Summary of the doctoral dissertation entitled "Influence of malocclusion on speech disorders in adult patients treated with orthognathic treatment"

Introduction

The doctoral dissertation was developed on the basis of the series of publications presented in highly ranked scientific journals. All the articles are convergent in terms of the subject, materials, and methods. The presented dissertation includes the following articles:

1. The Effectiveness of Frenotomy on Speech in Adults

[Lichnowska, A .; Kozakiewicz, M. The Effectiveness of Frenotomy on Speech in Adults. Appl. Sci. 2021, 11, 2727. https://doi.org/10.3390/app11062727]

2. The Logopedic Evaluation of Adults Patients after Orthognathic Surgery

[Lichnowska, A .; Kozakiewicz, M. The Logopedic Evaluation of Adult Patients after Orthognathic Surgery. Appl. Sci. 2021, 11, 5732. https://doi.org/10.3390/app11125732]

3. Speech Disorders in Dysgnathic Adult Patients in the Field of Primary Functions in the Stomatognathic System.

[Lichnowska, A .; Kozakiewicz, M. Speech Disorders in Dysgnathic Adult Patients in the Field of Severity of Primary Dysfunction. Appl. Sci. 2021, 11, 12084. https://doi.org/10.3390/app112412084]

Research on the relationship between malocclusion and speech disorders has long been the subject of interest of both Polish and international scientists. This topic connects the community of speech therapists with specialists in various branches of medicine. The first mentions of possible connections between malocclusions and speech impediments appeared at the beginning of the 20th century. The first of them only indicated that various malocclusions may be related to incorrect pronunciation. In the 1950s, research on the influence of malocclusion on the formation of speech defects was started and the research continues to this day. At the turn of this period, many scientific articles were published in various fields of medicine, not only speech therapy. Research on this phenomenon has been and is conducted by such specialists as speech therapists, ENT specialists, phoniatricians, dentists, orthodontists, maxillofacial surgeons, prosthetists, and physiotherapists. It is worth mentioning here one of the first studies from 1961, where Van Riper and Irwin then showed the very controversial view of the possible relationship between occlusal and dental disorders. Moreover, they pointed to some defective articulation of phonemes. In their study, they focused on the phonemes of the labial group and dentalized. They examined the relationship between the correct positioning of central incisors and the correct pronunciation of sounds in children. The results of the research group were compared with the second group of children with missing incisors or dental disorders, such as the wrong size or shape of the teeth. They showed that improper tooth positioning or their size and shape may disturb the pronunciation of the described sounds. In subsequent years, researchers

such as Turvey et al., 1976, Laine et al., 1985, Laine, 1986, Vallino, 1993 discussed the quality of pronunciation in people with various malocclusions in their works. One of the most important studies was the study of L. Vallino, which assessed the effect of combined orthodontic and surgical treatment on the improvement of pronunciation in patients undergoing orthognathic surgery. It showed the effectiveness of the orthognathic procedure in restoring proper pronunciation. L. Vallino proved that in 9 out of 10 cases, speech therapy as the only form of treatment was ineffective, and only combining it with a maxillofacial surgery procedure allowed for the improvement of anatomical conditions necessary for proper articulation. Turvey, who studied people with skeletal open bite and disturbed pronunciation of phonemes /s/ and /z/, describes his research in more detail. In his research protocol, an experienced speech therapist diagnosed participants before and after orthognathic surgery. Before the procedure, 8 out of 9 people had an abnormal articulation of these sounds. The study showed that despite the lack of exercises to improve articulation, and despite speech therapy, pronunciation improved spontaneously after surgical treatment. The longitudinal research of T. Laine et al. conducted in Finland since 1985 turned out to be a breakthrough for world speech therapy. T. Laine in her studies showed a relationship between incorrect articulation of dental sounds and the occurrence of various malocclusions. In addition, in her work, she concluded that the sound /s/ is the most susceptible to deformation and that its non-normative implementation may be caused by occlusal disorders (in vertical and horizontal planes) from both class II and III according to Angle's classification. T. Laine also pointed out in her articles that the phoneme /s/ is the most frequently distorted sound in various languages from the Indo-European group, including Polish. Hassan, in the prepared review of articles devoted to the topic of malocclusion and methods of their treatment, presented a list of 18 scientific papers, most of which had little substantive value, because it did not have a control group, and the size of the research groups was small. Most of the works concerned II and III skeletal classes.

Polish reports against this background are modest, however, it is impossible not to notice such important works as Dr. Liliana Konopska and her publication "Pronunciation of people with malocclusion" from 2007 and articles on anterior, posterior and dorsal tongue positioning in people with prognathism, Dr. Ewa Jeżewska-Krasnodębska's "Causes of articulation disorders localized to the peripheral system" 2015, and prof. Danuta Pluta – Wojciechowska's "Circumferential Dyslalia. Diagnosis and speech therapy for selected forms of disorders ", 2017.

