"CAROL DAVILA" UNIVERSITY
OF MEDICINE AND PHARMACY
OF BUCHAREST
DOCTORAL SCHOOL
DENTAL MEDICINE

Considerations on the variation of cephalometric parameters in mandibular prognathism

DOCTORAL THESIS ABSTRACT

PhD supervisor:
PROFESSOR IONESCU ECATERINA

PhD student:
ARISTIDE ANDREI SORIN

2024

CONTENTS OF THE DOCTORAL THESIS

INTRODUCTION

Regarded rather late as an important indicator of the general health of the entire body, oral health is defined by the World Health Organization (WHO) as a state characterized by the absence of pain in the oro-maxillofacial region, carious lesions, periodontal disease, oral mucosal lesions, congenital defects (cleft lip and palate), and other disorders that may affect the oral cavity (Petersen, 2003).

In the context of oral health, dento-maxillary anomalies, as growth and development disorders of the components of the dento-maxillary apparatus, result in considerable functional and esthetic imbalances which, most often, due to repercussions in the patient's psycho-emotional sphere, alter his/her quality of life.

Within the dento-maxillary anomalies, mandibular prognathism represents a group of anomalies characterized by changes in bone, alveolar, dental and/or occlusal structures in all planes, which are significantly representative in terms of aesthetic impact and major functional disorders. In addition, they are difficult to address from a therapeutic point of view, mainly owing to the peculiarities of the growth and development process, with certain specificity in the case of this anomaly.

As an anomaly that significantly affects the patient's facial appearance and the functions in which the dento-maxillary apparatus participates, essentially altering the quality of life, due to the complex phenomenology of the cranio-facial growth and development processes, mandibular prognathism still remains a challenge to specialists, with quite a few controversies related, particularly, to its etiopathogenic mechanisms. In this context, in addition to anamnesis and clinical examination, which are irreplaceable even in the digitization era, radiological investigation, especially profile cephalograms, is an objective necessity.

By analyzing the three-dimensional changes of the maxillomandibular complex and corroborating clinical examination data with the analysis of cephalometric parameters on cephalograms, one can more accurately determine the clinical form of the class III malocclusions and, implicitly, the therapeutic attitude, either the conservative orthodontic approach or the orthodontic-surgical one.

In the light of these aspects, the scientific research carried out within the framework of my doctoral thesis aimed to investigate the features of the cephalometric skull base, maxillomandibular and dental parameters, in the sagittal and vertical planes, in patients with different clinical forms of mandibular prognathism, at the age of growth and adults (in whom the growth and development processes are completed or have a reduced rate of intensity) in order to anticipate the evolution and directions of the growth and development of the maxillary bones, towards normal or pathological, as early as possible.

The PhD thesis is structured in two parts, namely the general part and the scientific research part (special part), to which are added the introduction, the final conclusions and the bibliographical references.

I. GENERAL PART

The general part is organized in three distinct chapters which, through the prism of the information and results of relevant scientific research, summarize the current state of knowledge of this type of malocclusion on important coordinates.

CHAPTER 1. GENERAL ASPECTS OF MANDIBULAR PROGNATHISM

The first chapter contains information on the terms used over time to define mandibular prognathism, with details of their meaning. The review of the epidemiologic aspects is followed by the categorization of mandibular prognathism in the national and international classifications and a summary of the etiologic factors involved in this pathology.

CHAPTER 2. FEATURES OF GROWTH AND DEVELOPMENT PROCESSES IN THE SKULL BASE AND MAXILLARY BONES

The second chapter describes and elaborates on the formation, growth and development of craniofacial structures and maxillary bones in terms of their specificity. Generally, the process of growth and development of the bony components of the dento-maxillary apparatus follows the characteristics of the growth and development processes of the human organism, including the cephalocaudal gradient, being guided by the basic concepts of these processes, but it is also underlain by specific mechanisms that individualize it in relation to the rest of the body, an important role being played by the condylar cartilage (secondary growth cartilage), an extremely important cartilage with certain evolutionary particularities, especially in class III patients.

CHAPTER 3. CRANIOFACIAL MORPHOLOGIC FEATURES AND FEATURES OF CEPHALOMETRIC PARAMETERS IN MANDIBULAR PROGNATHISM

Considering that, etiologically and morphogenetically, maxillomandibular morphologic changes in mandibular prognathism occur, in variable proportions, during growth and development, the information in this chapter focuses on the most representative craniofacial morphologic features and the features of cephalometric parameters, i.e. those of the skull base, maxilla and mandible.

II. PERSONAL SCIENTIFIC RESEARCH

CHAPTER 4. GENERAL METHODOLOGY OF SCIENTIFIC RESEARCH

The review of the studied literature highlighted the way the features of craniofacial growth and development processes lead to an impressive phenotypic diversity of mandibular prognathism, in terms of various skeletal, alveolar and dental changes.

The antero-posterior and vertical discrepancies, revealed by characteristic changes in some cephalometric parameters, contribute to the correct diagnosis of dento-maxillary anomalies and may point towards an exclusively orthodontic therapy or an interdisciplinary orthodontic-surgical approach.

Thus, within my doctoral scientific research, by investigating and elucidating certain coordinates regarding the site and type of skeletal and dento-alveolar changes in a group of patients with mandibular prognathism in Romania, I hope to contribute to an increase in the quality and efficiency of orthodontic/orthodontic-surgical treatment.

4.1 Goals of the research

Within the scientific research, my general goal was to study the skeletal, alveolar and dental changes that occur in patients with mandibular prognathism (Angle class III malocclusions) by means of specifically selected linear and angular cephalometric parameters, and to highlight the parameters of practical utility for both orthodontists and maxillofacial surgeons (who deal with this type of pathology).

For this purpose, I analyzed the variation of some parameters of interest by gender and age group and I compared the results of my research with those of some studies in the literature.

As for the ***specific objectives***, my scientific research focuses on:

- identifying the site and direction of skeletal changes in patients with mandibular prognathism (Angle class III malocclusions);
- evaluating the direction of dento-alveolar changes in the sagittal plane in the maxillary and mandibular incisor group, in patients with mandibular prognathism (Angle class III maloclusion);
- assessing the amplitude of skeletal and dento-alveolar changes in mandibular prognathism (Angle class III malocclusions), depending on the patient's gender and age.

4.2 Research group

In order to achieve the proposed goals, the cases were randomly selected from among the patients who came for consultation and specialized treatment at the Orthodontics and Dento-Facial Orthopedics Clinic of "Carol Davila" University of Medicine and Pharmacy of Bucharest. The data required to carry out the doctoral research were obtained from the patient's documentation: observation sheet, study models and profile cephalograms.

The criteria for inclusion in the research group (the group of Angle class III patients) were the diagnosis of Angle class III malocclusions, both dental (on the study model) and skeletal (based on the profile cephalogram analysis) by modifying the cephalometric parameters ∡ANB (º) and the AoBo distance (mm), which shows the sagittal position of the mandible in relation to the maxilla. Similarly, the control group (group of subjects with Angle class I malocclusions) was selected based on the diagnosis of Angle class I dental and skeletal malocclusion. We excluded from the study the subjects with a history of orthodontic treatment, genetic syndromes, congenital malformations, a history of traumas or dental group mesial positions.

