Chapter

Clinical and Phonetic Features of Dentognathic Deformations, Their Orthodontic Treatment

Alona Melnyk and Valerii Filonenko

Abstract

The substantiation of the current task of modern dentistry is presented, which consists of increasing the effectiveness of the treatment of dentognathic deformations accompanied by phonetic disorders through a multidisciplinary approach to the development and application of a complex of diagnostic and therapeutic measures based on the determined and clarified etiopathogenetic connections of dentognathic deformations with phonetic disorders, and causal mechanisms of the development of dentognathic deformations in cleft lip and palate and the importance of anatomic and morphometric characteristics of the tongue as a prognostic indicator of an effective orthodontic treatment as well are substantiated.

Keywords: dentognathic deformations, phonetic disorders, cleft lip and palate, multidisciplinary approach, orthodontic treatment

1. Introduction

Statistical data given in scientific sources testify to the high level of prevalence of dentognathic pathologies in Ukraine and the tendency of its growth [1–5]. According to the authors' research, it reaches more than 80% [6–8]. During the examination of 462 children aged 6–12 years in schools of Kyiv, anomalies and deformations of the dentognathic apparatus were found in 385 subjects, which is 83.3%. Distal bite is the most common pathology of the dentognathic apparatus, found in 58.2% (n = 224). Distal deep bite was 26.2% (n = 101), mesial bite—10.1% (n = 39), open bite—4.7% (n = 18), and transverse bite—0.8% (n = 3) [8].

The majority of dentognathic deformations are accompanied by phonetic disorders. They are caused by changes in the dentognathic relations of indicators of the functional activity of the masticatory muscles, circular muscle of the mouth, lips, tongue, and ear, nose, throat (ENT) organs [8–13]. Out of 385 people with dentognathic deformities, speech disorders were identified in 306 people, which was 66.2%. Out of 77 people with no orthodontic pathology, only 16.7% had speech disorders. Phonetic disorders combined with bite pathologies were found in 96.1% (n = 294), of which 52.0% (n = 153) had a distal bite, 31.3% (n = 92)—distal deep bite, mesial—10.9% (n = 32), and open—5.8% (n = 17) [8].

The outlined factors are in a close cause-and-effect relationship; therefore, they require a simultaneous complex approach in solving the problem of treatment of patients with dentognathic deformities accompanied by speech disorders.

Today, new methods of orthodontic treatment have been developed for this category of patients using various types of myogymnastics and taping, as well as a program-methodical complex of corrective speech therapy work using innovative and original technologies [9, 12, 14, 15].

The use of well-known methods of orthodontic treatment without directed logopedic correction reduces the effectiveness of rehabilitation of patients with dentognathic deformations accompanied by phonetic disorders. Attention should be paid to the study of the relationship between inflammatory diseases of the nasopharyngeal and palatine tonsils, narrowing of the upper respiratory tract with dentognathic deformations accompanied by phonetic disorders, the state of functional activity of the temporal muscles, circular muscle of the mouth depending on the types of deformations and phonetic changes. Attempts to normalize the bite without logopedic correction and functional reconstruction complicate orthodontic treatment and make it impossible to achieve a stable result [16, 17].

When carrying out a complex medical and rehabilitation measures in children with congenital cleft lip and palate, it is important to study the conditions of development of the dentognathic apparatus. According to statistical data, more than 500 children with various types of cleft lip and palate and syndromes are born in Ukraine per year, in which almost 94% of cases have combined dentognathic deformations of varying severity in the sagittal, transverse, and vertical directions (**Figure 1**) [18, 19].

In order to increase the effectiveness of the complex treatment of children with cleft lip and palate, it is advisable to justify pathogenetically directed personalized orthodontic therapy based on the definition of medical and social predictors, a set of diagnostic criteria, experimental modeling of the stressed-deformed state of the tissues of the upper jaw, and its clinical and morphometric characteristics.

The tongue is a powerful muscular factor influencing the development of the dentognathic apparatus. In maintaining myodynamic balance, an important role is played by the functional state of the tongue muscles, which depends on its anatomical features, namely its shape, size, position, and hyper- or hypotonus. Anatomical and topographic features of the tongue are important when choosing the tactics of orthodontic treatment and corrective speech therapy work in children with deformities of the dentognathic apparatus [18, 20].

Figure 1.
Combined dentognathic deformity with unilateral cleft lip and palate.

DOI: http://dx.doi.org/10.5772/intechopen.109636

Children with cleft lip and palate and violations of the anatomical and topographical parameters of the tongue have complex mechanisms of speech disorders, and the severity of violations of the phonetic component of speech varies from the damage of one group of sounds to their total violation.

In view of the aforesaid, there is a need for an in-depth study of the relationship between speech function disorders and deformations of the dentognathic apparatus, the development of modern preventive, diagnostic and therapeutic measures based on a multidisciplinary approach to overcome the identified problems, and in order to increase the effectiveness of orthodontic treatment—the development and justification of a complex diagnostic and therapeutic measures based on a multidisciplinary approach.

2. Clinical and laboratory research and principles of complex treatment of dentognathic deformations, and its results in accordance with the proposed complex of diagnostic and therapeutic measures

In order to study the influence of the state of the ENT organs on the formation of maxillofacial deformities and phonetic disorders, 155 children aged 6–12 years were subjected to rhinoscopy, pharyngoscopy, otoscopy, tonal and speech audiometry, tympanometry, and cone-beam computed tomography. Out of 155 subjects, 82 had dentognatic deformities accompanied by phonetic disorders, 73 subjects had phonetic disorders, orthodontic pathology was not observed [21].

Among 82 children with deformities of the dentognathic apparatus accompanied by phonetic disorders, hypertrophy of the nasopharyngeal tonsils (adenoid vegetations) of the I degree was diagnosed in 51.2% (n = 42), the II degree in 30.5% (n = 25), and the III degree—in 18.3% (n = 15). Among 73 children without orthodontic pathology with speech disorders, adenoid enlargement of the I degree was diagnosed in 43.8% (n = 32), the II degree (n = 15)—20.5%, and III degree (n = 2)—2.7%. An increase in the size of nasopharyngeal tonsils was not detected in 32.9% (n = 24) without orthodontic pathology.

Adenoid growths of the I degree in children with existing orthodontic pathology are observed 1.2 times more often than in children without orthodontic pathology, the II degree—1.5 times, and the III degree—6.8 times, respectively. Children without abnormalities in the size of the nasopharyngeal tonsils were not observed among people with deformities of the dentognathic apparatus.

During a pharyngoscopy to determine the size and condition of the palatine tonsils in 82 children with anomalies and deformations of the dentognathic apparatus, accompanied by phonetic disorders, hypertrophy of the I degree was diagnosed in 42.7% (n = 35), the II degree in 32.9% (n = 27), and the III degree—in 24.4% (n = 20). A different degree of hypertrophy of the palatine tonsils was detected in all subjects with deformities of the dentognathic apparatus. Among 73 children without orthodontic pathology with speech disorders, an increase in palatine tonsils of the I degree was determined in 38.4% (n = 28), the II degree—in 16.4% (n = 12), and the III degree—in 6.8% (n = 5). Disturbances in the size of palatine tonsils were not detected in 38.4% of children (n = 28) without orthodontic pathology.