It is also very important that speech therapy is a field addressed mainly to very young children and school youth. Dissemination of the results obtained in the presented study will facilitate the development of proper speech therapy care for patients with deformities in the facial

part of the skull. It is extremely important due to the very low availability of this care in the current health care system.

Taking the above into account, the research on the influence of malocclusion on the formation of speech defects in adults presented in this paper becomes extremely important.

Research hypothesis:

Does the surgical correction of a skeletal malocclusion improve the pronunciation of adult Poles?

Supporting questions:

1. Which type of malocclusion is most often associated with articulation disorders?

2. What is the influence of the decreased efficiency of the lips and tongue, which coexists with various malocclusion on the development of speech defects?

3. Which phonemes are most often disturbed in Poles with malocclusion?

Material and methods

The presented study was approved by the Bioethics Committee of the Medical University of Łódz under the number: RNN / 73/19 / KE. 181 patients participated in the study, 61 men and 120 women, mean age 26.4 ± 7.6, diagnosed with Angle's class II and III (4 patients with laterogenia, 117 patients with progenia, 44 patients with retrognathism, and 16 patients with skeletal open bite). The subjects were patients of the Maxillofacial Surgery Clinic of the Medical University of Łódź. All patients underwent a combined orthodontic and surgical treatment, thorough speech and pronunciation diagnosis and, if indicated, speech therapy before and after surgery. Additionally, some patients underwent the surgical correction of the frenulum of the tongue before the main procedure, which was the bilateral osteotomy of the mandibular branch and Le Fort I osteotomy of the maxilla.

For the presented studies, general inclusion and exclusion criteria have been established depending on the stage of the research, they were modified.

Tab. 1. Criteria for Part I - Effectiveness of the frenotomy procedure on the pronunciation of adult patients:

Inclusive criteria	Exclusion criteria
The degree of shortening of the frenulum of the tongue	Lack of malocclusion
Malocclusion - skeletal class II or III	Lack of active participation of the patient in the rehabilitation / diagnosis process
Age over 18	Previous procedures on the frenulum of the tongue
No previous treatments for the frenulum	Lack of consent
Good overall health	
Consent for examination	

Tab. 2. Criteria for part II - : The Logopedic Evaluation of Adult Patients after Orthognathic Surgery

Inclusive criteria	Exclusion criteria
skeletal Class II or skeletal Class III	cleft lip/palate
age between 18 and 50	alveolar process cleft
misarticulation	treatment protocol: surgical correction of dysgnathia (surgery first), followed by orthodontic treatment
patients' consent for surgery	lack of any dysgnathia
patients' consent for speech diagnosis	lack of any of patients' consent or documents
treatment protocol: orthodontic decompensation, followed by surgical correction of dysgnathia	age under 18 and above 50
speech diagnosis before and after surgery	hearing loss/disorder

Tab. 3. Criteria for part III – Speech Disorders in Dysgnathic Adult Patients in the Field of Severity of Primary Dysfunction

Inclusive criteria	Exclusion criteria
skeletal class II or skeletal class III	cleft lip/palate
age between 18 to 50 years old	alveolar process cleft
misarticulation and primary function disorders	treatment protocol: surgical correction of dysgnathia (surgery first), followed by orthodontic treatment
lack of any dysgnathia	lack of any dysgnathia
patient consent for full speech pathology examination	lack of any of patients' consent or documents
treatment protocol: orthodontic decompensation, then surgical correction of dysgnathia	age under 18 and above 50
speech diagnosis before and after the surgery	hearing loss/disorder

The first speech diagnosis was made at the time of qualification of the patient for surgical treatment, the next 3 months after the main surgery to assess the immediate changes after surgery, and the last one at 12 months after the surgery to be able to assess the stability of all

interventions. During the speech diagnosis, external and intraoral examinations were carried out, as well as a detailed articulation examination using the adapted Speech Therapy Test for Children and Adolescents by Dr. Iwona Michalak-Widera, and additionally. Moreover, the evaluation used an adaptation of the Card for Testing the Efficiency of Articulation Apparatus by Dr. Ewa Jeżewska - Krasnodębska. Using the aforementioned card, the motor efficiency of individual articulation organs (lips, tongue, including the length of the frenulum, the shape of the palate, etc.) was assessed on a scale from 0 to 3. During the extraoral examination, the following elements were assessed: the general appearance of the facial skull and the symmetry of its elements.

