency** | Beginning of the study | 212.5 | 14.3 |
| | First follow-up | 211.8 | 16.0 |
| | Second follow-up | 209.7 | 15.0 |
| **First formant** | Beginning of the study | 351.7 | 20.2 |
| | First follow-up | 355.9 | 30.3 |
| | Second follow-up | 361.2 | 23.8 |
| **Second formant** | Beginning of the study | 2053.5 | 146.5 |
| | First follow-up | 2256.5 | 214.4 |
| | Second follow-up | 2487.1 | 159.3 |
| **Third formant** | Beginning of the study | 2985.2 | 148.8 |
| | First follow-up | 3028.7 | 121.1 |
| | Second follow-up | 3253.3 | 122.4 |

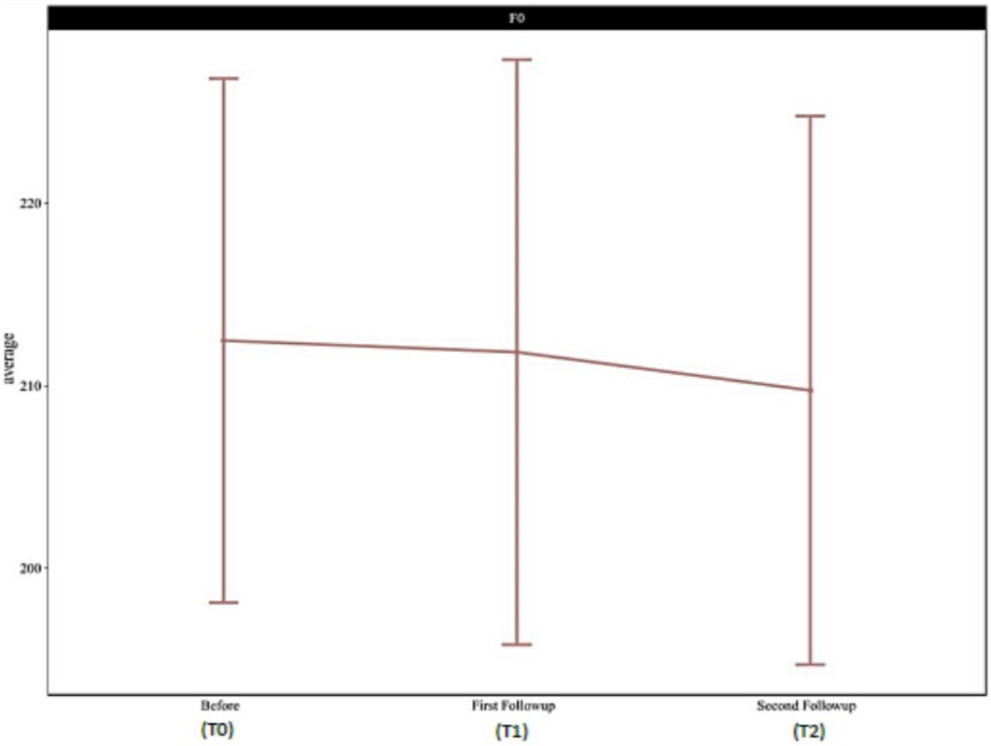

**Figure 1:** Evaluating the F0 changes during the study

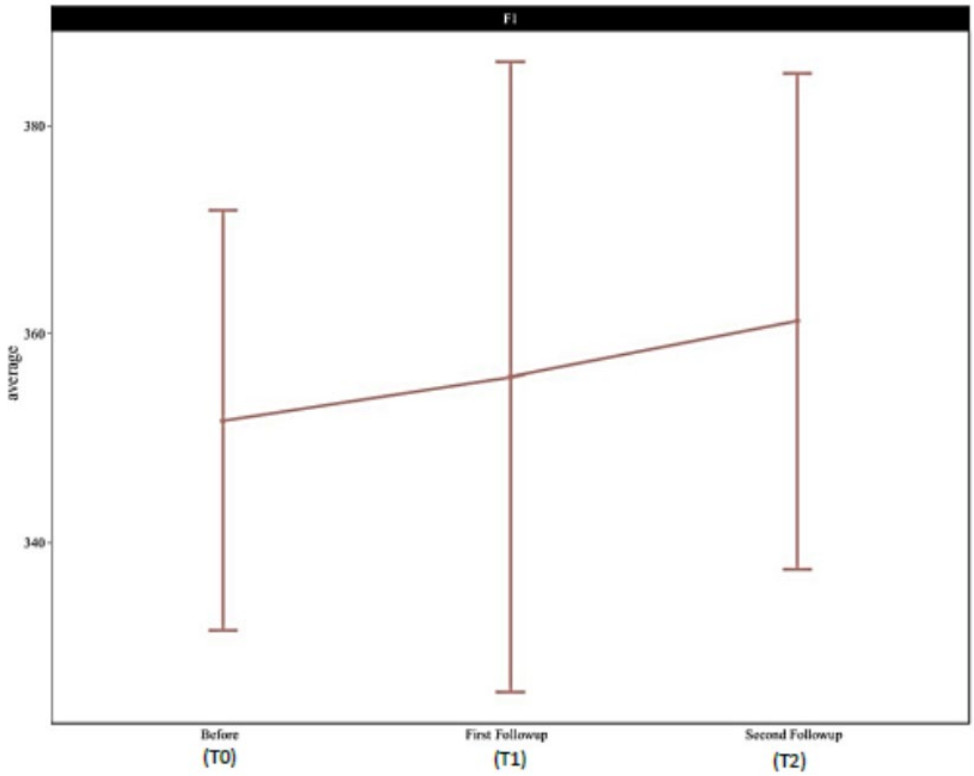

**Figure 2:** Evaluating the first formant changes during the study

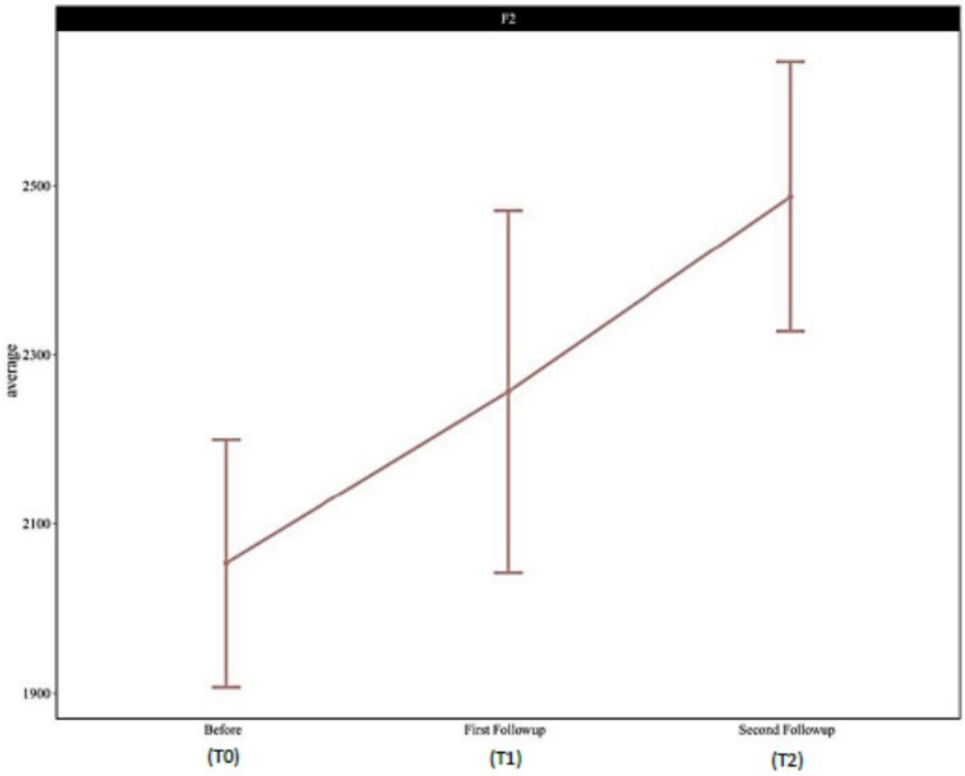