In order to capture different periods of the patients' growth and development, the patients included in the study were aged between 7 and 18. To analyze the relationship between the changes in cephalometric parameters and the patients' chronological age, each research group was divided into four age groups (AG). Thus, the first age group (AG1) included subjects aged between 7 and 9 (including 9); the second age group (AG2) included subjects aged between 10 and 12 (including 12); the third age group (AG3) included subjects aged between 13 and 15 (including 15); and the fourth age group (AG4) included subjects aged between 16 and 18 (including 12 years).

Based on the aforementioned criteria, 75 subjects were thus included in the research group, the group of patients with Angle class III malocclusions consisting of 45 subjects, and the group of patients with Angle class I of 30 subjects (figure 4.1).

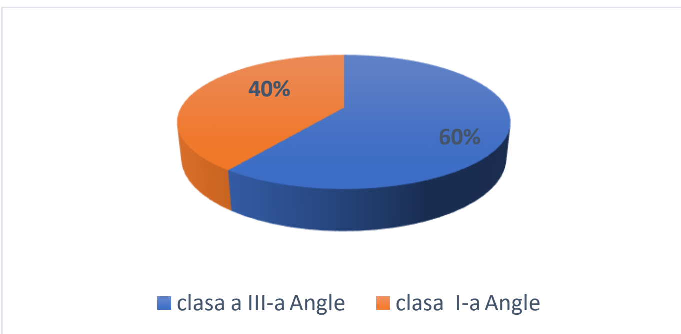

Figure 4.1. Distribution of the study group depending on the diagnosis of dento-maxillary malocclusion as per the Angle classification

The percentage distribution of the patients included in the two groups, depending on the age at which the investigations were carried out, is illustrated by the graph in figure 4.2. The average age of the patients in the Angle class III group is 11 years and 6 months, with most patients being over 13 years old (28% aged between 13 and 15, and 28% aged 16-18). The average age of the patients in the Angle class I group is 12 years and 4 months, with an equal percentage of patients from the first and third age groups (18.75%), respectively from the second and fourth age groups (31.25 %).

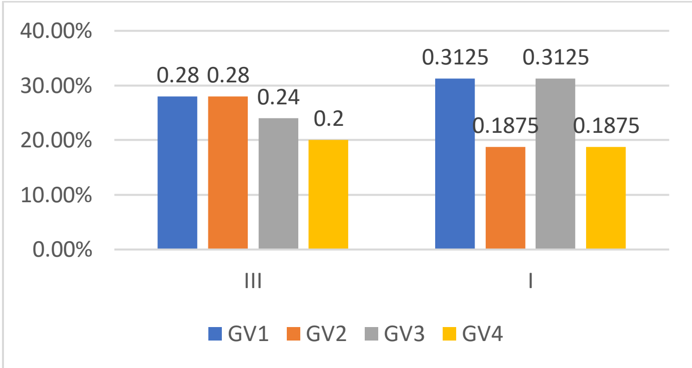

Figure 4.2. Percentage distribution of patients in the two study groups, depending on age

The representation of the two sexes in the study groups was slightly in favor of the female sex (figure 4.3). The Angle class III group consisted of 66% female subjects and 34% male subjects and the Angle class I group consisted of 60% female subjects and 40% male subjects.

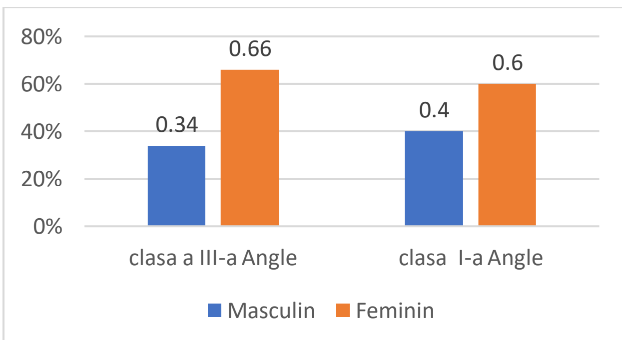

Figure 4.3. Percentage distribution of the subjects in the study groups, by sex

4.3. Research method

In the first stage, subjects were selected according to the data recorded in the observation sheet and to the static occlusion analysis on the study model. After the analysis of the (lateral) profile cephalogram, the research groups were to be determined according to the ANB angle and AoBo distance. Sex and age were recorded for each subject at the time of lateral cephalogram.

For all selected cases, the patient's informed consent was obtained (directly or through their legal guardians). The doctoral research studies were conducted in compliance with the 1975

Declaration of Helsinki on medical research, as revised in 2000 (World Medical Association, 2009), with the approval of the committee for the ethics of scientific research of "Carol Davila" University of Medicine and Pharmacy of Bucharest.

Since my study aims to evaluate cephalometric parameters that describe skeletal and dentoalveolar changes in patients with mandibular prognathism, the interpretation of profile cephalograms was essential and indispensable in the framework of my doctoral research.

The profile cephalograms used in the study were performed in standardized conditions, in the same radiological center, in maximum intercuspation position. The analysis of the profile cephalograms was carried out in the same time interval for all selected subjects, the interpretation of the teleradiographic data being performed once in the same age group.

The profile cephalograms were interpreted by a single examiner using the technique of contour copying on tracing paper and manually marking the anthropometric points of interest. On the basis of these anthropometric points, a total of ***26 cephalometric parameters*** could be studied (15 angular, 10 linear and 1 expressed as a percentage).

In order to illustrate as clearly as possible the imbalances that define the profile of mandibular prognathism (Angle class III malocclusions), my doctoral research was structured in two retrospective observational studies. The cephalometric parameters observed were described in each particular study.

Thus, in the first study of the personal research I focused on analyzing the variation of cephalometric parameters that describe the sagittal and vertical skeletal changes in Angle class III patients compared to those in the control group.

The second study aimed to evaluate the cephalometric parameters that reveal dentoalveolar changes in the sagittal plane in the upper and lower incisor group, in subjects with Angle class III malocclusions.

4.4. Research data processing

The data collected were centralized and statistically processed using Microsoft Office Excel (2019). Quantitative variables were expressed as mean values (Mean) with standard deviations (SD), minimum values (min) and maximum values (max). The values were tested for distribution using the Shapiro-Wilk test, the parametric distribution allowing the use of the Student T-Test for comparative analysis of the results. We set the value of the statistical significance coefficient p at a maximum of 0.05 as threshold of the test statistical significance, a threshold that is accepted by the scientific community to reject the research hypothesis.

The statistical analysis and interpretation of the results, as well as their comparison with data from similar studies in the field, enabled me to draw the conclusions of my scientific research.

On the basis of the data collected from observation sheets and the interpretation of the profile cephalograms, a total of 26 variables were recorded for each of the 75 patients in the group. The 1950 numerical values thus obtained were statistically processed to identify the skeletal and dentoalveolar particularities of patients with mandibular prognathism in the population group under study, this information having a role in establishing the diagnosis and treatment plan for patients with this type of dento-maxillary malocclusion.