In the intraoral examination the type of malocclusion (based on orthodontic diagnosis), the shape of the dental arches, the position of the teeth (retrusion, protrusion of the incisors), missing teeth, crowding, the presence of diastema, and other types of gaps were inspected. The shape of the hard palate, the resting position of the tongue and lips were also assessed. In the next step, the stomatognathic system functions were examined: breathing, biting, chewing, and swallowing patterns. Additionally, in the speech diagnosis, the rate of speech and its fluency were taken into account. Patients were also asked to subjectively evaluate their physical hearing. The assessment of the motor functions of each of the articulators was assessed on a scale from 0 to 3, where 0 meant the impossible movement, and 3 the movement was performed correctly. Patients were instructed by a speech therapist how the movement should look like. During the articulation assessment of individual phonemes, the study inventory includes those that were indicated as most frequently disturbed in the international and Polish literature: / s /, / z /, / c /, / t /, / d /, / n /, / l / , / r /, / f /, / w /, / sz /, / ż /, / cz /, / dż /, / ś /, / ź /, / ć /, / dż /, / p /, / b /. Auditory and visual assessment of phonemes was used during the diagnosis. The main factor that conditioned the recognition of whether a given phoneme is normative or non-normative was the place of articulation adopted as a norm in phonetics. The articulation was assessed on a 1-5 point scale (1 - no sound, 2 - phoneme deformation, interdental realization, 3 - anterior articulation, 4 - lateral articulation, 5 - correct articulation). The classification of the articulation site was also based on 4 variants adapted from the T. Laine study as the anterior variant (articulation too close to the incisors), the interdental variant (articulation with the tongue placed flat between the dental arches), the lateral variant (articulation with the movement of the tongue to one side) and the posterior variant (articulation with the mass of the tongue retracted towards the oropharynx). Visual assessment of sounds was marked on a 0-3 point scale. Individual phonemes were analyzed in a word, where a given phoneme appeared in different vocal positions: at the beginning (onset), in the middle (mid-voice), and at the end (final). In the study of individual functions, observations were used, as well as consumption (apple pieces) and drinks (50 ml of water). Breathing was assessed both statically and dynamically throughout the study when patients were asked to perform simple exercises (10 squats), and the nasal breathing pattern was assumed to be

normative. Swallowing was assessed by checking for a proper lip seal, without excessive mental activity, with the correct position of the tongue on the transverse folds and no thrusting on the incisors. During the diagnosis of the biting function, the method of biting (with central incisors) and whether there was a shift towards the canines were examined. Normative chewing was defined as bilateral, without excessive muscular effort, with tight lips and circular movements instead of only vertical ones.

Results:

The study focused on the analysis of the influence of the short frenulum of the tongue on the pronunciation quality of individual first part in Polish, indicated as the most frequently disturbed in literature. Likewise, the likely connections between the shortening of the frenulum of the tongue were checked during the study with the ability to maintain a proper resting position, swallowing, chewing, and breathing. P values <0.05 were considered statistically significant. Two groups of sounds were tested - international phonemes and local phonemes. Fig. 1 and Fig. 2. show the distribution of results. It is noticeable that the patients, before the correction of the frenulum, articulated most of the sounds in a manner inconsistent with the standard of the Polish pronunciation. After surgical correction, the pronunciation of the sounds improved in most patients, but only the combination with the orthognathic procedure significantly improved the pronunciation.

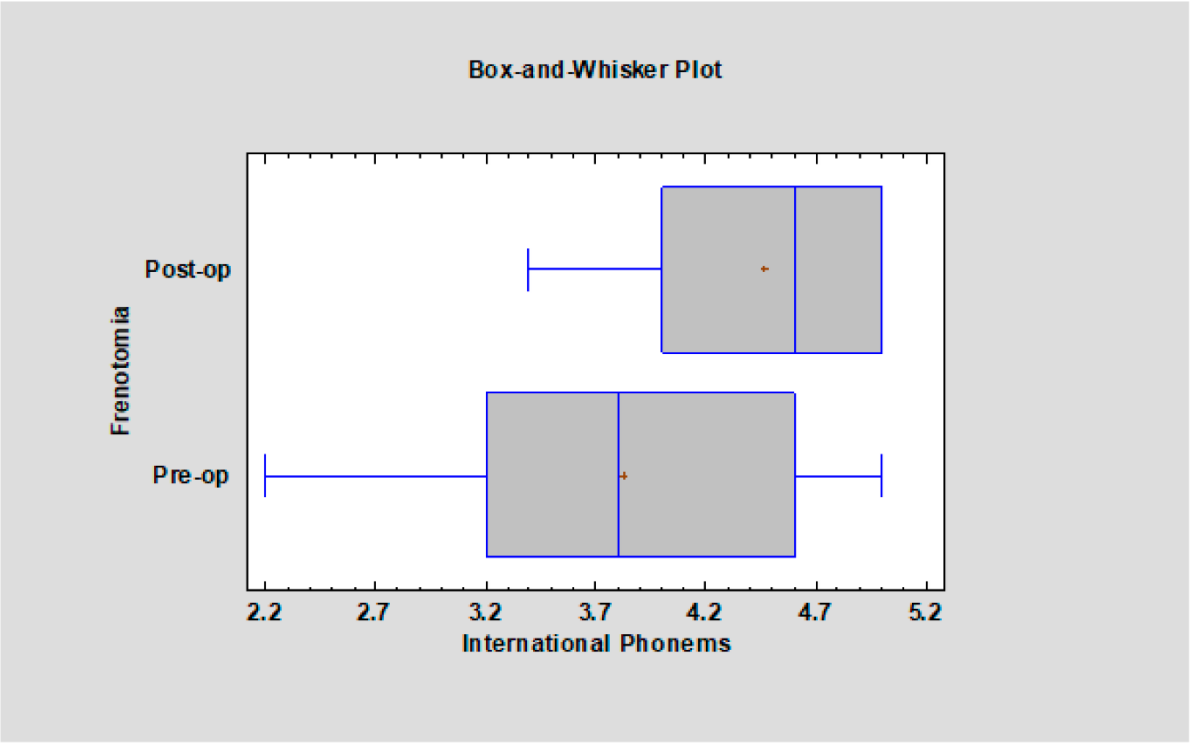

Fig. 1. Frenotomy influence on international phonemes. Kruskal-Wallis test (test-statistic = 10.28; p<0.005).