**Figure 3:** Evaluating the second formant changes during the study

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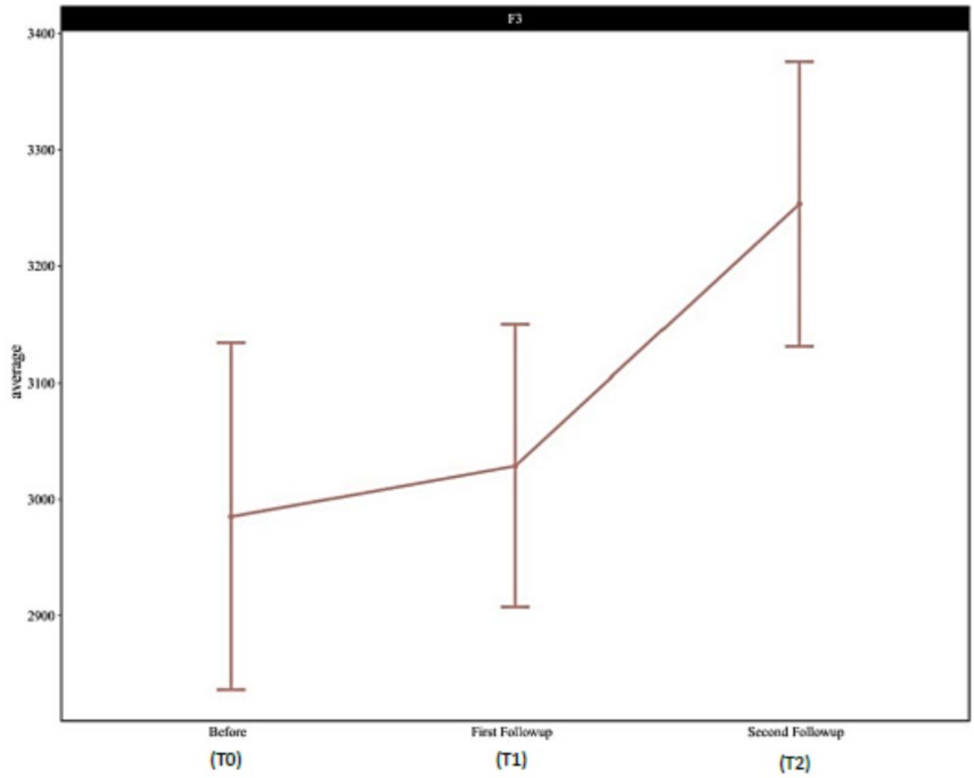

**Figure 4:** Evaluating the third formant changes during the study

**Table 2:** Investigating the average HNR variable during different follow-ups

| **Variable** | | **Average** | **Standard deviation** |
|---|---|---|---|
| **HNR** | Beginning of the study | 15.4 | 1.3 |
| | First follow-up | 20.1 | 1.9 |
| | Second follow-up | 24.9 | 1.3 |

**Table 3:** Investigating the average Jitter variable during different follow-ups

| **Variable** | | **Average** | **Standard deviation** |
|---|---|---|---|
| **Jitter** | Beginning of the study | 1.6 | 0.4 |
| | First follow-up | 0.9 | 0.3 |
| | Second follow-up | 0.6 | 0.1 |

for each). Furthermore, the HNR value in the first follow-up is also significantly higher than the baseline follow-up (*P*-value<0.001).

Table 3 displays the average Jitter variable across different follow-up periods. The highest average Jitter was observed at the beginning of the study, with a value of 1.6, while the lowest average Jitter was recorded at the second follow-up, with a value of 0.6.

Fig. 6 illustrates the changes in Jitter during the investigated periods. The data indicate a statistically significant difference between the second follow-up and the baseline, as well as between the first follow-up and the baseline. The *P*-values for these comparisons are both less than 0.001.

Table 4 presents the average Shimmer variable across different follow-up periods. The highest average Shimmer was observed at the beginning of the study, with a value of 8.7, while the lowest average Shimmer was recorded starting from the second follow-up, with a value of 3.8 (Table 4).