CHAPTER 5. CHANGES IN SKELETAL CEPHALOMETRIC PARAMETERS IN MANDIBULAR PROGNATHISM

As stated in the general part, mandibular prognathism is a group of anomalies characterized by changes in the bone, alveolar, dental and/or occlusal structures, the site and the direction of the changes influencing both the therapeutic attitude and the prognosis of this dento-maxillary malocclusion.

The anatomical forms that involve skeletal changes are often expressed by severe clinical pictures, with, as a rule, an unfavorable evolution over time in terms of the complications they are associated with. Jacobson et al. (1974) identified different types of skeletal patterns, arguing that Angle class III malocclusions may result from the variation of five different components, namely:

1. the mandible may be larger than the maxilla;
2. the maxilla may be smaller than the mandible;

3. the maxilla may be retropositioned to the mandible;
4. the mandible may be positioned anterior to the maxilla;
5. anterior rotation of the mandible in relation to the skull, which may cause the displacement of the menton into a protruding position, thus resulting in a prognathic mandible associated with reduced height of the lower facial floor.

Starting from this premise, the first study of this doctoral scientific research intends to assess the dimensional and positional changes of the skeletal components, in the sagittal and vertical planes, in different age groups, by analyzing lateral cephalograms.

5.1. Working hypothesis

In the case of mandibular prognathism there are complex skeletal changes, which combine changes in the skull base, maxilla and mandible, respectively, with different expression, depending on the patient's sex and age.

5.2. Goals of the study

In this context, the goals of this study are:

- to identify the site of skeletal changes in the sagittal and vertical planes, in patients with mandibular prognathism (class III malocclusions) compared to a control group;
- to identify the direction of skeletal changes in the sagittal and vertical planes, in patients with mandibular prognathism (class III malocclusions) compared to a control group;
- to identify the extent/severity of skeletal changes, in the sagittal and vertical planes, in patients with mandibular prognathism (class III malocclusions), depending on the patient's sex and age.

5.3. Material and method

5.3.1. Research group

In order to carry out this retrospective statistical study, as described in detail in the chapter "General methodology of scientific research" (Chapter 4), I selected the relevant documentation for a group of patients who sought consultations and specialized treatment in the Orthodontics and Dento-Facial Orthopedics Clinic of "Carol Davila" University of Medicine and Pharmacy of Bucharest.

5.3.2. Working method

As indicated in the preceding chapter, the profile cephalograms were interpreted by a single examiner, who used the technique of contour copying on tracing paper and manually marking the anthropometric points of interest for the evaluation of the cephalometric parameters that I considered as variables in this study (table IV.1). From these anthropometric points, a total of 18 cephalometric parameters could be studied (9 angular, 8 linear and 1 expressed as a percentage). They are summarized in table V.1.

Table V.1. Cephalometric parameters and limits of normal variability (after Rakosi, 1979)

Cephalometric parameter	***Description and limits of normal variability***
Sagittal plane	
SNA angle (∡SNA)	shows the position of the maxilla in the sagittal plane in relation to the anterior portion of the skull base. Normal values: 80-84°
A to N perp. (mm) (A-N perp.)	is the distance between the basal point A and the perpendicular to the Frankfurt horizontal starting from point N. Normal values: 0-1 mm
SNB angle (∡SNB)	describes the position of the mandible in the sagittal plane in relation to the anterior portion of the skull base. Normal values: 78-82°
Pg to N perp.(mm) (Pg-N perp.)	indicates the distance between the bony point Pg and the perpendicular to the Frankfurt horizontal starting from point N. Normal values: (-9) – 1 mm
B to N perp. (mm) (B-N perp.)	is the distance between the basal point B and the perpendicular to the Frankfurt horizontal starting from point N. Normal values: (between -12 mm and 1.4 mm)
Co-A (mm)	describes the antero-posterior length/size of the maxilla Normal values: 93.5 mm
Co-Gn (mm)	shows the antero-posterior length/size of the mandible.

	Normal values: 97.7 - 121.5 mm
Maxillomandibular difference	is the difference between the length of the maxilla (Co-A) and the length of the mandible (Co-Gn). Normal mean value: 28 mm
Sphenoidal angle (∡NSAr)	is the angle between the anterior portion and the declivous portion of the skull base. Normal values: 118-128º
Articular angle (∡SArGo)	is the angle between the declivous portion of the skull base and the mandibular ascending ramus. Normal values:137 – 149º
Vertical plane	
SN-GoGn angle (∡SN-GoGn)	is the angle between the mandibular basal plane and the anterior portion of the skull base. Normal values: 32º
FMA angle (∡FMA)	is the angle between the mandibular basal plane (Go-Me) and the Frankfurt horizontal (Or-Po). Normal values: 22-28º
Gonial angle (∡ArGoMe)	is the mandibular angle, measured between the horizontal ramus (Go-Me) and the vertical ramus of the mandible (Ar-Go). Normal values: 121-135º
Upper gonial angle (∡ArGoN)	is the angle between the mandibular vertical ramus (Ar-Go) and the line joining points Go and N. Normal values: 52-55º
Lower gonial angle (∡NGoMe)	is indicated by the angle between the horizontal ramus (Go-Me) and the line joining points Go and N. Normal values: 70-75º
S to Go (mm)	indicates the posterior facial height as the linear distance between points S and Go.
N to Me (mm)	describes the anterior facial height, measured between points N and Me.
Jarabak index (SGo/NMe) x 100 (%)	is the percentage ratio of posterior facial height to anterior facial height (SGo/NMe) x 100 (reason for which it is also known as the Jarabak ratio) Normal values: 59-63%

5.4. Results

The results of this study highlight the diversity of changes in cephalometric parameters in the sagittal and vertical planes, in terms of their location, direction and amplitude.

5.4.1. Skeletal cephalometric changes in the sagittal plane

Considering that sagittal changes may involve both the maxilla and the mandible, it is necessary to determine the degree of impairment/modification of each structure and the correlation between these changes for each age group. The results of the statistical analysis of cephalometric parameters values that indicate skeletal changes in the antero-posterior plane are summarized in table V.2.