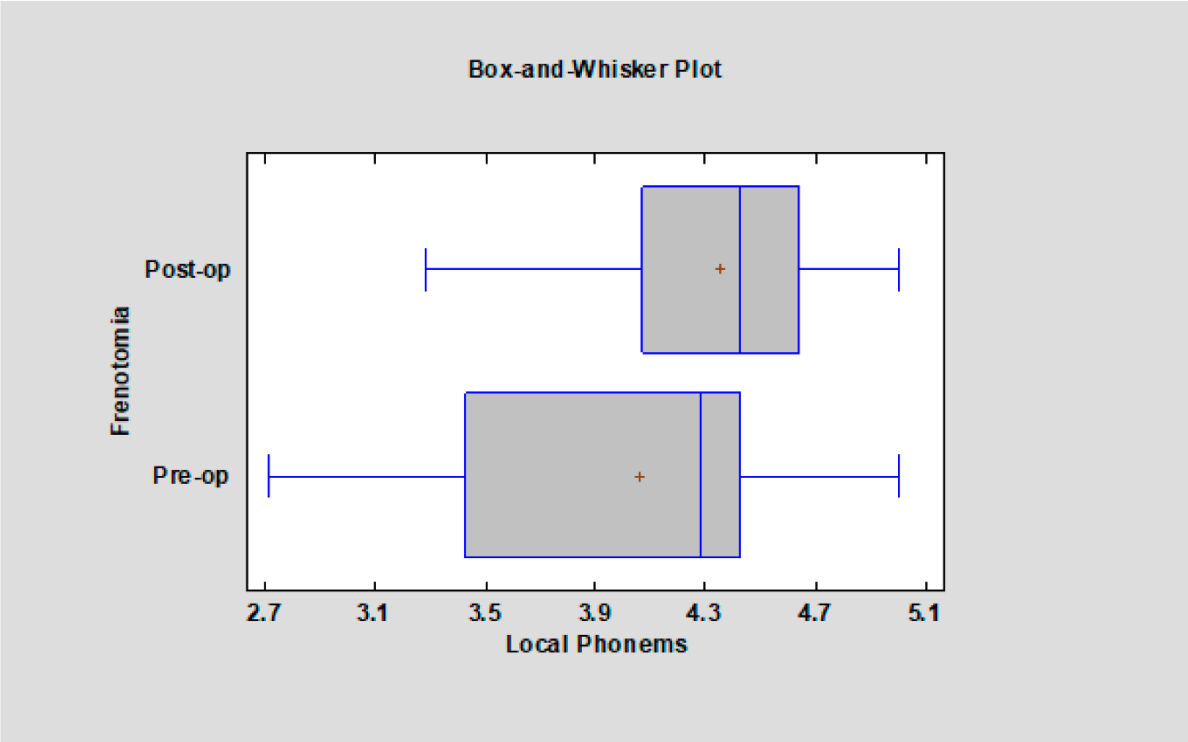

Fig. 2. Frenotomy influence on local phonemes. Kruskal–Wallis test (test statistic = 3.4; p =0.06).

In addition, the study proved that the surgical correction of the frenulum of the tongue increases the mobility of the tongue, in particular the movements necessary for the correct articulation of the indicated sounds. Statistical significance was between p <0.0001 - p <0.05 depending on the tested language movement.

The second part of the study focused on the analysis of selected aspects:

- the relationship between a skeletal malocclusion and the quality of pronunciation of sounds before and after the procedure;

- the relationship between the surgical procedure and the improvement of the pronunciation of the examined sounds;

- types of sounds that are distorted by adult Poles with a malocclusion;

The following sounds of the Polish language were examined: / s /, / z /, / c /, / dz / / t /, / d /, / n /, / l /, / r /, / f /, / w /, / sz /, / ż /, / cz /, / dż /, / ś /, / ź /, / ć /, / dż /, / p /, / b /.