Fig. 7 illustrates the changes in Shimmer during the

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**Table 4:** Investigating the average Shimmer variable during different follow-ups

| Variable | | Average | Standard deviation |
|---|---|---|---|
| **Shimmer** | Beginning of the study | 8.7 | 1.2 |
| | First follow-up | 5.8 | 1.7 |
| | Second follow-up | 3.8 | 0.9 |

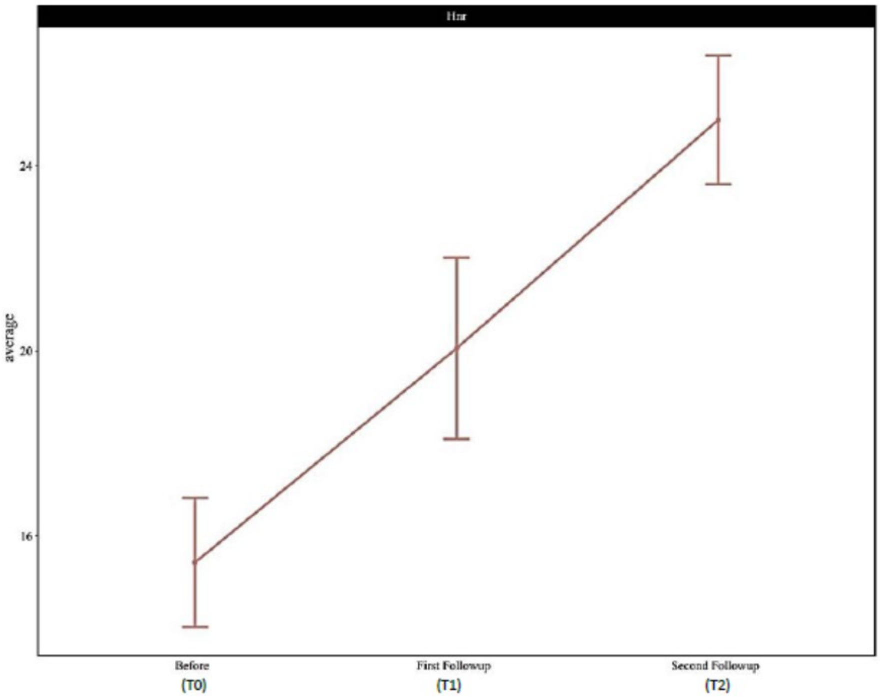

**Figure 5:** Evaluating the HNR changes during the study

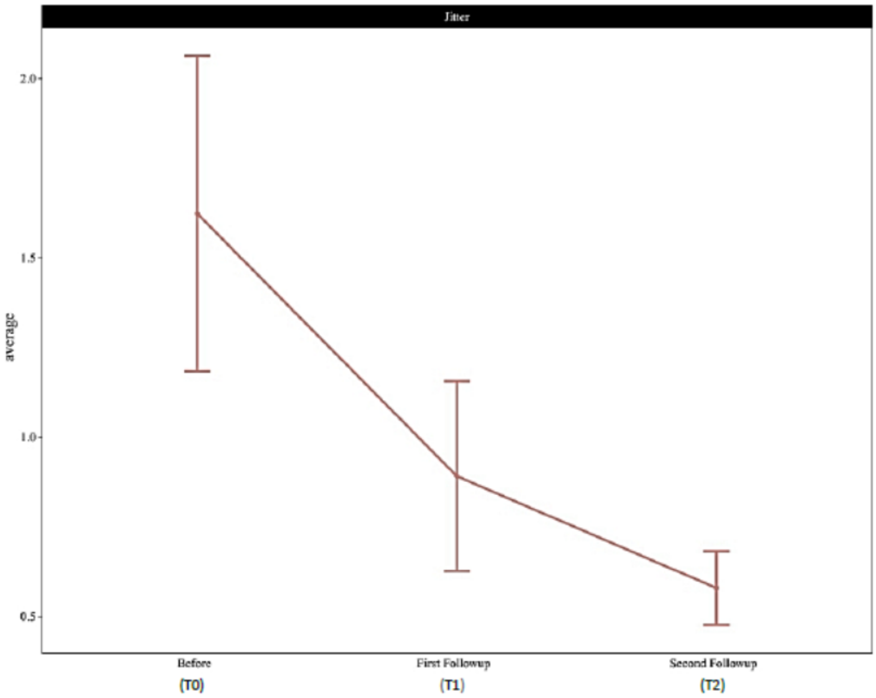

**Figure 6:** Evaluating the Jitter changes during the study

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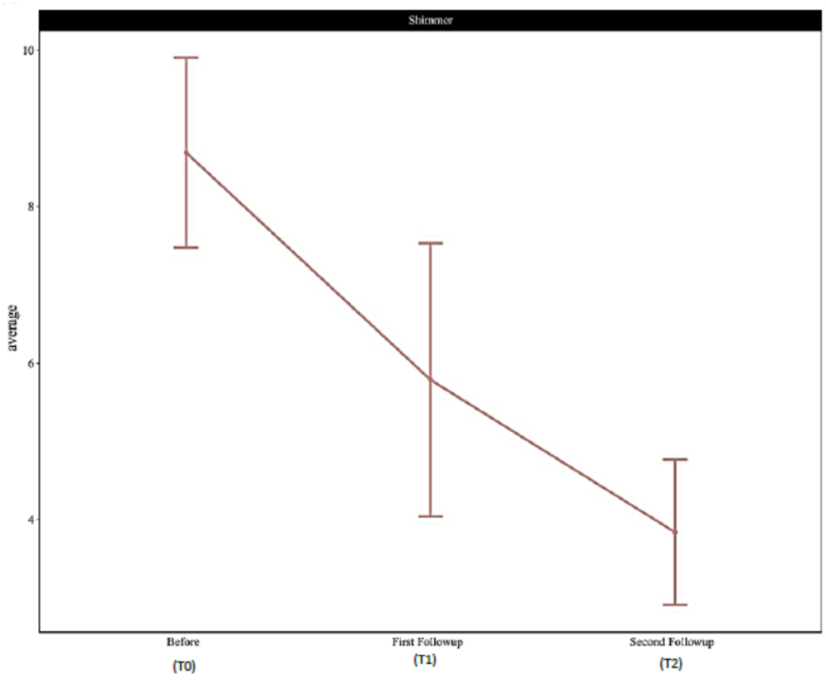

**Figure 7:** Evaluating the Shimmer changes during the study

**Table 5:** Relation between the changes of quantitative dependent variables and independent variables

| Variable | | Age | Sex | BMI | Degree of deformity before surgery | Amount of maxillary advancement | Amount of maxillary setback | Amount of mandibular setback | Maxillary Impaction |
|---|---|---|---|---|---|---|---|---|---|
| Fundamental frequency | Spearman's correlation coefficient | -0/28 | - | -0/46 | 0/28 | -0/09 | 0/31 | -0/08 | 0/03 |