Analysis of the state of the palatine tonsils indicates that hypertrophy of the I degree in children with existing orthodontic pathology is observed 1.1 times more often than in children without orthodontic pathology, the II degree—2 times, respectively, and the III degree—3.6 times.

The obtained data proved the presence of interrelationship of dentognathic deformations with inflammatory diseases of the ENT organs, which lead to changes in the volume of the upper respiratory tract, articulation zones, speech breathing and cause disorders of sound and speech.

Otoscopy of 155 children showed that their tympanic membranes are gray in color with a shiny shade, not retracted, mobile. The average thresholds of tonal hearing during tonal audiometry in the audiometer range of 125–8000 Hz ranged from 0 to 10dB. Suprathreshold tests corresponded to physiological values (Luscher test—1.5–2.0 dB, SiSi test—0%). In total, 50% legibility of air and bone conduction numerators was achieved at a sound pressure level of 15 dB and 100% legibility of the air conduction speech test at a sound test level of 30 dB. Therefore, according to the data of tonal and speech audiometry, no hearing disorders were detected, and speech tests proved normal hearing perception of speech in the subjects.

According to impedance measurements, 81.29% (n = 126) had a tympanogram of type “A” according to the Jerger classification, which indicates normal function of the auditory tube and auditory nerve. In 18.71% (n = 29), a tympanogram of type “C” was found, which indicates a violation of the function of the auditory tube with the occurrence of negative pressure in the middle ear cavity. Identified minor disorders of the condition of the middle ear did not significantly affect the hearing function. Compliance values ranged from 0.71 to 1.11 cm^3 (with an average statistical value of 0.77±0.12 cm^3), and intratympanic pressure ranged from −35 to +25 dRa. At a sound pressure level of 95 dB, ipsilateral and contralateral acoustic reflexes were recorded in all subjects [21, 22].

After an otolaryngological examination in order to study the influence of the state of the ENT organs on the formation of dentognathic deformations and, if necessary, after conservative and/or surgical treatment (adenoiditis, tonsillitis, etc.), 82 patients aged 6–12 with dentognatic deformations and phonetic disorders were given a detailed clinical dental orthodontic examination according to the generally accepted scheme with the usage of objective and additional research methods [22–24].

Anthropometric measurements were carried out using the 3Shape Viewer computer program on scanned models of the jaws of 82 patients with the determination of the length of the front part of the tooth rows before and after treatment by the method of M. Mirgazizov (n = 328), the transverse dimensions of the tooth rows using the Moorrees method before treatment in all 82 people (n = 164), after—in 71 (n = 142), because 11 lost temporary canines as a result of physiological changes in the teeth [25–27].

Out of 82 patients with dentognatic deformities, with the consent of the parents and on the condition that there were no general contraindications, cephalometric study was performed in 45 patients, and cone-beam computed tomography in 30 patients before and after orthodontic treatment.

A cephalometric study was carried out on 45 patients (n = 90) by the method of A. Schwarz using the computer program RadiocefStudio2, and superimposition of cephalometric images before and after orthodontic treatment was carried out according to the structural landmarks of the supraorbital plane Cl-RO and Se [26].

Cone-beam computed tomography of the skull of 30 patients was performed to determine the volume of the respiratory tract (paranasal sinuses) before and after treatment (n = 60) using a Gendex by iCAT CB-500 tomograph. A systematic analysis of changes in the respiratory tract was carried out by comparing tomograms before and after complex treatment, and the obtained data were processed in the graphic dental program SIMPlant (Materialise Software, Belgium) with the construction of multiplanar, panoramic, and 3D reconstructions.

The functional state of the group of muscles, the activity of which suffers the most due to certain orthodontic pathology, was determined by the method of total (surface) electromyography using the eight-channel electromyograph "BioEMG III" of the company "BioResearch Inc." (USA). Electromyograms of the surface part of the proper masticatory, anterior bundles of the temporal, sternoclavicular-mastoid, and anterior bellies of the biventricular muscles and the circular muscle of the mouth of 44 patients before and after treatment (n = 440) were studied and analyzed. The state of physiological rest, volitional contraction, and swallowing were subject to analysis [22, 28].

Diagnosis of the phonological aspect of speech was carried out in 155 patients, which were mentioned before, with phonetic disorders. The indicators of sound speech, the ratio of the most frequently detected distortions of sounds, and the average number of sound speech violations per child were determined [23, 24].

The 82 patients (38 patients with distal deep, 16—with distal, 18—with open, and 10—with mesial bites) were subjected to orthodontic treatment using removable and fixed orthodontic appliances for 10–12 months followed by a retention period [22].

Mechanically active elements in Schwarz', Andresen-Haupl's and Flis PS.–Filonenko VV. appliances (Patent of Ukraine for the utility model "Orthodontic appliance by Flis PS.–Filonenko VV. for the treatment of an open bite" No. 69548 A61C7/00 dated 04.25.12) (**Figure 2**) were used for narrowing of tooth rows, inclined or biting planes in Schwartz appliances on the upper jaw—in the treatment of distal and distal deep bites, occlusal linings in Bruckl's-Reeykhenbach appliances depending on the degree of reverse incisor overlap—mesial bite, Flis PS.–Filonenko VV. appliances—open bite. Marco Ross-fixed appliances (**Figure 3**) were used for narrowing of the upper tooth row, lack of space for upper incisors, correction of malocclusion associated with narrowing of the upper dental arch against the background of difficult nasal breathing [22, 29].

Removable orthodontic appliances were recommended to be used freely for the first one or two days, after the adaptation period—necessarily during sleeping and all free time, with the exception of periods of staying at school, eating, and practicing sports. The total time of usage during the day should have been at least 14–16 hours [29].

Figure 2.
Orthodontic appliance by Flis PS.–Filonenko VV. for the treatment of an open bite.

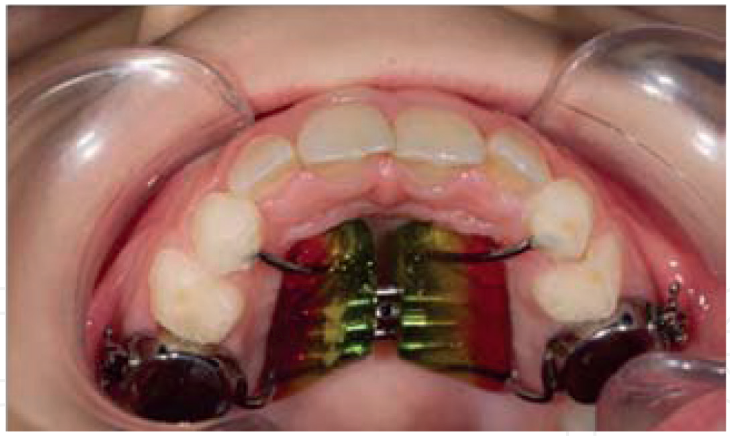

Figure 3.
Marco Ross appliance in the oral cavity.