Table V.2. Descriptive statistical elements of the cephalometric parameters describing skeletal cephalometric changes in the sagittal plane

Age group	Class III		Class I		Mean difference	P
	M	SD	M	SD		
∡SNA (°)						
AG1	80.29	2.78	80.42	1.99	0.13	0.946
AG2	80.93	2.20	79.11	5.54	1.82	0.286
AG3	80.05	2.29	81.49	0.74	1.44	0.327
AG4	80.16	1.12	82.82	1.67	2.66	0.086
A-N perp. (mm)						
AG1	-0.35	2.21	-0.30	0.75	0.05	0.973
AG2	-1.33	1.24	-4.31	1.67	2.98	0.108
AG3	-1.27	2.03	0.34	1.44	1.61	0.315
AG4	-1.12	1.26	-0.25	1.74	0.87	0.642
∡SNB (°)						
AG1	81.35	2.57	77.18	1.99	4.17	**0.029**
AG2	81.35	2.56	76.73	3.83	4.62	**0.050**
AG3	81.21	1.78	78.45	0.87	2.76	**0.047**
AG4	83.76	3.38	78.35	1.37	5.41	**0.05**
Pg-N perp. (mm)						
AG1	-2.70	3.51	-4.54	1.97	1.84	0.524
AG2	-0.14	2.78	-6.75	2.15	6.61	**0.009**
AG3	0.67	2.65	-2.09	2.87	2.76	0.232
AG4	4.62	3.30	-4.05	1.34	8.67	**0.035**
B-N perp. (mm)						
AG1	-2.25	3.33	-4.81	1.63	0.62	0.294
AG2	-0.69	2.56	-4.46	2.45	3.77	**0.05**
AG3	-0.21	3.14	-4.58	1.56	4.37	**0.05**
AG4	2.35	3.49	- 5.50	1.36	7.85	**0.049**
Co-A (mm)						
AG1	76.43	5.39	74.86	1.57	1.57	0.686
AG2	74.11	3.30	72.54	0.74	1.58	0.584
AG3	81.12	4.65	84.40	3.39	3.36	0.328

AG4	83.38	1.13	82.17	1.79	1.21	0.495
Co-Gn (mm)						
AG1	100.64	6.06	95.16	1.63	5.48	0.237
AG2	104.99	7.71	89.96	1.13	15.03	**0.05**
AG3	118.56	4.41	109.01	4.65	9.55	**0.026**
AG4	121.47	0.53	103.65	2.56	17.82	**<0.0001**
Maxillomandibular difference (mm)						
AG1	25.39	1.49	19.85	1.51	5.54	**0.001**
AG2	30.87	4.41	17.42	1.69	13.45	**0.016**
AG3	37.30	2.45	26.81	2.85	10.49	**<0.001**
AG4	38.09	0.73	21.48	2.12	16.61	**<0.001**
∡NSAr (º)						
AG1	124.07	4.96	121.96	2.46	2.12	0.266
AG2	122.21	1.91	124.55	5.26	2.34	0.294
AG3	118.59	4.99	122.05	2.06	3.46	0.164
AG4	121.62	4.71	123.03	0.93	1.41	0.242
∡SArGo (º)						
AG1	147.15	4.47	142.86	1.07	4.29	0.099
AG2	145.06	4.29	146.13	3.24	-1.07	0.79
AG3	144.30	4.09	144.51	3.63	-0.22	0.474
AG4	141.44	2.33	143.24	1.08	-1.80	0.212

The SNA angle showed that the sagittal position of the maxillary base in relation to the skull base did not differ statistically significantly between patients with class III and class I malocclusions, irrespective of the age group. For class III patients, the mean values of this parameter fell within the normal range of variability. On the whole, in descriptive terms, although they were not statistically significant, the largest differences were observed for GV4 (patients aged 16-18) and the smallest for GV1 (patients aged 7-9).

The results shown by the parameter ***A-N perp.*** (mm), which describes the sagittal linear position of the maxillary base relative to the skull base, are similar to those obtained for the previous parameter, in that the values are similar between the two study groups.

Unlike the parameters described earlier, where the values were similar between the two groups, in the case of ***SNB angle***, the position of the mandible relative to the skull base was significantly different between class III and class I patients, in all age groups. Thus, the ∡SNB values were higher in Angle class III patients, with the most substantial differences being recorded for the largest age group, i.e., patients aged 16 and older.

Irrespective of the age group, the mean values of ***Pg-N perp.*** (mm) were lower in Angle class III patients than in the control group. Nevertheless, the differences between the two groups were statistically significant only for the 10-12 and 16-18 age groups.

As with the changes in the previous cephalometric parameter, the ***B- N perp.*** (mm) mean values were lower in Angle class III patients. In the case of this parameter, the differences between the two groups were statistically significant for patients over 10 years.

As regards the antero-posterior size of the maxilla, assessed by ***Co to A*** (mm), no significant differences were observed between the mean values recorded for the two research groups, regardless of the age group.

As expected, the mean mandibular length (***Co to Gn***) was greater in class III patients than in class I patients. However, the differences were statistically insignificant for patients aged 7-9. The statistical significance increased with age (patients over 10), with the largest differences recorded for the age group 16-18 years, the result being highly statistically significant ($p<0.001$).

In correlation with the parameters presented above, the results displayed higher values of ***the difference between the maxillary and the mandibular lengths*** in class III patients compared to class I patients. The highest value of this parameter was found in Angle class III patients aged over 16.

The statistical analysis highlighted significant differences between the values obtained for this parameter, independently of the age group studied. The smallest mean differences between the values recorded for this parameter were observed in patients under 9 years of age, while in the last two age groups, i.e. in patients over 13 years of age, the T-test results showed the highest statistical significance, exceeding the 0.001 confidence level.

Another parameter that plays a role in the evaluation of the sagittal discrepancy of the maxilla and mandible is the ***∡NSAr*** or sphenoidal angle (after Björk-Jaraback analysis). The results did not show significant differences between the two groups for any age group. However, it is worth noting that for Angle class III patients aged over 10, the values of this parameter were slightly lower than those obtained for the control group (1.41-3.46º), suggesting a more anterior positioning of the mandible and glenoid fossa.

Closely related to the previous parameter is **∡SArGo** or articular angle (part of the Björk-Jarabak polygon analysis) for which the results did not differ statistically significantly between the groups under study for any age group. However, in the group of Angle class III patients, the values were lower compared to the control group, except for the first age group, where the mean value of this parameter was higher for Angle class III patients. In both groups, the values fell within normal variability. It is also noted that, globally, the values of the articular angle in class III patients decreased as the patients' age increased, suggesting an inversely proportional relationship between this parameter and age. Thus, it can be assumed that the position of the mandible becomes more anterior with age due to changes in the posterior portion of the skull base during the growth period.

5.4.2. Skeletal cephalometric changes in the vertical plane

Although mandibular prognathism/Angle class III malocclusion is principally characterized by sagittal changes, vertical changes are also quite evident (table V.3). The latter are closely correlated with sagittal changes, their association outlining a strong variety of clinical pictures.