In the presented study, the correct pronunciation of sounds in words was checked, taking into account different sound positions in the word. The normative sound was one in which no undesirable phonetic features were detected. The desired phonetic features are consistent with their articulation structure, with the description of the normative phoneme and its features, and are consistent both acoustically and visually. Undesirable phonetic features are those which, in the visual assessment, deviate from the norm and place of articulation, and whose sound differs from the pattern established in phonetics. This division was based on the research of Dr. Konopska, who created her classification of undesirable phonetic features. The basis of the nomenclature is the name of the articulators or places of articulation, i.e. bipolarity, laterality, and disidentalization. In addition, an undesirable feature may be additional articulation, i.e., passive or active labial activity (i.e., pronouncing / b / or / p / with central incisors on the lower lips instead of a labial closure). The pronunciation assessment included visual and acoustic observation during the pronunciation of the sounds in words and in the syllable (CV), i.e. / sa /, / so /, / se /. Fig. 3 presents a list of consonant groups according to IPA. Fig. 4 presents the word material used in the study.

Group of Consonants	Phonemes Included
Bilabial	/b/, /p/
Alveolar	/t/, /d/, /n/
Labiodental	/f/, /w/
Palatal	/sz/, /ż/, /cz/, /dż/
Palatal_PL *	/ś/, /ź/, /ć/, /dź/
Dental	/s/, /z/, /c/, /dz/

* group of specific Polish regional palatal consonants which are not represented by the International Phonetic Alphabet.

Fig. 3. Investigated phonemes were combined into groups according to their place of articulation in Polish.

Group of Consonants	Words Included in the Test with Their Word Position (Front, Middle, Final)
Bilabial *	Babcia, balon, diabeł, kubek, bęben, farby Pająk, papuga, łapa, mapa, ptak, sklep
Alveolar *	/t/, /d/ *, /n/ Tory, telefon, buty, kwiaty, samolot, płot Dywan, dym, buda, pudło, deszcz, biedronka Namiot, nuta, kolano, korona, wagon, banan
Labiodental *	/f/, /w/ Fotel, foka, ławka *, wafle, mikrofon, lew * Worek, wanna, owoce, krowa, włosy, krawat * **In ławka /w/ is pronounced as voiceless /f/ because of /k/.** **/w/ is always pronounced voiceless in the final position.**
Palatal	/sz/, /ż/, /cz/, /dż/ Szalik, szafa, wieszak, muszla, mysz, kapelusz Rzeka *, żaba *, jeże, orzech, grzyby, łyżwy Czajnik, czapka, tęcza, kaczka, klucz, mlecz Dżungla, dżem, dżokej, dżokejka, zjeżdżalnia, dżdżownica
Palatal_PL *	/ś/, /ź/, /ć/, /dź/ Siatka *, świnia, huśtawka, wiśnie, gęś, miś Ziemniaki, zima, bazie, guziki, łazienka, gałęzie Cień, ciastko, pociąg, bocian, paznokieć, niedźwiedź * Dzieci, dziupla, budzik, łabędzie, dźwig, gwoździe
Dental	/s/, /z/, /c/, /dz/ Sanki, sowa, pasek, parasol, nos, pies Zapałki, zamek, koza, wózek, znak, lizak Cukierek, cebula, taca, plecak, widelec, palec dzwon, dzbanek, rodzynki, kukurydza, pędzel, pieniądze

Fig. 4 The list of words included in the Articulation Test for Children and Adolescents.

In the study group, a significant improvement in the pronunciation of two-lipped, palatal, middle-lingual-palatal, and dentalized sounds was noticed. The gingival consonants improved ($p < 0.001$) in the postoperative group as opposed to the preoperative group. When it comes to the assessment of lab-dental consonants, the postoperative outcomes were significantly better ($p < 0.001$) than the preoperative ones. The distribution of results for individual groups of consonants is presented in Fig. 5.

Consonants	Reference Average ± SD	Pre-Operational Pre-OP Average ± SD	Post-Operational Post-OP Average ± SD	Statistical Significance Pre-OP vs. Post-OP
Bilabial	4.59 ± 0.80	4.43 ± 0.83	4.95 ± 0.33	$p < 0.01$
Alveolar	3.55 ± 0.85	4.36 ± 0.85	4.68 ± 0.54	n.s.
Labiodental	4.38 ± 1.00	4.08 ± 1.14	4.89 ± 0.31	$p < 0.001$
Palatal	3.89 ± 0.94	4.12 ± 0.90	4.69 ± 0.48	$p < 0.001$
Palatal_PL *	3.66 ± 1.03	4.22 ± 0.97	4.82 ± 0.50	$p < 0.001$
Dental	2.72 ± 0.67	3.49 ± 1.23	4.55 ± 0.69	$p < 0.001$

Fig. 5. Articulation before and after surgery divided into consonant groups according to the International Phonetic Alphabet revised to 2015.

A significant improvement is visible in the visual assessment of the consonants in question in terms of the positioning of individual articulators, i.e. lips and tongue, after a surgical procedure.