Figure 4.
Appliance for elimination and prevention of harmful tongue habits and training the muscle structures of the articulating apparatus.

In accordance with the proposed complex of diagnostic and therapeutic measures, the speech therapist carried out individual corrective work to overcome phonological disorders of speech, studied the semiotic component of speech, conducted speech therapy research methods (psychological-pedagogical—analysis of the child's speech therapy examination cards, observations, conversations with children and parents; neuropsychological—tests to determine the level of formation of oral kinetic and kinesthetic praxes; tests to determine the state of sound speech formation).

Children without orthodontic pathology were prescribed 10 classes of logopedic correction three times a week, with deformations of the dentognathic apparatus and speech disorders—2–3 courses of 10 classes with breaks of 1–2 months. In 12 cases, standard vestibular plates of Dr. Hinz—MUPPY-P with a bead were used in addition to speech therapy classes, in eight cases—removable appliances with a bead, in nine cases—fixed Bluegrass appliances, in six cases—appliances for eliminating and preventing harmful tongue habits and training the muscle structures of the articulating apparatus (Patent of Ukraine for the utility model "Appliance for elimination and prevention of harmful tongue habits" No. 126393 A61C7/00 dated 11.06.18) (**Figure 4**) [22, 30].

We offered a set of diagnostic and treatment measures for patients with dentognathic deformities accompanied by phonetic disorders, which consists of motivational, diagnostic, and treatment blocks [22, 25].

The motivational block envisages the formation of a positive result of orthodontic and speech therapy treatment; creating an atmosphere of emotional comfort among the orthodontist, the speech therapist, the child and his/her parents; formation of personally oriented treatment and corrective training.

The diagnostic block provides for the establishment of the type of dentognathic deformations based on clinical examination, anthropometry, electromyography, cephalometry, cone-beam computed tomography; determination of the state of formation of the phonetic side of speech using neuropsychological and speech therapy tests; examination of the state of the ENT organs by the methods of rhinoscopy, pharyngoscopy, otoscopy, tonal and speech audiometry, tympanometry, cone-beam computed tomography, and impedance measurement.

The treatment block included orthodontic treatment with the usage of removable and non-removable orthodontic appliances depending on the type of deformities, the age of the patient, the degree of formation of the dentognathic apparatus, etiology; phonetic correction with mandatory (orofacial gymnastics, formation of speech breathing) and correction-oriented (setting automation and differentiation of sounds) tasks; otolaryngological conservative and/or surgical treatment of adenoids and tonsillitis; control of the level of oral hygiene, therapeutic treatment of diseases of the hard tissues of the teeth, inflammatory processes of periodontal tissues, and the mucous membrane of the oral cavity. This made it possible to carry out complex multi-vector treatment of dentognathic deformations accompanied by phonetic disorders.

The criteria for evaluating the effectiveness of complex treatment of children with dentognathic deformities accompanied by phonetic disorders were based on the results of additional diagnostic methods, namely anthropometric, electromyographic, radiographic, and speech therapy.

After the orthodontic treatment, the results of the anthropometric measurements of the scanned models of the jaws according to the method of M. Mirgazizov and Moorrees showed a change in the dimensions of the tooth rows. A statistically significant decrease in the length of the front part of the upper tooth row was noted in the treatment of patients with a distal bite by 2.51±1.39 mm, with distal deep bite by 1.06±1.05 mm, in the treatment of a mesial bite, a decrease in the lower one by 1, 72±1.79 mm and an increase of the upper one by 3.43±1.36 mm; expansion in the area of canines on the upper jaw of patients with a distal occlusion by 3.32±1.03 mm; and a distal deep bite by 2.59±1.04 mm compared with the initial clinical picture.

Analysis of cephalograms using the A. Schwarz technique confirms positive changes after the treatment. The most informative improvements are related to the placement of the apical base of the lower jaw in relation to the base of the skull in the sagittal direction in the treatment of distal and distal deep bites (angle SeNB), the vertical position of the jaws in the treatment of open bite (angle B). The inclination of the axes of the teeth (angle 1SpP, angle 1MP) relative to the planes of the base of the jaws improved (**Figure 5**).

The narrowing of the upper jaw leads to forced retention of the tongue in the lower position, which interferes with its function and leads to speech defects.

The expansion of the upper jaw leads to the expansion of the bottom of the nasal cavity, which results in the expansion of the respiratory tract at all levels, which in turn causes an increase in the flow of air inhaled through the nose.

With the help of cone-beam computed tomography, it was objectively proven that the volume of the upper respiratory tract increased by 53.80±4.21% in patients from 11.82±2.06 ml to 18.01±3.84 ml after expansion of the upper jaw at the alveolar level, which are shown on figures (**Figures 6** and **7**). These leads to a change in the position

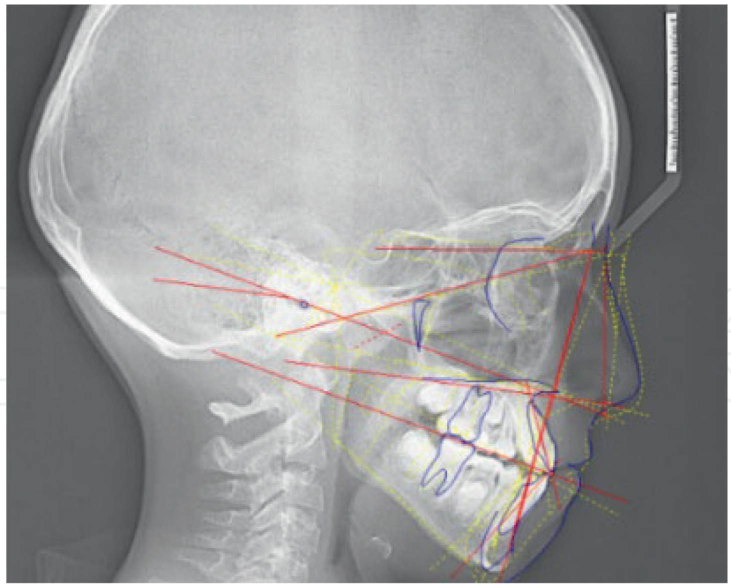

Figure 5.
Superimposition of cephalograms with an open bite before and after treatment.

of the tongue with its dislocation to the hard palate, which improves the results of orthodontic treatment and correction of speech. 3D reconstruction of the upper respiratory tract and superimposition of volumes before and after treatment were shown on figures (**Figures 8** and **9**).