Table V.3. Descriptive statistical elements of cephalometric parameters describing skeletal cephalometric changes in the vertical plane

Age group	CLASS III (GROUP A)		CLASS I (GROUP B)		Mean difference	P
	M	SD	M	SD		
∡SN-GoGn (º)						
AG1	31.97	2.78	34.41	6.27	2.44	0.524
AG2	34.12	4.42	33.01	3.58	1.11	0.781
AG3	35.88	4.41	29.26	1.62	6.62	**0.026**
AG4	33.19	3.01	24.38	4.48	8.81	**0.031**
∡FMA (º)						
AG1	24.48	1.58	22.97	2.64	1.51	0.466
AG2	26.92	2.59	24.40	3.73	2.52	0.187
AG3	27.54	2.71	22.96	1.52	4.58	**0.015**
AG4	28.29	2.74	18.34	5.45	9.95	**0.024**
∡ArGoMe (º)						
AG1	127.52	2.60	125.04	1.43	2.47	0.476
AG2	131.29	3.66	125.14	2.34	6.15	**0.025**
AG3	129.78	4.40	124.96	1.69	4.82	**0.003**
AG4	128.59	3.44	117.88	5.24	10.71	**0.02**
∡ArGoN (º)						
AG1	52.63	1.94	56.36	2.08	3.73	**0.017**

AG2	53.14	0.88	54.80	1.46	1.66	**0.05**
AG3	50.72	2.37	52.69	2.29	1.97	0.169
AG4	53.34	1.33	51.55	0.30	1.79	**0.05**
∡NGoMe (º)						
AG1	74.30	1.81	69.71	3.20	4.59	0.131
AG2	78.15	4.86	70.35	3.15	7.80	**0.034**
AG3	79.06	3.95	72.34	1.76	6.72	**0.001**
AG4	76.98	1.55	66.33	4.94	10.65	**0.019**
S-Go (mm)						
AG1	64.89	2.91	62.67	2.15	2.23	0.148
AG2	66.87	4.55	60.26	1.10	6.60	**0.041**
AG3	68.96	4.42	73.55	1.74	4.59	0.078
AG4	74.21	6.00	76.58	1.44	2.37	0.323
N-Me (mm)						
AG1	103.76	5.23	93.93	2.40	9.84	**0.05**
AG2	114.63	12.19	96.10	2.49	18.53	**0.031**
AG3	118.94	7.95	108.25	3.63	10.68	**0.05**
AG4	128.03	10.21	104.57	3.81	23.46	**0.019**
S-Go/N-Me (%)						
AG1	62.66	3.29	66.82	3.99	4.15	0.237
AG2	58.71	3.99	62.76	2.14	4.06	**0.005**
AG3	58.03	0.92	67.98	1.42	9.96	**<0.0001**
AG4	57.96	0.16	73.38	3.68	-15.42	**0.016**

The ∡SN-GoGn angle, which describes facial divergence, had higher values in the group pf Angle class III patients aged over 10 years, in which the resulting values were higher than the limits of normal variability. The differences between the two groups were statistically significant, but only for the last two age groups, i.e. for subjects aged over 13 years (6.62 mm for AG3 and 8.81 mm for AG4, respectively).

As for ***the angle between the mandibular basal plane and the Frankfurt horizontal***, the results revealed higher values for Angle class III patients in all age groups, the differences being statistically significant in patients aged over 13 years (AG3 and AG4). For Angle class III patients in the age group of 16-18 years, ∡FMA had a mean value of 28.29 º, that is 9.95 º more than the mean value of this parameter for Angle class I patients. This important difference may be due to the low values of ∡FMA (18.34 º) in the Angle class I group for this age group, a value which is below the limit of normal variability. It can also be noted that the values of the FMA angle increased as the age of Angle class III patients increased.

The results recorded for ***the gonial angle*** were higher in all age groups, in Angle class III patients compared to those in the control group, the differences being statistically significant for subjects aged over 10 years.

Like for the previously analyzed vertical cephalometric parameters, in the case of the gonial angle the largest differences between the mean values obtained for the two study groups (10.71º) were recorded for patients aged between 16 and 18.

Starting from the cephalometric analysis proposed by Björk Jaraback, we studied the gonial angle from the perspective of its two components, i.e. the upper and the lower parts of the gonial angle. In the case of ***the upper gonial angle***, which provides information on the prognosis of mandibular growth in horizontal plane, the mean values recorded for Angle class III subjects were significantly higher than those in the control group only in the last age group, namely the 16-18 olds (table V.15, figure 5.15). Nevertheless, even in this age group, the values did not exceed the normal mean values (52-55°), which would have suggested a protrusive tendency of the mandible. It is noteworthy that, for the first age group, the upper gonial angle was increased in the Angle class I group. Unlike the aforementioned cephalometric parameter, in the case of ***the lower gonial angle*** (which describes the direction of mandibular growth in vertical plane), the values recorded for Angle class III subjects were higher than those in the Angle class I group (table V.16, figure 5.16). The mean values of this angle exceeded the upper limit of normal variability (70-75°) in all Angle class III patients aged over 10 years, generally indicating a vertical growth pattern.

The mean values of the posterior facial height, as evidenced by **S to Go distance** (mm), were not significantly different between the two study groups for any age group. It can be noted, however, that, in descriptive terms, for the first two age groups (7-12 years), the values of this parameter were higher in Angle class III patients, in contrast to the last two age groups (13-18 years) for which the values were higher in Angle class I subjects.

If no significant differences were noted between the research groups for the posterior facial height, in the case of the anterior facial height, objectified by **N to Me distance** (mm), the results revealed significantly higher values in all Angle class III patients, irrespective of their age. In contrast to the posterior facial height, the differences between the two groups in terms of anterior facial height were more important (between 9.84 and 23.46 mm), with the largest being recorded for patients aged over 16 years.

The Jaraback index, as the ratio between the posterior facial height and the anterior facial height, expressed as a percentage, was found to have low values, below 59%, in the Angle class III subjects aged over 10 years. The values of this parameter differed statistically significantly between the two study groups only in the case of patients over 13 years old (AG3 and AG4).

It should be noted that, in the case of Angle class III patients, the Jaraback ratio fell within the limits of normal variability (59-63%) only in the case of the first age group (7-9 years). For Angle class III patients aged 13 to 18 years, the mean values suggest a tendency for posterior mandibular rotation.

Regarding the ***sexual dimorphism*** of Angle class III patients from the perspective of the variation of the cephalometric parameters under study, generally the results did not reveal statistically significant differences between the two sexes. Only for 5 investigated parameters and only for part of the age groups were significant differences found, all those parameters being dependent on the size and position of the mandible. Thus, the mean values of Pg-N perp., B-N perp. and Co to Gn were significantly higher in female subjects (aged 10–12 for the first two parameters and 7–9 for the third parameter). Significant differences between the two genders were also highlighted for the position of the mandibular horizontal ramus in vertical plane relative to the anterior portion of the skull base (∡SN-GoGn) and the Frankfurt horizontal (∡FMA), in the sense of significantly higher values in Angle class III male patients from age groups 16 and 18.

5.5. Discussions

Currently, the existing studies on the changes in cephalometric parameters in mandibular prognathism do not show a consensus. On the contrary, their results are contradictory.

In Angle class III malocclusions, changes in the sagittal plane are representative, even pathognomonic, shaping the characteristic clinical appearance of this group of anomalies. The most striking and aesthetically obvious changes are found in forms with severe mandibular and maxillary skeletal disorders, in terms of size and position.

Thus, regarding the maxilla, for the population sample of this research, the results showed that ***the position and size of the maxilla*** of Angle class III patients did not significantly differ from those of the Angle class I group.