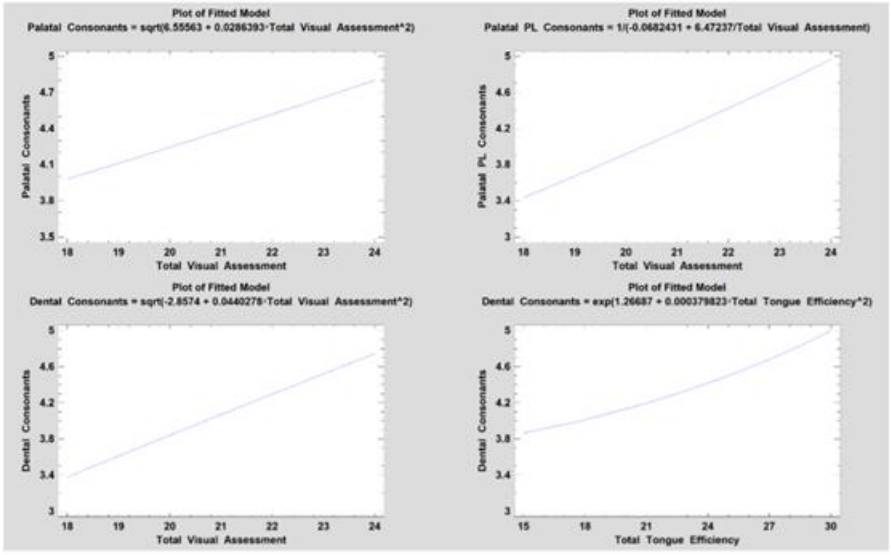

Fig. 6. Final palatal, palatal_pl, and dental consonant articulation was related to the postoperational Total Visual As assessment ($p < 0.05$). Such a relationship was also observed between dental consonants and total Tongue Efficiency assessed postoperatively ($p < 0.05$). Such a relationship was also observed between dental consonants and Total Tongue Efficiency assessed postoperatively ($p<0.05$).

In this part of the study, a new sound classification model was developed based on soft tissues or skeletal elements necessary for the articulation of a specific sound. Bilabial, alveolar, labiodental, palatal, palatal_pl and dental consonants were combined into two factors with an eigenvalue greater than 1. Together they account for 57% of the variability in the original speech therapy data obtained from the IPA groups.

Since the principal components method was chosen, the initial estimates of commonality have been established to assume that all data variability occurs due to common factors. Equations were developed to estimate common factors after matrix rotation. Matrix rotation was performed to clarify the factors. The explanations of the factors calculated in this way are skeletal consonants and soft-tissue consonants. Fig. 7 presents the components of factors. Fig. 8 presents the developed equations.

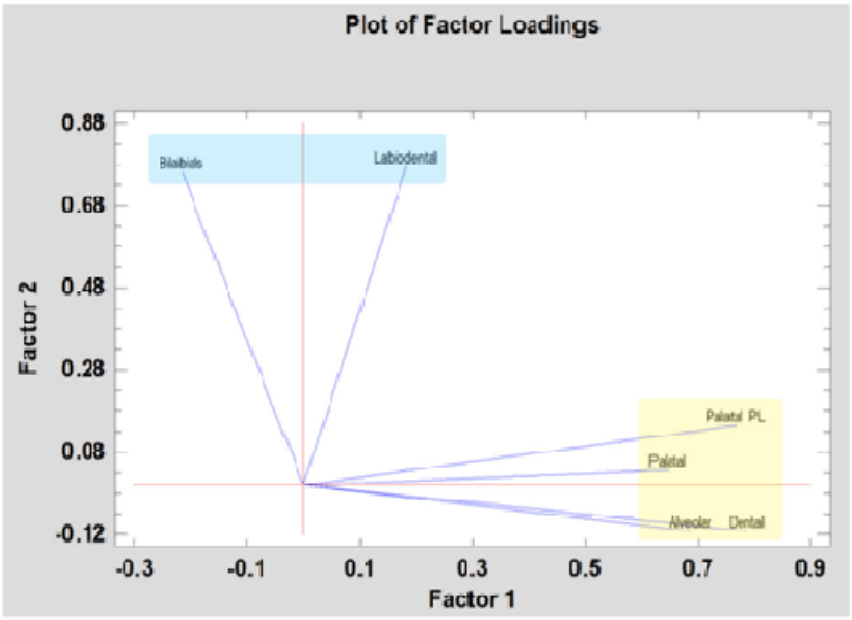

Fig. 7. Components included in the two factors that achieved an eigenvalue higher than 1 (factor analysis). Factor 1 is called Skeletal Consonants (major components highlighted in yellow), and Factor 2 is called Soft Tissue Consonants (major components highlighted in blue). The data for 88 untreated patients.

$$\text{Skeletal Consonants} = -0.216 \times \text{Bilabials} + 0.686015 \times \text{Alveolar} + 0.182536 \times \text{Labiodental} + 0.646587 \times \text{Palatal} + 0.76647 \times \text{Palatal\_PL} + 0.78603 \times \text{Dental} \quad (1)$$

$$\text{Soft Tissue Consonants} = 0.760932 \times \text{Bilabials} - 0.111715 \times \text{Alveolar} + 0.774208 \times \text{Labiodental} + 0.0366595 \times \text{Palatal} + 0.144866 \times \text{Palatal\_PL} - 0.111252 \times \text{Dental} \quad (2)$$

Fig. 8. The presentation of the equations.