| | *P*-value | 0/21 | 0/04* | 0/03* | 0/21 | 0/68 | 0/15 | 0/72 | 0/86 |
| First formant changes | Spearman's correlation coefficient | -0/02 | - | -0/06 | -0/27 | -0/23 | 0/008 | -0/04 | -0/27 |
| | *P*-value | 0/9 | 0/32 | 0/77 | 0/21 | 0/29 | 0/9 | 0/82 | 0/21 |
| Second formant changes | Spearman's correlation coefficient | 0/002 | - | 0/22 | -0/08 | 0/009 | -0/15 | -/014 | -0/15 |
| | *P*-value | 0/99 | 0/52 | 0/31 | 0/72 | 0/96 | 0/49 | 0/52 | 0/47 |
| Third format changes | Spearman's correlation coefficient | -0/20 | - | 0/17 | 0/03 | 0/07 | 0/16 | -0/21 | -0/26 |
| | *P*-value | 0/35 | 0/49 | 0/42 | 0/87 | 0/75 | 0/45 | 0/33 | 0/22 |
| HNR | Spearman's correlation coefficient | -0/35 | - | 0/16 | -0/23 | -0/06 | 0/11 | -0/28 | -0/13 |
| | *P*-value | 0/10 | 0/17 | 0/45 | 0/29 | 0/75 | 0/62 | 0/19 | 0/56 |
| Jitter | Spearman's correlation coefficient | 0/07 | - | -0/17 | 0/38 | 0/32 | -0/14 | 0/28 | 0/01 |
| | *P*-value | 0/74 | 0/76 | 0/42 | 0/07 | 0/14 | 0/52 | 0/19 | 0/95 |
| Shimmer | Spearman's correlation coefficient | 0/21 | - | -0/09 | 0/09 | -0/09 | -0/24 | -0/08 | 0/14 |
| | *P*-value | 0/34 | 0/06 | 0/67 | 0/68 | 0/68 | 0/27 | 0/70 | 0/50 |