The angular parameter SNA (∡SNA) showed that *the position of the maxillary base in the sagittal plane* relative to the anterior region of the skull base did not differ statistically significantly between the two groups, irrespective of the age group. However, from a descriptive point of view, it was nevertheless noted that in class III patients aged 16-18, the position of the maxilla was slightly more posterior compared to the class I patients. The results recorded for this parameter are also supported by A-N perp. (mm), which describes the linear position of the maxillary base in the sagittal plane in relation to the same region of the skull base, with similar values for the two study groups, irrespective of the age group. In these terms, the results of our study are in line with those of an extensive study conducted on a large group of adults, which shows that the position of the maxilla in relation to the anterior skull base, generally does not present significant differences between patients with mandibular prognathism and the control group with normal occlusion ratios (Vela, 2012). In turn, the research of Ramezanzadeh et al. (2007), who analyzed the antero-posterior position of the maxilla in relation to the cranial base in its anterior region, revealed a significantly more retrusive position of the maxilla in Iranian Angle class III patients aged 16-30 . In terms of *maxillary length*, respectively Co to A (mm), again there were no significant differences between the values of the two study groups for any of the age groups. Similarly to the results obtained by us, Farias et al. (2012) found that Brazilian child subjects with Angle class III malocclusions, who had no history of orthodontic treatment, had a similar maxillary length to that measured for the class I control group with the same stages of cervical vertebral maturation.

The cephalometric parameters that characterize the mandible showed the most significant, relevant and, also, specific variations in our research. Thus, for our study group, the mandible had *a significantly more anterior position* compared to the control group, the discrepancies being indicated by the angular parameter SNB and the linear parameters Pg-N perp. (mm) and B-N perp. (mm). In addition to the positional change, the mandibular length (measured between Co and Gn) was greater in the Angle class III sample than in the Angle class I sample. The increase in the mandible size was found for all age groups, with values ranging from 5.48 to 17.82 mm, the statistical significance being reached only in patients over 10 years of age. Our results were similar to those described by a substantial number of studies conducted on profile cephalograms in different age groups and populations (Mitani et al., 1993; Miyajima et al., 1997; Filho et al., 1997 and Farias et al., 2012). For example, the comparative study of the variation of cephalometric parameters in Japanese and Americans with European ancestry showed that mandibular protrusion may be considered the main component of Angle class III malocclusions in individuals of European ancestry (Miyajima et. al, 1997). Other studies (Sargod et al., 2013; Usman et al., 2022) also showed that in Angle class III patients, the mandible is prognathic even in the early stages of deciduous dentition, and becomes even more protruding over time. The data from our study confirm this assertion, highlighting the variation of mandibular parameters in the Angle class III group compared to the control group. In the context of our results, in conjunction with the findings reported in the literature, it can be considered that the total mandibular length and its anterior positioning are particular and specific criteria for the differential diagnosis of Angle class III anomalies.

The maxillomandibular difference provides information on the horizontal positioning of the mandible with respect to the maxilla, and is correlated with the angular parameter ANB and the linear parameter AoBo. Thus, in our study, the difference between the maxillary and mandibular length was significantly greater in Angle class III patients compared to Angle class I patients, regardless of their age, but the greatest difference between the two groups was recorded in patients older than 16 years.

As for ***the variables related to the skull base***, our research analyzed the sphenoidal angle and the articular angle, both of which are described in the Björk-Jarabak cephalometric analysis.

As pointed out in the first part of the PhD thesis, data from the literature emphasize the existence of a correlation between the marked flexion of the skull base and the more anterior positioning of the mandible, with a tendency to evolve towards Angle class III malocclusions. However, the results of our study did not reveal any significant difference between the mean values of the sphenoid angle for the two groups, regardless of the age group. Yet, the values of the sphenoid angle were within the normal range of variability for both groups. Although most studies show a reduction of the sphenoid angle in mandibular prognathism (Björk, 1955; Korkhaus, 1957; Ellis and McNamara, 1984; Reyes et al., 2006; Proff et al., 2008; Berger et al., 2011), there are other studies with similar results to ours regarding the value of this angle. Thus, Farias et al. (2012) revealed that the values of this parameter were not found to be lower in patients with Angle class III malocclusions than in Angle class I controls.

Closely related to the preceding parameter and part of the Björk-Jarabak polygon is the articular angle. Rakosi (1982) argues that the importance of the SArGo angle assessment is related to its practical applicability in orthodontic therapy, as the articular angle is one of the few cephalometric angles that can be modified during orthodontic treatment. In our study, the articular angle did not differ statistically significantly between the groups under study for any age group and the mean values were within normal variability. Our results are not in line with the findings of Björk (1963) and Hashim et al. (2023) who showed that a lower articular angle suggests an anterior position of the glenoid fossa, associated with a class III skeletal pattern.

The clinical expression of sagittal skeletal discrepancies in mandibular prognathism also varies according to the changes that occur in the vertical plane.

The angles formed between the mandibular basal plane and the Frankfurt horizontal, respectively with the anterior portion of the skull base, represent relevant cephalometric parameters in assessing the facial skeletal typology in vertical direction. Recording the values of these angles during the analysis of profile cephalograms is useful when diagnosing the type of dento-maxillary malocclusion, as an important indicator in determining the subsequent therapeutic conduct.

In our study, statistically significant differences were noted between the two groups analyzed as regards the vertical position of the mandibular horizontal ramus relative to the anterior portion of the skull base expressed by ∡SN-GoGn, and to the Frankfurt horizontal shown by ∡FMA. The values obtained for ∡SN-GoGn and ∡FMA were generally higher for the Angle class III malocclusion, the differences being statistically significant for subjects older than 13 years. As can be seen from the analysis of these two cephalometric parameters, most of the patients with Angle class III malocclusion from our research group show a hyperdivergent growth pattern, with marked obliquity of the mandibular horizontal ramus and posterior rotation of the mandible. In a study that is similar to my research, conducted in a group of Caucasian patients from Brazil (Vasconcelos et al., 2014) in patients with Angle class III malocclusions, ∡SN-GoGn and ∡FMA were within normal variability, but the values were discretely lower than those recorded for the patients in the control group, although the differences were not statistically significant.

The gonial angle is a valuable parameter in describing mandibular morphology and plays an important role in predicting the direction of mandibular growth in the vertical plane. Values of the angle exceeding the normal range indicate a vertical pattern of mandibular growth (posterior mandibular rotation), whereas low values suggest a horizontal growth pattern (anterior mandibular rotation). In our study, the mean values of the gonial angle (∡ArGoMe) were higher in all patients with Angle class III malocclusions than in the control group, and the results were statistically significant for subjects older than 10 years. The results of our research are in line with those obtained in other studies in the field with a similar methodology (Guyer et al., 1986; Sato, 1994; Al-Shamout et al., 2012, Leversha et al., 2016). The increased values of the gonial angle in our research and in the studies mentioned above suggest the existence of mandibular excess in the group of patients with Angle class III malocclusion, with clear clinical expression in the vertical plane. On the other hand, in a 1998 study, Singh, McNamara and Lozano found that in a group of 73 subjects aged 5 to 11, the gonial angle values were lower in Angle class III subjects than in those with Angle class I malocclusions.