Analysis of variance provided data on the relationship of skeletal consonants and soft tissue consonants with skeletal deformation (Fig. 9). It turned out that the pronunciation quality of soft-tissue consonants did not depend on the skeletal defect ($p = 0.1507$), in contrast to the class III maxillofacial deformity, where there was a significant deterioration in the pronunciation of skeletal consonants ($p < 0.01$) before the procedure. The weakest results are found in patients with mandibular prognathism (laterogenia and retrogenia).

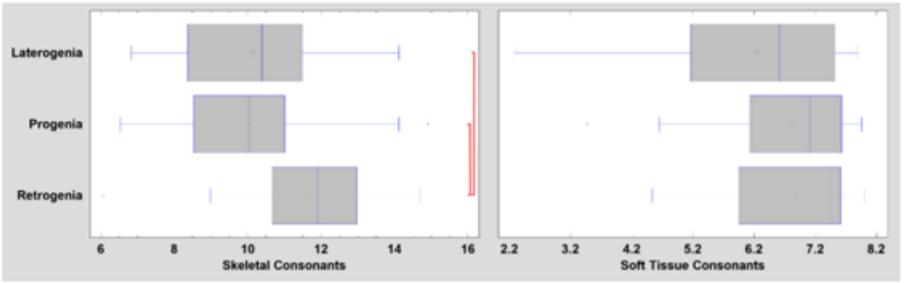

Fig. 9. Effects of skeletal deformity on Skeletal Consonants and Soft Tissue Consonants. The pronunciation quality of Skeletal Consonants in patients affected by Skeletal Class III was significantly worse than in Class II patients. Red brackets indicate groups between which there is a significant difference in the quality of consonant articulation ($p < 0.01$).

Examination of these two groups of consonants also revealed a directly proportional relationship with three other aspects of the patient's examination: total lip function ($p < 0.05$), complete language proficiency ($p < 0.01$), and complete visual assessment ($p < 0.001$) of lips and tongue.

The third part of the study focused on the analysis of the basic biological functions of the stomatognathic system: breathing, biting, chewing, and swallowing. The correct course of these functions is crucial for the development of the bite in the developmental period, as well as for the maintenance of correct bite relations later in life. The key part of the study was to conduct motor tests for lips and tongue to assess the correct or improper functioning which affects the course of individual functions or the formation of compensation in the form of excessive muscle activity. During the study, the patients were asked to drink about 50 ml of water and to eat a piece of apple to assess their biting, chewing, and swallowing functions. Respiration was monitored throughout the study.

The scale of dysfunctions in the stomatognathic system was developed by counting the number of dysfunctions from 0 to 4. The quality of pronunciation of patients with normal and incorrectly performed functions. Dig. 10 presents the distribution of individual functions and the impact of incorrectly performed functions on the pronunciation of individual voice groups.

Primary Function		Consonants							
		Bilabial	Alveolar	Labiodental	Palatal	Palatal_PL	Dental	Skeletal	Soft Tissue
Breathing	Cor	4.59 ± 0.83	4.27 ± 0.86	4.68 ± 0.73	4.65 ± 0.60	4.61 ± 0.72	3.75 ± 1.09	12.29 ± 1.92	7.06 ± 0.94
	Inc	4.68 ± 0.71	3.95 ± 0.96 *	4.43 ± 0.97	4.15 ± 0.96 *	4.12 ± 1.07 *	3.21 ± 1.20 *	10.87 ± 2.47 *	6.94 ± 1.07
Swallowing	Cor	4.51 ± 0.82	4.41 ± 0.85	4.61 ± 0.77	4.46 ± 0.82	4.60 ± 0.77	3.79 ± 1.20	12.28 ± 2.07	6.92 ± 0.98
	Inc	4.75 ± 0.69 #	3.81 ± 0.91 *	4.46 ± 0.98	4.27 ± 0.89	4.08 ± 1.06 *	3.13 ± 1.08 *	10.75 ± 2.38 *	7.05 ± 1.05
Chewing	Cor	4.84 ± 0.54	4.20 ± 0.88	4.72 ± 0.71	4.52 ± 0.73	4.55 ± 0.74	3.62 ± 1.12	11.96 ± 2.02	7.29 ± 0.71
	Inc	4.50 ± 0.86 *	4.00 ± 0.97	4.39 ± 0.98	4.23 ± 0.93	4.14 ± 1.09 *	3.28 ± 1.21 *	11.06 ± 2.54 *	6.76 ± 1.15 *
Biting	Cor	4.85 ± 0.36	4.31 ± 0.88	4.74 ± 0.69	4.56 ± 0.74	4.65 ± 0.62	3.73 ± 1.20	12.21 ± 1.98	7.30 ± 0.68
	Inc	4.56 ± 0.86	3.98 ± 0.95	4.44 ± 0.95 *	4.27 ± 0.90	4.18 ± 1.06 *	3.30 ± 1.16 *	11.11 ± 2.45 *	6.85 ± 1.11

Abbreviations: Cor—Correct; Inc—Incorrect; * statistically significant worsening of speech in the group with incorrect primary function versus correct group ($p < 0.05$); # inverse significant difference ($p < 0.05$).