*: significant relation.

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investigated periods. The average Shimmer values for the third and first follow-ups were significantly lower compared to the baseline follow-up, with a *P*-value of 0.01.

Table 5 explores the relationship between dependent and independent variables. The data indicate that only BMI shows an inverse correlation, and sex has a significant relationship with the base formant. However, no correlation was observed between the other variables.

## DISCUSSION

The objective of the present study was to examine the impact of maxillary impaction orthognathic surgery on the acoustic characteristics of voice in patients who require such surgery. The obtained results indicated noticeable enhancements in the acoustic characteristics of voice, voice resonance, and a reduction in production errors following maxillary impaction surgery. During the observed periods, the second and third formants exhibited an increase, while the F0 and first formants showed no significant differences. Moreover, there was an increase in Shimmer and HNR compared to the initial stages of the study. Conversely, the jitter variable demonstrated a decrease during the follow-up assessments as opposed to the initial stages of the study. The superior reposition and impaction maxilla altered nasal airflow from turbulent to linear, resulting in improved nasal airflow and speech. This finding was consistent with Eshghpour et al. study [17].

Orthognathic surgeries are extensively utilized for addressing a range of congenital and acquired skull, jaw, and facial deformities. While the primary objective of orthognathic surgery is to restore natural occlusion and enhance facial aesthetics, functional enhancements in chewing and speech production are also significant outcomes of these procedures [12, 21, 22, 25]. Only a limited number of studies have focused on examining the specific impact of movements resulting from orthognathic surgery on speech characteristics [10, 12, 20, 22, 25]. Lefort I maxillary surgery enables the repositioning of the maxilla in various directions. It is important to note that alterations in bone tissue have an impact on the surrounding soft tissue [26].

As mentioned before, it is crucial to acknowledge that orthognathic surgery not only alters the relationship between the jaw and teeth but also has an impact on the soft tissues within the oral cavity and lips. These factors can influence speech characteristics, including sound quality, resonance, and production [10-12, 20]. A thorough examination of past studies reveals that orthognathic surgery leads to substantial modifications in the dimensions of the upper airway. However, the investigation of the surgery's effects on phoneme and voice production quality has been relatively scarce.

Jaw orthognathic surgery involves altering the position of the facial skeleton, which in turn affects the connected soft tissues due to its impact on facial anatomy. Structures such as the soft palate, tongue, hyoid bone, and orofacial muscles are linked, directly or indirectly to the maxilla and mandible, and therefore, they are influenced by orthognathic surgery [10, 13, 22]. Consequently, movements of the jaw can result in changes in the positioning of these structures, leading to variations in the tension of the soft tissues and associated muscles. This, in turn, affects the size and volume of the nasal and oral cavities, as well as the posterior airway space (PAS), depending on the direction and magnitude of skeletal movements [27].

Muto et al. conducted a study that established a significant correlation between the PAS and the positioning of the maxilla, mandible, and soft palate [28]. As a result, the impact of skeletal movements during mandibular surgery on the oropharyngeal airway becomes an important consideration, as it can potentially lead to voice alterations. Numerous studies have explored the relationship between different types of orthognathic surgery, changes in pharyngeal airway size, and obstructive sleep apnea (OSA) [29].