By dividing the gonial angle into two components by tracing a straight line from N to Go, additional information about the mandibular growth pattern can be obtained. Thus, in our study we found an important variation in the two segments of the gonial angle, especially in its lower portion. The values recorded for the upper gonial angle were within normal variability but, for the lower gonial angle, the values were higher in subjects with Angle class III malocclusions than those in the Angle class I group. Furthermore, the mean values of the lower gonial angle exceed the limit of normal variability (70-75°) in all patients older than 10 years with Angle class III malocclusion, which generally indicates a posterior mandibular rotation.

In the literature there is no consensus on the variation of the gonial angle and its segments as proposed by Jaraback (1972). In their 2015 study, Rubika et al. noted that the upper gonial angle was the same regardless of the facial pattern examined. The same authors conclude that the gonial angle and the lower gonial angle may be used as indicators of the mandibular growth pattern. Using the Björk-Jarabak cephalometric analysis, Rodriguez-Cardenas et al. (2014) found that patients with skeletal class III malocclusions had significantly higher values of the gonial angle and upper gonial angle than the other skeletal classes.

For *Jarabak ratio*, our study recorded lower values for Angle class III patients, suggesting that these patients generally have posterior mandibular rotation and, extrapolating, in some cases, a tendency towards skeletal open occlusion. This is not a favorable finding for our Angle class III group, as the association of mandibular prognathism with open occlusion is known to be an aggravating factor in terms of prognosis. Most authors agree that a favorable outcome of early treatment of Angle class III malocclusion is associated with a smaller gonial angle and facial hypodivergence, whereas an unfavorable outcome is related to a vertical growth pattern (Tahmina et al., 2000; Moon et al., 2022). As shown by the statistical analysis, the variation in Jarabak ratio was not predominantly due to changes in the *posterior facial height*, but to significantly higher values of the *anterior facial height* in Angle class III patients in all age groups.

In relation to gender, our study generally found no statistically significant differences in cephalometric parameters between female and male subjects with mandibular prognathism. Statistically significant differences were only found for 5 cephalometric parameters concerning the size and position of the mandible. In this regard, for the linear cephalometric parameters Pg-N perp., B-N perp. and Co-Gn, the values recorded in the female group were higher than those of the male subjects. The mean values of the angles formed between the mandibular basal plane and the Frankfurt horizontal, respectively the anterior portion of the skull base, were significantly higher for male subjects only in the 16-18 age group. The variation of these 5 cephalometric parameters in our research can be explained by the particularities of mandibular growth and development processes. According to the research conducted by Lewis and Roche (1997) on the general population, mandibular growth spurts occur 1.5 to 2 years later in males, but over a longer period of time compared to female subjects. According to the studies conducted by Baccetti et al. (2007), mandibular length growths were substantially greater in the Angle class III group than in the neutral occlusion group, even in the more mature age range (15 to 16 years), and the anterior facial height increased significantly more in class III individuals during the later stages of development.

5.6. Conclusions

The research highlighted a series of cephalometric changes specific to the Angle class III malocclusion for the study group under analysis. Thus, it was found that:

- the position of the maxilla in the sagittal plane in relation to the skull base (assessed by the angular parameter ∡SNA and linearly by A-N perp.) and its mean size (assessed by Co to A) did not differ significantly between Angle class III patients and Angle class I patients, the values falling within the normal variability;
- the variation of the mandibular cephalometric parameters showed representative changes, in the sense of mandibular overdevelopment (assessed by Co to Gn);
- the sagittal position of the mandible in relation to the skull base showed a protrusion of the mandible (revealed by the angular parameter ∡SNB and linearly by the B-N perp. and Pg-N perp.). The mandibular protruding aspect is also emphasized by the considerably longer mean length in class III patients compared to the control group;
- the greatest differences in the size and position of the mandible were recorded for patients aged 16-18, with mandibular changes becoming more evident/marked as the patient grew older;
- the mean difference between the maxillary length (Co-A) and the mandibular length (Go-A) in Angle class III was at least 5.54 mm greater than in class I in all age groups (5.54 mm in AG1 and 16.61 mm in AG4), this parameter correlating with the discrepancies highlighted by ∡ANB and Ao to Bo;
- the sphenoidal angle and the articular angle did not significantly differ from Angle class I patients. The values were generally within the normal range of variability for both parameters. However, the sphenoidal angle suggested a tendency of mandibular protrusion in patients older than 10 years (the values were at the lower limit of the normal range);
- the values of the gonial angle were higher in Angle class III subjects than in Angle class I subjects, with differences becoming more significant as aged increased;
- the most important changes were recorded for the lower gonial angle, the values of this parameter being significantly higher for Angle class III patients older than 10 years. These results suggest a tendency to predominantly vertical changes, with a reduction in frontal overcoverage, in Angle class III patients, there being a risk of association of Angle class III malocclusion with open occlusion;
- the upper gonial angle had higher values in Angle class III patients (except for the last age group) but still within normal variability;

- the values of the gonial angle correlated with changes in the anterior facial height (N-Gn), which were higher in Angle class III patients than in Angle class I patients, for all age groups;
- the aforementioned changes, together with the results for Jaraback index, indicate a tendency to posterior mandibular rotation in the Angle class III patients from our research group;
- the position of the horizontal mandibular ramus in the vertical plane in relation to the anterior portion of the skull base and to the Frankfurt horizontal varied between the two groups examined, with more pronounced obliquity for Angle class III subjects, significantly for patients over 13 years of age;
- the severity and evolution of the Angle class III malocclusion (∡SNB and the difference between maxillary and mandibular length) can be recognized by certain features as early as the age of 7-9 years, but their best expression is after pubertal growth spurt (after 13-15 years) with maximum shaping for the 16-18 olds. The last age group displays the most important cephalometric changes in the vertical plane as well, but there are still parameters suggesting a vertical growth pattern already in the first age group, namely the gonial angle and the anterior facial height;
- in general, the values of the cephalometric parameters under investigation do not show sexual dysmorphism (except for 5 parameters characterizing the position and size of the mandible);

In conclusion, for our research group, mandibular prognathism is largely the consequence of mandibular (positional and dimensional) rather than maxillary changes, and is associated with a vertical growth pattern.

Our research underlines the importance of studying cephalometric changes in both the sagittal and vertical in patients with mandibular prognathism as early as childhood, since such changes may suggest an evolution of the malocclusion towards severe skeletal imbalances.

CHAPTER 6. CHANGES IN DENTOALVEOLAR CEPHALOMETRIC PARAMETERS IN PATIENTS WITH MANDIBULAR PROGNATHISM

As already presented, the Angle class III malocclusion (mandibular prognathism) is characterized by a remarkable phenotypic heterogeneity, with complex skeletal discrepancies in terms of location and severity. In this malocclusion, dentoalveolar changes may significantly alter the clinical picture (worsening it or masking underlying skeletal imbalances) thus increasing the variety of its forms.

In this regard, the study of dental and dentoalveolar changes becomes necessary, on the one hand from a diagnostic perspective and on the other hand from the perspective of orthodontic treatment planning.