Fig. 10 Articulation outcome of consonants in dysgnathic patients with correct versus incorrect primary function.

The disturbance of the basic biological functions of the stomatognathic system is associated with a statistically significant deterioration in the pronunciation of the examined sounds. In each group of tested sounds, at least one incorrectly performed biological function was observed. The results indicate that malocclusion (examined in 21 selected categories) was statistically related to the quality of articulation of skeletal consonants ($p < 0.01$), palatal ($p < 0.05$), and dental consonants ($p < 0.05$). Such a relationship was not found in the case of soft-tissue consonants: double-lip, lab-dental, and middle-lingual palatine consonants. Similarly, no relationship was found between malocclusion (as defined above) and the disturbance of biological functions ($p = 0.0516$). Disruption of individual biological functions was associated with a variety of factors: improper

breathing was associated with abnormal complete function of the lips and decreased overall language proficiency. However, no direct relationships were found with the type of malocclusion. Disturbed swallowing was most often associated with an anatomical defect in the form of a highly arched or gothic palate. In addition, it has been observed that in patients who do not properly perform the swallowing function, the total visual score for lips and tongue was lower. Abnormal chewing and biting were most common in patients with reduced overall function of the lips and tongue, additionally with a very low overall visual assessment. In these patients, the most common symptoms were chewing on one side, abnormal positioning of the lips (open lips), and decreased motor skills of the tongue. In terms of biting off, compensation in the form of tearing off the bite was observed, most often with the canines or the first premolars. In terms of respiration, the oral respiratory tract was mainly observed, which was related to the reduced overall efficiency of the lips (lack of the so-called lip seal) and an incorrect resting position of the tongue. It was also observed that in skeleton class III the number of improperly performed biological functions was increasing.

Conclusions:

The shortening of the frenulum of the tongue is a serious limitation, especially in adult patients, as it permanently affects the articulation changes. Implementation of surgical procedures for treatment improves the mobility of the tongue in the directions necessary for correct pronunciation and positively influences its expressiveness. Ankyloglossia causes dental, orthodontic, and speech therapy problems. Surgical correction of the frenulum of the tongue carried out in adults perfectly supports the treatment and therapy of the above-mentioned problems, as well as has a preventive effect and reduces the risk of recurrence of a bite defect associated with an incorrect resting position of the tongue. In addition, it helps in improving basic functions such as food intake, chewing, and swallowing. Effective surgical correction of the frenulum of the tongue and speech therapy has a positive effect on the quality of life of patients. Surgical correction of the frenulum of the tongue should be performed in patients with malocclusion, as there is often an imbalance of all the muscles of the face and skeleton, which may lead to less functionally stable effects of orthodontic and orthognathic treatment.

One of the most critical risk factors for incorrect articulation concerning the sounds of the Polish language is malocclusion, causing changes in the position of the tongue and lips and their activities. In addition, bite deformities affect the biological functions of the stomatognathic system, such as breathing, swallowing, and chewing, which are inherent elements for the normative articulation of sounds Interdisciplinarity of speech pathology and its effectiveness in the treatment of the adult population, it requires the cooperation of a speech therapist with a maxillofacial surgeon, orthodontist, and even a physiotherapist. Such activities can eliminate

articulation abnormalities and change the movement patterns into normative with the use of myofunctional therapy. In the above study, it was found that class II and III bone defects are similarly subject to speech therapy in adults (as part of multimodal treatment). However, it was pointed out that some malocclusions better respond to the implemented speech therapy, this mainly applies to defects not complicated by additional occlusal disorders that affect the quality of pronunciation of sounds. It is only thanks to teamwork combined with the will of the patient that the goal of normative articulation can be achieved. Orthodontic preparation combined with surgical correction of malocclusion is often the only effective solution that helps to improve the articulation.

In the case of Polish sounds, other significant risk factors are incorrect implementation of biological functions and their intensity. They cause changes in the position of the mandible tongue and lips. The biological functions of the stomatognathic system are fundamental for the articulations mentioned in the study of sounds.

The entire study confirmed the hypothesis that the surgical correction of malocclusion is invaluable and improves not only the pronunciation, but also the functions of the stomatognathic system, facial aesthetics, and the overall quality of life of patients. The subject of the coexistence of malocclusion and any disorders of biological functions and articulation disorders should be subject to constant analysis. Thanks to statistical calculations, it was possible to develop models for the rapid assessment of the occurrence of functional disorders and the possibility of combining them with articulation assessment.

Moreover, it is extremely important to educate patients on the impact of dysfunction of the stomatognathic system on their future treatment outcome. If patients are aware of how they can control their stomatognathic functions - thanks to the knowledge of orthognathic and myofunctional speech therapy - they will be able to partially independently support effective treatment or therapy.