In the past, the evaluation of voice primarily relied on auditory and subjective judgments made by speech therapists, which introduced a higher level of subjectivity. However, in the early 20th century, researchers such as Miller, Stumpf, and Paget made significant contributions by identifying the formant structure and highlighting its role in the acoustic analysis of voice. Furthermore, Ladefoged proposed the use of measured acoustic values as an alternative to assessing tongue height during speech production, enabling more accurate judgments in the analysis of vowels [4, 10-12]. These studies demonstrated that the acoustic analysis of vowels holds substantial power in describing their

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production characteristics and can be utilized for more confident statistical analysis [3, 30].

Formants are crucial acoustic features that play a significant role in distinguishing different speech sounds. They are considered distinctive elements of speech sounds. Following the F0, the formant with the lowest frequency is referred to as F1. Next, the format with the second lowest frequency is labeled as F2, and subsequently, the formant with the third lowest frequency is designated as F3. In other words, the first three lowest audio frequencies after the base frequency are identified as the first to third formants. These three formants contribute to determining the quality of a vowel sound, including its perceived height or lowness, the positioning of the tongue (front or back), and the lip configuration (rounded or extended) during its production [9, 22, 31].

In other words, the combined frequencies of a vowel's formats are referred to as the formant structure. The formant structure holds significant importance as it constitutes the primary component that contributes to the auditory recognition of vowels by listeners. The frequency composition of a vowel's formants directly influences its sound quality. While vowels typically have more than three formants, the first three formants play a predominant role in distinguishing one vowel from another [4, 11, 20].

Upon further examination of the literature, it was discovered that first formant (F1) is influenced by the extent of jaw opening, while second formant (F2) is affected by tongue movement. Researchers have proposed that the formation of formants can be employed to analyze acoustic properties, considering the shape of the mandible and the position of the tongue. Additionally, the fundamental frequency and formants utilized in this study for acoustic evaluation enable the examination of alterations made in the structure of the vocal tract [10, 11, 14, 19, 20, 22, 31].

The majority of studies conducted in this field have primarily focused on examining the impact of mandible or double jaw surgery on voice, while fewer studies have specifically investigated the effects of maxillary changes on voice. For instance, Chua et al. [32] explored the influence of maxillary advancement surgery on voice characteristics in individuals with cleft palates. Their study revealed that regardless of the degree of advancement, changes in voice characteristics were observed in patients. Ha, and Han [33] observed that altering the height of the maxilla through impaction resulted in a reduction in the volume of the nasal cavity. Another study conducted by Haarmann et al. [34] demonstrated that irrespective of the type of maxillary movement (increasing or decreasing the height), nasal airflow increased while nasal resistance decreased.

Pourdanesh et al. [23] conducted a study revealing that alterations in the vertical dimension of the maxilla lead to improved nasal airflow and decreased nasal resistance. In a separate study [35], upper maxilla displacement, with or without nasal floor involvement, generally resulted in reduced nasal resistance. Furthermore, Ghoreishian et al. [36] examined changes in the nasal airway following maxilla displacement and noted that upper and anterior displacement of the maxilla could contribute to improved nasal respiratory function. In the study conducted by Erbe et al. [37], it was demonstrated that despite a reduction in intranasal dimensions (when the upper posterior displacement is not more than 5 mm), the average nasal airflow, as measured by anterior rhinomanometry, remained unchanged and indicated no increase in resistance. In a recent study focusing on patients requiring upper maxilla displacement, one of the factors leading to discrepancies in previous research was the failure to report the displacement rate. The precise displacement rate is an influential and predictive factor for subsequent airflow. The findings of this study indicate that upper air passage displacement of less than 5.6 mm results in increased nasal airflow, while displacement values of 6.5 mm and above lead to decreased nasal airflow.

## CONCLUSION

Following maxillary impaction surgery, noteworthy changes in acoustic frequencies could be observed when comparing vowel sounds before and after the procedure during the initial follow-up period. Improvements in voice quality, can be observed compared to the preoperative condition. It is advisable to conduct preoperative acoustic analysis in all patients undergoing orthognathic surgery, particularly in cases of severe deformity where jaw surgery is necessary. Furthermore, it is recommended to carry out additional clinical trials with larger sample sizes and longer follow-up periods to investigate further this topic.

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## CONFLICTS OF INTEREST

None.

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