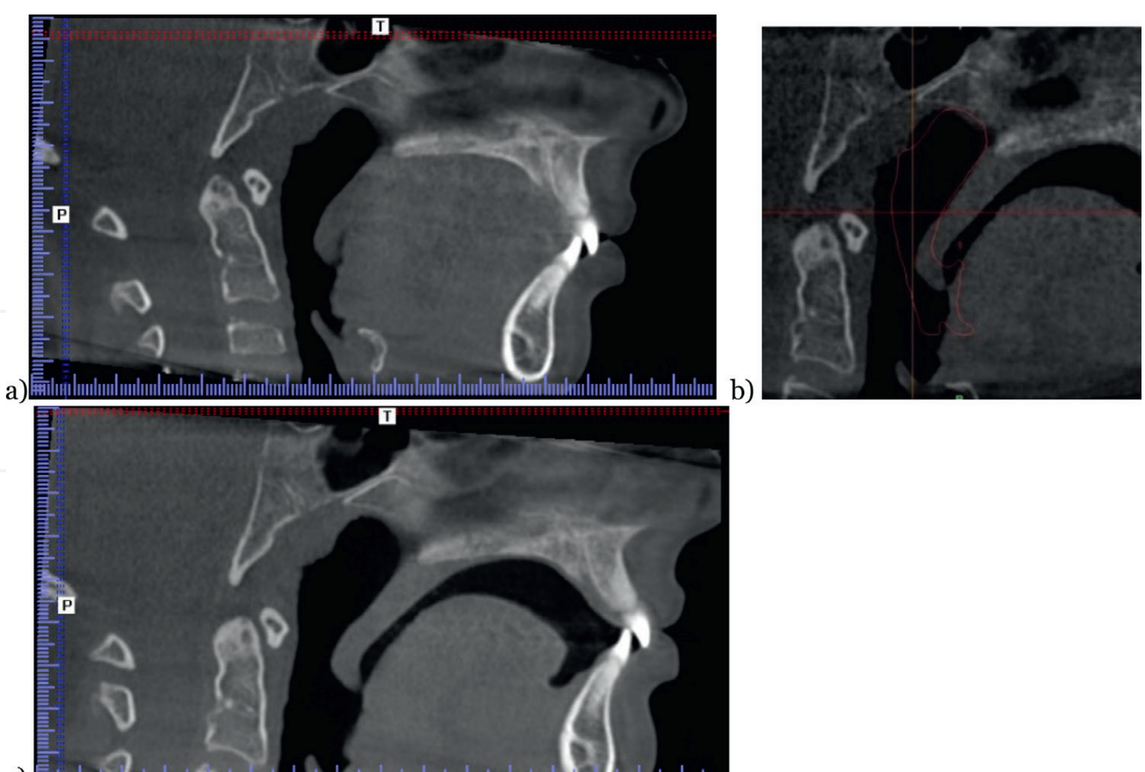

Figure 6.
Analysis respiratory tract, coronary section. Before treatment (a), after treatment (b), superimposition of pre-treatment airway profile on cone-beam computed tomography of post-treatment image (c) shows an increase in airway volume in the anteroposterior direction and in length.

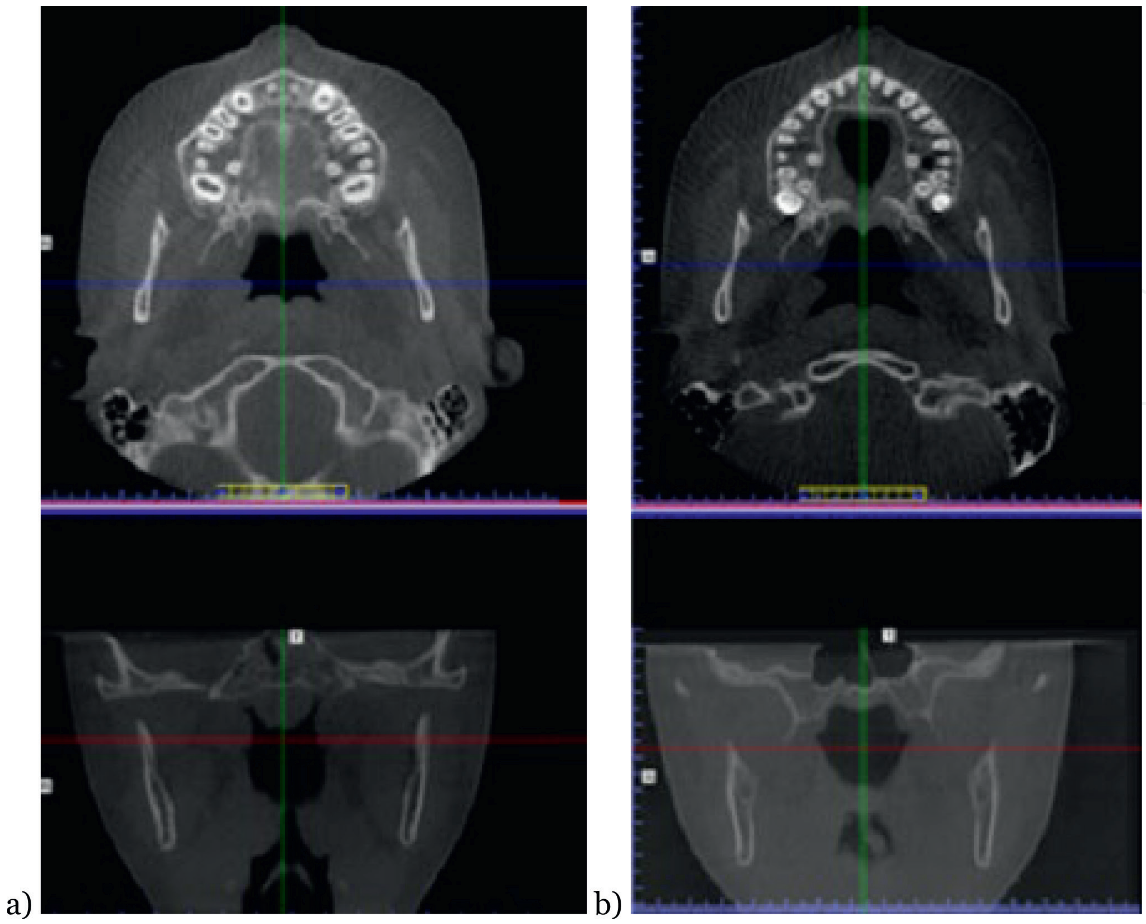

Figure 7.
Images of axial and frontal sections from the cone-beam computed tomography data before the start of treatment (a) and after treatment (b), demonstrating an increase in the area of the respiratory tract.

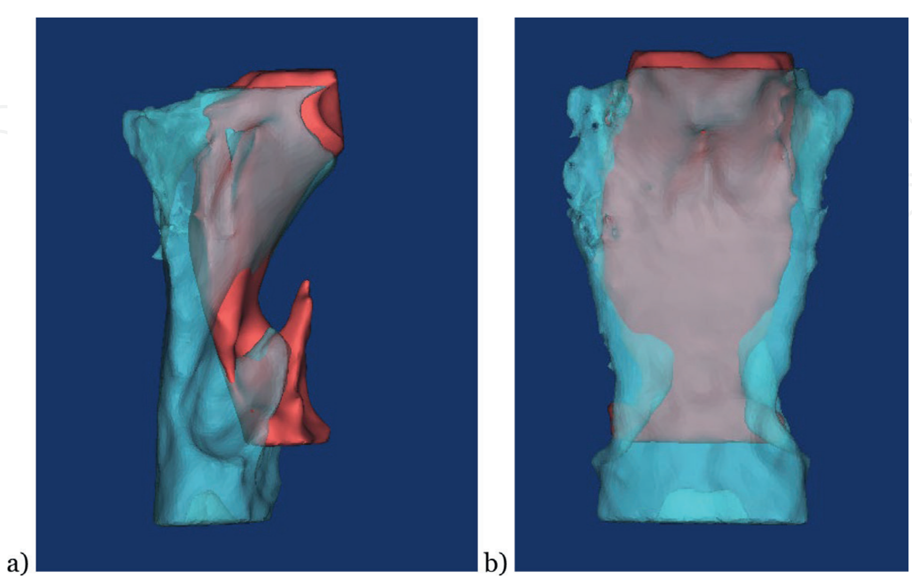

Figure 8.
3D reconstruction of the upper respiratory tract and superimposition of volumes (before the start of treatment—volume reconstruction in red, after treatment—in blue; side view (a), front view (b).

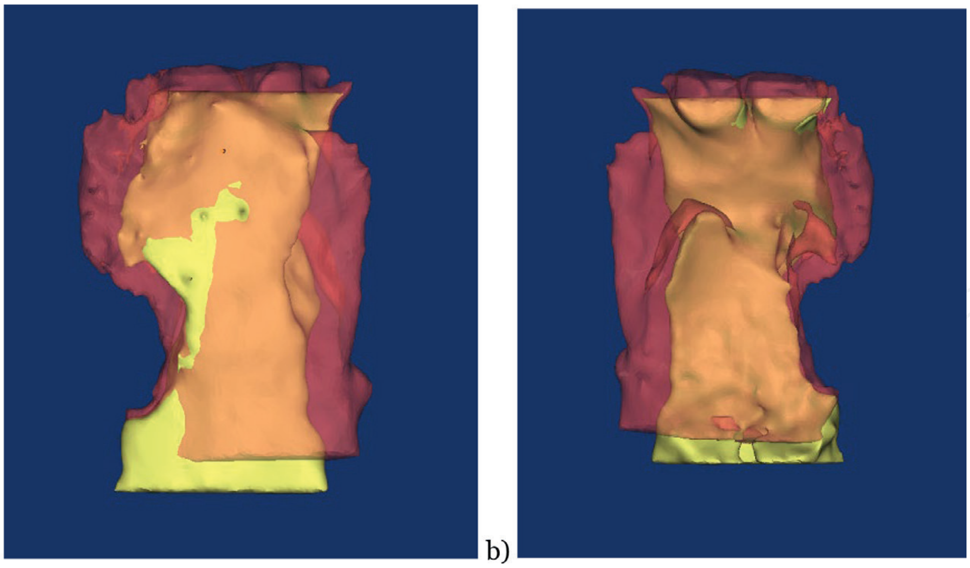

Figure 9.
3D reconstruction of the upper respiratory tract and superimposition of volumes (before the start of treatment—volume reconstruction in red, after treatment—in yellow; side view (a), front view (b).

Changes in indicators of biopotentials of muscular structures of the articulating apparatus depending on the forms of dentognathic deformations, accompanied by phonetic disorders, testify to their correlation. The results of the electromyographic analysis of the state of the surface parts of the proper masticatory, anterior bundles of the temporal muscles, sternoclavicular-mammoid, anterior belly of the biventricular muscles, and the circular muscle of the mouth before orthodontic treatment indicate the group of muscles with the biggest functional impairment according to established orthodontic pathology and direct the work of the orthodontist and speech therapist to restore the neuromuscular balance of this particular group.

In patients with a mesial bite prior to orthodontic treatment, an increase in the bioelectric activity of the anterior temporal bundles (7.81±2.07 mV) and the proper masticatory muscles (2.29±1.03 mV) at rest and a significant decrease in the contractile activity of the latter during volitional compression (19.94±7.37 mV) were recorded; with an open bite—the amplitude of the biopotentials of the upper part of the circular muscle of the mouth is reduced at rest (3.21±1.07 mV) and during volitional compression as well (9.25±2.38 mV), an increase in the bioelectric activity of the anterior bundles of the temporal muscles at rest (4.62±1.13 mV); with distal and distal deep bites—the amplitude of biopotentials of the upper part of the circular muscle of the mouth at rest is the highest (5.24±1.17 mV and 5.04±2.01 mV, respectively).

After orthodontic treatment at the same time as logopedic correction, changes in electromyogram indicators were detected, which proved an improvement in the functional state of muscles and the effectiveness of the treatment by an average of 2.5 times. Patients with a mesial bite at rest had a decrease in the bioelectric activity of the anterior bundles of the temporalis (2.11±0.97 mV) and the masticatory muscles (1.32±0.78 mV), an increase in their contractile activity during volitional compression (44.48±6.33 mV) as well; with an open bite—increase in the amplitude of the biopotentials of the upper part of the circular muscle of the mouth during volitional compression (12.84±3.51 mV) and decrease in the bioelectric activity of the anterior bundles of the temporal muscles at rest (0.87±0.22 mV); with distal and distal deep bites—a decrease in the amplitude of biopotentials of the upper part of the circular muscle of the mouth at rest (3.22±1.37 mV and 2.76±1.02 mV, respectively).

Diagnostic screening of speech disorders was carried out and their dependence on dentognathic deformations was established. The average number of violations of the pronunciation of whistling sounds per child is the highest in mesial bite at the age of 6–8 years—2.4 and in open bite at the age of 9–12 years—2.0, and sonorous sounds in the distal and distal deep bites at the age of 6–8 years old—1.7, at the age of 9–12 years—1.1. The ratio of sonorous to whistling speech disorders in mesial bite at the age of 6–8 years is 6.0, in open bite—4.7, at the age of 9–12 years, 4.5 and 3.0, respectively. The lowest average number of sibilant sound-speech disorders was determined at the age of 6–8 years—0.4, at the age of 9–12 years—0.6 per child with all bite pathologies.

Staged work was carried out to overcome phonetic disorders of speech, which contributed to the normalization of the sound pronunciation of whistling, and sonorous and hissing sounds in various types of dentognathic deformations. The expediency and effectiveness of using the proposed non-removable appliance, which contributes to the training of the muscular structures of the articulating apparatus in combination with speech therapy correction, to improve kinetic and kinesthetic praxes in the temporary and first period of variable bite, was proven. The appliance includes a bracket soldered to two thin-walled cast perforated crowns designed to be fixed on temporary canines with a composite flowable photopolymer material (e.g., Filtek flow 3M ESPE, USA) or hybrid glass ionomer cement with a triple curing mechanism (e.g., Vitremer 3M ESPE, USA), in the middle part to which a functionally active element in the form of a bead is attached.

The advantage of the offered appliance, in our opinion, is the following: Fixation on temporary canines makes the appliance compact due to the reduction of the structure size, which in turn allows to facilitate hygienic care and improve the hygienic condition of the oral cavity, reduces the risk of caries in the non-mineralized cervical area at the stage of permanent teeth unformed root; compactness helps to increase the articulation zones of the tongue, trains the tip of the tongue, which speeds up the speech therapist's work at the stage of producing sounds, and eliminates their interdental pronunciation; the use of a functional element in the form of a bead allows to control the usual palatal position of the tongue and activate the work of the root of the tongue, because during a conversation the child involuntarily rolls it in the area of the palate, stimulating the muscles of the tongue.

The evaluation of the effectiveness of the diagnostic and treatment complex of measures offered on the basis of a multidisciplinary approach for patients with dentognathic deformities accompanied by phonetic disorders proved the need to determine the condition of the nasopharyngeal and palatine tonsils and the effectiveness of orthodontic treatment at the same time as logopedic correction as well. Improvements in electromyography, anthropometric measurements of scanned jaw models, and cephalometry were noted in 86.6% of patients; analysis of cone-beam computed tomography data showed a significant increase in the volume of the upper respiratory tract by 53.8±4.2% in patients after orthodontic treatment.

3. Predictors of the development of dentognathic deformations in cleft lip and palate, the basis of orthodontic correction

In most cases with cleft lip and palate, combined deformations of the dentognathic apparatus are observed. A congenital defect is the basis for the development of upper jaw deformity. Children with cleft lip and palate have at least one or more dentognathic deformities due to the development or position of the teeth themselves or the development and mutual arrangement of the jaws.

With cleft lip and palate, and unilateral cleft lip and palate, the following anomalies or deformations are most often observed: primary adentia, more often upper lateral incisors; presence of natal/neonatal teeth; presence of supplemental teeth; anomalies of the eruption of teeth; abnormalities in tooth morphology, e.g., fused teeth; tooth size abnormalities, e.g., microdontia; abnormalities of individual teeth, e.g., enamel hypoplasia; abnormalities in the position of the teeth; crowding of teeth or vice versa—tremas; mesial bite; cross bite; deep bite or open bite.

It should be noted that changes in the development of the upper jaw quite often affect the position and size of the lower jaw.

An integral component of deformations is the functional component.

A comprehensive approach to the orthodontic rehabilitation of children, taking into account the multifactorial determination of unilateral cleft lip and palate, allows to reduce the severity of dentognathic deformities caused by both congenital defects and surgical intervention. Orthodontic support during all periods of the formation of the dentognathic apparatus in children with congenital malformations of the lip and palate makes it possible to restore the size and shape of the dental arches, ensuring the stability of the complex treatment results.

The reason for the formation of deformations of the dentognathic apparatus in cleft lip and palate is pathogenetic predictors, which lay the foundation for the formation of deformations from the birth of a child. They can be divided into groups: primary congenital defects of soft (upper lip, soft palate) and hard tissues (defect of the alveolar process, hard palate); the influence of the tongue and cheek muscles, feeding method (pacifier, presence of an obturator); primary surgical interventions (cheilo-rhinoplasty, veloplasty, uranoplasty). The cascade of changes forms cause-and-effect mechanisms for the development of dentognathic deformations.

When studying the predictors, morphometric measurements of photograms and scanned models of the upper jaws of 72 children with unilateral cleft lip and palate were carried out.

Primary congenital defects of soft and hard tissues determine the presence of non-unions of the tissues of the lip and palate. It was showed that the largest soft tissue defect was located in the area of the nasolabial complex, non-union fragments of the soft palate. The largest defect of hard tissues was found at the border of the hard and soft palate. The distance between the ends of the alveolar process varied between 2.31 and 15.32 mm. The alveolar process of the large fragment deviated outward, while the small fragment shifted backward, which is due to the absence of both the muscular closure of the upper lip and the lack of its fusion with the vomer.

The influence of the pacifier on the mutual location of the fragments of the upper jaw and the position of the horizontal plate of the palatine bone was established. In most children with cleft lip and palate, who were artificially fed with the help of a pacifier, the shift of the alveolar process in the sagittal plane and the movement of the horizontal plates of the palatine bone to a vertical position were noted.

The development of the upper jaw in case of unilateral cleft lip and palate is also influenced by primary surgical interventions (cheilo-rhinoplasty, veloplasty, uranoplasty, uranostaphyloplasty), which restore the anatomical integrity of unfused fragments of the lip and palate, and create conditions for their functional capacity. The foundation for optimal orthodontic treatment is laid already at the stages of surgical interventions.

Cheilo-rhinoplasty is the primary surgical intervention performed on a child with cleft lip and palate. After primary cheilo-rhinoplasty, which is usually performed in 3–5 months for unilateral nonunions, the main muscle constrictor of the oral cavity is restored. It creates the conditions for regulating the mutual location of the unfused fragments of the upper jaw: It limits their further movements relative to each other, and optimizes and prepares them for the second stage of surgical interventions—veloplasty. Studying the dynamics of changes in the morphometric indicators of the upper jaw after veloplasty in children with cleft lip and palate showed changes in sagittal and transverse indicators of its dimensions. It was proven that cheilo-rhinoplasty, veloplasty, and uranoplasty affect the size of the defect by reducing it, but the risk zones for the growth of the upper jaw are the distances between the distal edges of the canines and between the points of the transition of the gingival mucosa to the hard palate in the area of the first molar, since in these areas there is a decrease in transverse sizes.

For orthodontic treatment of children with cleft lip and palate, orthodontic appliances are used, the scientific justification of which took place at the beginning of the twentieth century [29, 31]. However, there is still no universal orthodontic protocol for the treatment of dentognathic deformities in cleft lip and palate. To eliminate bite deformities caused by congenital defects of the palate, to obtain a satisfactory overjet (sagittal overlap) and overbite (vertical overlap), expansion of the upper jaw (dental arch) is usually performed. For this purpose, a number of appliances are used, which include the following:

- sectional removable appliances with one or more screws, occlusive side plates, spring pushers if necessary;

- appliancess for rapid expansion of the upper jaw depending on the type and volume of the required expansion (Hyrax appliance with screw, Mcnamara appliance with occlusive side plates, Hyrex-expanderr, Mini expander, Fan-type expander, Bobded Fan Expander with occlusive side plates, Expander with differential opening (EDO), etc.);

- stationary (non-removable) quad-helix/tri-helix appliances, etc. [26, 31–34].

The choice of orthodontic appliances in children with cleft lip and palate, especially in the period of variable bite, depends on the type of dentognathic deformities, existing conditions for fixation and socio-economic components.

Corrective speech therapy work with children with cleft lip and palate is carried out during the entire treatment and rehabilitation period and includes preparatory and main stages. The preparatory stage precedes the main one and is carried out in all age periods, and it involves the formation and development of basic psychomotor (kinetic and kinesthetic praxes), cognitive processes (visual, auditory gnosis, perception, auditory-speech memory, different types of thinking, spatial representation, attention), which are the basis for the child's speech development. The main stage is aimed at the formation and development of all constituent components of speech: speech breathing, phonetics, phonemic processes, vocabulary, grammar, coherent speech.

4. Interrelationship of the development of dentognathic deformations with anatomical and topographic indicators of the tongue, and prevention of dentognathic deformations in macroglacia

The action of the muscles of the maxillofacial area is decisive in the process of development of the dentognathic apparatus. The shape and size of the tooth rows are determined by the direction of growth and the influence of muscle forces, which depend on the anatomical features of the muscles and their functional state. The functional state of the tongue muscles plays an important role in maintaining myodynamic balance and depends on its anatomical features. They include the shape and size of the tongue, its position, and hyper- or hypotonus.

Deformations of the dentognathic apparatus in children of various ages develop as a result of congenital and acquired causes. One of them is macroglossia, which can be a manifestation of syndromic diseases, vascular malformations, congenital malformations, etc., which leads to a forced position of the tongue between the teeth rows, a change in the functional capacity of the tongue during articulation and eating, as well as the formation of conditions of constant excessive pressure on the lingual surface of the teeth and the alveolar process of the lower jaw.

Determining the state of formation of the tongue muscle tone, its anatomical and morphometric indicators, and its position are important for choosing the tactics of orthodontic treatment and corrective speech therapy work in children with dentognathic deformities [35].

Cone-beam computed tomography, electromyography, and anatomic and morphometric indicators of the tongue of 72 children aged 9–12, 44 with distal and distal deep bites and 28 without orthodontic pathology were performed. Adapted speech therapy functional tests were used to diagnose tongue muscle tone [20].

When examining children without orthodontic pathology, we determined the average thickness of the front, middle and back 1/3 of the tongue, which were 29.1±0.16 mm, 42.3±0.06 mm, and 44.4±0.08 mm, respectively. Average length m. genioglossus was 17.9±1.41 mm, and the total length of the tongue was 60.6±0.12 mm.

Anatomical and morphometric indicators in children with distal and distal deep bites showed that the thickness of the front, middle, and back 1/3 of the tongue were 22.9±0.11 mm, 42.1±0.09 mm, and 44.1±1.05 mm, respectively. Average length m. genioglossus—19.7±1.08 mm, total tongue length—54.1±2.16 mm.

The given data indicate a significant decrease in the thickness of the front 1/3 of the tongue, the total length of the tongue, and a significant increase in the length of m. genioglossus in children with distal and distal deep bites compared with children without orthodontic pathology.

Adapted speech therapy functional tests revealed an increase in tongue muscle tone by 65% among children with distal and distal deep bites. Hypertonus of the tongue was indicated by a change in its position and shape, increased mobility, and subtle differentiated movements, especially its tip. Displacement of the tongue backward to varying degrees was determined in all subjects with distal and distal deep bites. Among them, in 85% the tongue took the form of a "hill," in 15%—a "sting". In all patients, when trying to hold the tongue in a resting position, a muscle contraction was observed on the lower lip.

The results of electromyographic studies indicate an increased muscle tone of the tongue in children with distal and distal deep bites, which coincides with certain changes in mimic muscles.

Changes in the anatomical and morphometric indicators of the tongue are the main factors for moving its root to the back-lower position, which contributes to reducing the volume of the oral cavity, reducing the length of the lower dental arch, and increasing the tone of the tongue. The functional state of the muscles of the tongue has a direct correlation with the shape and size of the tooth rows and their type of closure.

Figure 10.
Appliance for the prevention of bite deformations in children with macroglossia.

To prevent the development of bite deformations caused by a violation of the tone and position of the tongue, well-known orthodontic appliances are used, for example, standard vestibular plates of Dr. Hinz, removable orthodontic appliances with support for tongue (the tongue guard), glued to the inner surface of the upper or lower teeth medical alloy spikes that force the tongue to seek the correct position during swallowing, speaking, and at rest.

The action of preventive appliances in children with macroglossia of various origins is aimed at limiting the effect of excessive pressure of the tongue on the teeth and the alveolar process of the lower jaw from the lingual side, which contributes to the stabilization of the position of the teeth and prevents their movement at the alveolar level without injuring the tissues of a significantly enlarged tongue. A device comprising an element for limiting excessive tongue pressure and support elements is offered. The element for limiting excessive pressure of the tongue is made in the form of a cast-perforated buckle modeled after the shape of the lingual surfaces of the lower teeth, and the supporting elements are made in the form of cast crowns (Patent of Ukraine for the utility model "Appliance for the prevention of bite deformations in children with macroglossia" No. 146224 A61C7/00 dated 27.01.21) (**Figure 10**).

Clinical indications for the usage of the offered appliance are the prevention of bite deformities in children with macroglossia of various origins, by limiting excessive tongue pressure and stabilizing the conditions for movement at the dentoalveolar level of the lower jaw at the stages of surgical treatment in temporary and variable periods of bite.

5. Conclusions

In order to timely detect dentognathic deformities with phonetic disorders and carry out preventive and therapeutic measures, it is necessary to conduct preventive examinations of children in preschool and school, followed by their referral to orthodontists, speech therapists, children's dentists, otolaryngologists, and mandatory monitoring and summarization of statistical data.

In case of detection of hypertrophy of nasopharyngeal and palatine tonsils of II-III degrees, children with dentognathic deformities accompanied by phonetic disorders require otolaryngological treatment simultaneously with orthodontic correction.

For children with dentognathic deformations accompanied by phonetic disorders, it is advisable to determine the bioelectrical activity of the chewing, and temporal and circular muscles of the mouth in a state of relative physiological rest and during voluntary compression, which is necessary to determine the volume of muscle load of the articulating apparatus during corrective work of a speech therapist.

In the final period of temporary and the first period of variable bites, for training the muscular structures of the articulating apparatus in combination with speech therapy correction, it is advisable to use a fixed appliance containing a bracket soldered to two thin-walled cast perforated crowns intended for fixation on temporary canines, in the middle part of which a functionally active element in the form of a bead is attached.

Developed on the basis of a multidisciplinary approach, the diagnostic and therapeutic complex of measures for patients with dentognathic deformities accompanied by phonetic disorders proved the need for coordinated corrective and developmental speech therapy work.

Dentognathic deformations in children with cleft lip and palate are cause-and-effect and depend on the type of defect, method of feeding, methods and age of surgical interventions.

The study of anatomical and morphometric characteristics of the tongue is a prognostic indicator of effective orthodontic treatment and requires differentiated corrective speech therapy work to develop kinetic and kinesthetic praxes.

Author details

Alona Melnyk* and Valerii Filonenko
Bogomolets National Medical University, Kyiv, Ukraine

*Address all correspondence to: melnik.alona@gmail.com

References

[1] Bezvushko EV, Miskiv AP. Dynamics of prevalence of dental jaw abnormalities in children of Lviv region. Bulletin of Problems in Biology and Medicine. 2015;**2**(2):21-24

[2] Boytsanyuk SI, Falinskyi MM, Ostrovsky PY. Prevalence of dental anomalies among school-age children of Ternopil. Young Scientist. 2017;**5**:57-60

[3] Kuroedova VD, Makarova AN. Prevalence of dental anomalies and the proportion of asymmetric forms in adults. World of Medicine and Biology. 2012;**4**:31-35

[4] Zaiats OR, Ozhogan ZR. Advancement of dental anomalies among children of the Ivano-Frankivsk region. Actual Dentistry. 2020;**1**:68-72. DOI: 10.33295/1992-576X-2020-1-68

[5] Drok VO. Prevalence of dental anomalies and periodontal diseases among adolescents. Ukrainian Dental Almanac. 2018;**1**:72-74. DOI: 10.31718/2409-0255.1.2018.17

[6] Flis PS, Leonenko GP, Filonenko VV. The frequency of abnormalities in the position of separate teeth and bite during the period of interchangeable bite. Actual Orthodontics. 2008;**1**(11):6-7

[7] Flis PS, Filonenko VV, Doroshenko NM. Frequency and prevalence of anomalies and deformations of dentognathic apparatus in the transitional period of occlusion. Ukrainian Dental Almanac. 2016;**1**(1):75-78

[8] Flis PS, Rashchenko NV, Filonenko VV, Melnyk AO. Advancement of powerable anomalies and speech disorders among children with 6-12 years old. Actual Dentistry. 2018;**4**:54-57

[9] Trofimenko MV. Orthodontic Treatment of Patients Aged 6-9 Years with Impaired Swallowing and Speech [autoabstract]. Poltava: Ukrainian Medical Stomatological Academy; 2010

[10] Bida OV, Zabuga YI. Functional state of the masticatory muscles of patients with defects of dentition, which are complicated by dentoalveolar deformities. Ukrainian Dental Almanac. 2016;**3**(2):27-31

[11] Khokhlich OY. Rehabilitation of patients with dental diseases in the conditions of their professional phonatory performance. Ukrainian Dental Almanac. 2012;**2**(2):67-71

[12] Petrychenko OV. Justification of the Effectiveness of Early Treatment and Prevention of Dental Anomalies in Children with Speech Disorders [autoabstract]. Kyiv: Shupyk National Medical Academy of Postgraduate Education of the Ministry of Health of Ukraine; 2018

[13] Zabolotny DY, Mytin YV, Bezshapochny SB, Deeva YV. Otorhinolaryngology: Textbook for Students of Higher Medical Institutions. Kyiv: Kyiv Medicine; 2010. p. 494

[14] Sheremet MK, Bazima NV, Moroz OV. The problem of speech anxiety in children with severe speech disorders. Speech Therapy. 2015;**5**:93-99

[15] Yakovenko AO. Formation of Speech Readiness of Older Preschoolers with Speech Pathology for Integrated Learning. Kyiv: National Pedagogical Dragomanov University; 2018

[16] Kuroyedova VD, Dmytrenko MI, Makarova OM, Stasyuk OA.

Comprehensive Orthodontics. Poltava: Astraya; 2016. p. 88

[17] Kuroyedova VD, Vyzhenko EE, Doroshenko SI, Makarova OM. Physiotherapy in Orthodontics. Poltava: Astraya; 2019. p. 135

[18] Yakovenko LM, Cherkasov VG, Chekhova IL. Surgical Dentistry and Maxillofacial Surgery of Pediatric Age: Textbook. 2nd ed. Kyiv: Kyiv Medicine; 2022. p. 496

[19] Sharma G. Orthodontic management of cleft lip and palate patients. In: Ayşe G, editor. Current Treatment of Cleft Lip and Palate. 2020. pp. 19-33. DOI: 10.5772/intechopen.77803(Chapter 2) DOI: 10.5772/intechopen.90076

[20] Melnyk AO, Shafeta OB, Yakovenko AO. Correlation of bite pathologies with anatomical and topographic indicators of the tongue. In: Materials of the Scientific and Practical Conference "Modern Dentistry and Maxillofacial Surgery". Kyiv; 2020. pp. 105-106

[21] Flis PS, Filonenko VV, Melnyk AO. Study of the state of ent-organs in children with anomalies and deformations of dentoalveolar apparatus and speech disorders. Ukrainian Dental Almanac. 2018;**3**:26-32. DOI: 10.31718/2409-0255.3.2018.04

[22] Flis P, Yakovenko L, Filonenko V, Melnyk A. Validation of the diagnostic and treatment for patients with orthognathic deformities and phonetic disorders. Georgian Medical News. 2019;**9**(294):62-68

[23] Flis PS, Rashchenko NV, Filonenko VV, Melnyk AO, Lopoha AB. Algorithm of patient's treatment with the presence anomalies of bite and speech disorders. Ukrainian Dental Almanac. 2018;**4**:60-64. DOI: 10.31718/2409-0255.4.2018.11

[24] Flis PS, Filonenko VV, Nemyrovych YP, Melnyk AO, Lopoha AP. Algorithm for speech disorders correction using proprietary construction device. Bulletin of Scientific Research. 2018;**4**:145-151. DOI: 10.11603/2415-8798.2018.4.9780

[25] Melnyk AO. Evaluation of the effectiveness of the complex of diagnostic and therapeutic measures in patients with anomalies of the dentoalveolar apparatus accompanied by phonetic disorders. Actual Dentistry. 2018;**5**(94):72-75

[26] Flis PS. Orthodontics: Textbook. Kyiv: Kyiv Medicine; 2008. p. 336

[27] Moorrees CF, Gron AM, Lebret LM, Yen PK, Frohlich FJ. Growth studies of the dentition: A review. American Journal of Orthodontics. 1969;**55**(6):600-616

[28] Flis PS, Rashchenko NV, Filonenko VV, Melnyk AO, Etnis LO. Functional state of the muscles of the maxillofacial apparatus before and after child treatment with bite anomalies and speech disorders. Clinical Dentistry. 2018;**4**(25):76-83. DOI: 10.11603/2311-9624.2018.4.9630

[29] Flis PS, Leonenko GP, Filonenko VV, DoroshenkoNM.Orthodontics.Dentognathic anomalies and deformations: Textbook. Kyiv: AUS Medicine Publishing; 2015. p. 175

[30] Flis PS, Filonenko VV, Melnyk AA. Correction of speech disorders with the use of a device of own construction. Azərbaycan Tibbi Jornali. 2018;**4**:109-113

[31] Koskela A, Neittaanmäki A, Rönnberg K, Palotie A, Ripatti S, Palotie T. The relationship of severe malocclusion to patients' mental and behavioral disorders, growth, and speech problems. European Journal of

Orthodontics. 2020;**43**(2):1-6. DOI: 10.1093/ejo/cjaa028

[32] Aura SC, Chen A. Orthodontic interventions in Cleft Lip and Palate Individuals [Internet]. 2019 . Available from: https://www.oralhealthgroup.com/features/orthodontic-interventions-in-cleft-lip-and-palate-individuals-an-overview-of-treatment-protocol/ [Accessed: September 10, 2019]

[33] Makeev VF. Orthodontic methods of treatment of patients with Clift Lip and Palate: Textbook. Lviv: Quart; 2013. p. 164

[34] Kovach IV, Khaletska VM. Features of the effectiveness of treatment of narrowing of the upper jaw in the transversal area in children with complete cleft palate in the state after uranoplasty in the early mixed dentition. Actual Dentistry. 2015;**2**:114-116

[35] Yakovenko LM, Chekhova IL, Yefimenko VP, Kiselyova NV, Egorov RI, Kovtun TO, et al. Examination of Children with Surgical Diseases of the Maxillofacial Area: Textbook. Kyiv: Book-plus; 2022. p. 164