6.1. Working hypothesis

Mandibular prognathism involves dental and dentoalveolar changes that may mask the underlying skeletal discrepancies or, on the contrary, may aggravate the clinical picture. Identifying the location, direction and severity of the dentoalveolar changes is an indispensable tool in establishing the diagnosis of the dento-maxillary anomaly and hence in developing the treatment plan.

6.2. Goals of the study

In the context of the hypothesis mentioned above, for the group of patients with mandibular prognathism in my doctoral research, I set out to identify:

- changes in the sagittal inclination of the mandibular and maxillary incisors;
- changes in the antero-posterior position of the mandibular and maxillary incisors;
- changes in the sagittal inclination of the mandibular and maxillary incisor alveolar process;
- the extent of changes in the inclination and position of the incisors according to the patient's age.

6.3. Material and method

For this purpose, 8 cephalometric parameters were analyzed, of which 6 angular and 2 linear (table VI.1).

As explained in Chapter 4 (General methodology of scientific research), the research group was the same in both studies, so that the interpretation of the profile cephalograms was extended to the dentoalveolar cephalometric parameters.

Table VI.1. Dentoalveolar cephalometric parameters and limits of normal variability

Cephalometric parameter	***Description and limits of normal variability***
Angular cephalometric parameters	
∡ IMPA (º)	the angle between the axis of mandibular incisors and the mandibular basal plane, showing the sagittal inclination of mandibular incisors relative to the mandibular basal plane. Normal values: 90+/-5°
∡i-NB (º)	the angle between the axis of the mandibular incisors and the line from Nasion to Downs B point, indicating the sagittal inclination of the mandibular incisors relative to the NB line. Normal values: 25° (pentru ANB 2°)
∡ IdB-GoMe (º)	the angle between the straight line running from Downs Id to B points and the mandibular basal plane, reflecting the sagittal inclination of the lower alveolar profile relative to the mandibular basal plane. Normal values: 80+/-5°
∡I-F(º)	the angle between the axis of maxillary incisors and the Frankfurt horizontal, describing the sagittal inclination of maxillary incisors relative to the Frankfurt horizontal. Normal values: 107°
∡I-NA (º)	the angle between the axis of maxillary incisor and the line from Nasion to Downs A point, indicating the sagittal inclination of the maxillary incisors in relation to the NA line. Normal values: 22° (for ANB 2°)
∡PrA-F(º)	the angle between the line joining point Pr with Downs A point and the Frankfurt horizontal, reflecting the inclination of the upper incisal alveolar profile relative to the Frankfurt horizontal. Normal values: 110+/-5°
Linear cephalometric parameters	

i to NB (mm)	the distance between the most vestibular crown point of the mandibular incisor and NB line, reflecting the sagittal position of the mandibular incisor. Normal values: 4 mm (for ANB 2°)
I to NA (mm)	the distance from the most vestibular point of the maxillary incisor crown to NA line, indicating the sagittal position of the maxillary incisor. Normal values: 4 mm (for ANB 2°)

6.4. Results

In terms of dentoalveolar changes, the research results were analyzed by two categories: mandibular cephalometric parameters and maxillary cephalometric parameters.

6.4.1. Mandibular dentoalveolar cephalometric parameters

The results of the statistical analysis of the dentoalveolar changes in the mandibular incisors as measured by IMPA angle, i-NB angle, i to NB distance (mm) and idB-GoMe angle indicated significant and highly significant differences between the two groups (table VI.2).

Table VI.2. Descriptive statistical elements of mandibular dentoalveolar cephalometric parameters

Age group	Class III		Class I		Mean difference	P
	M	SD	M	SD		
∡ IMPA (°)						
AG1	90.52	4.35	91.17	4.08	0.64	0.444
AG2	86.06	9.11	93.43	4.57	7.37	0.195
AG3	83.12	3.74	98.87	0.62	15.75	**≤ 0.001**
AG4	81.32	6.14	102.16	2.22	20.84	**0.004**
∡i-NB (°)						
AG1	24.22	4.88	21.85	4.10	2.36	0.283
AG2	24.25	6.64	21.66	0.77	2.58	0.325
AG3	19.70	1.64	28.95	1.02	9.25	**≤ 0.001**
AG4	18.00	6.4.	27.99	3.38	9.99	**0.053**
i-NB (mm)						
AG1	3.96	1.31	2.72	1.72	1.24	0.177
AG2	3.89	0.96	3.67	0.91	0.22	0.399
AG3	3.50	0.80	6.13	1.38	-2.63	**0.010**
AG4	2.60	0.88	6.46	1.68	-3.86	**0.007**
∡ IdB-GoMe (°)						
AG1	91.33	4.44	86.73	1.16	4.60	0.15
AG2	81.20	6.16	84.33	2.89	3.13	0.262
AG3	74.30	5.72	92.25	6.75	17.95	**0.024**
AG4	81.00	7.20	91.33	2.44	10.33	**0.045**

The ***IMPA angle***, which describes the sagittal inclination of the mandibular incisors in relation to the mandibular basal plane, showed lower values in the group of Angle class III patients, regardless of age. The differences between the two groups were statistically significant for the 16-18 age group and highly statistically significant for the 13-15 age group. For Angle class III subjects aged between 13 and 18 years, the mean values recorded were lower even in relation to the limits of normal variability described in the literature (90+/-5°). If in the 7-9 age group the mean values recorded for the IMPA angle were similar, as the age increased the variation of this parameter in the Angle class III group showed a progressive decrease, with the minimum value recorded in the 16-18 age group (i.e. 81.32°).

The variation of the results indicates significantly lower ***i-NB angle*** values in Angle class III patients over 13 years of age compared to the control group, with differences between the two groups reaching almost 10° (AG4). It is also found that, for Angle class III patients, the i-NB angle (°) decreases significantly after the age of 13.

The variation of ***i to NB***, as the distance between the most vestibular coronal point of the mandibular incisor and NB line, which indicates the antero-posterior position of the mandibular incisors, is similar to that of the i-NB angle in that the mean values are significantly lower in Angle class III patients aged 13 and more compared to the control group.

The cephalometric parameter that we used to assess the sagittal inclination of the alveolar process in the mandibular incisor region is the IdB-GoMe angle. The results of the statistical analysis indicated lower values of this parameter in Angle class III patients over 10 years of age than in Angle class I patients. Referring to the data reported in the literature as normal for idB-GoMe angle (80+/-5°), the mean values recorded for our Angle class III group fell within the normal range of variability. Exceptions were the subjects aged 7-9, for whom the mean idB-GoMe angle was above the upper limit of the normal range.

When comparing the mean values recorded in the Angle class III group for ∡IMPA and ∡IdB-GoMe, we found no significant differences between the antero-posterior inclination of mandibular incisors and that of the underlying alveolar process relative to the mandibular basal plane.

6.4.2. Maxillary dentoalveolar cephalometric parameters

With regard to the dentoalveolar changes in maxillary incisors, the results of the study revealed variation in all cephalometric parameters investigated between the two groups, but statistically significant differences were only found for 3 parameters, namely ∡I-NA, I to NA and ∡PrA-F (table VI.3).

Table VI.2 Descriptive statistical elements of maxillary dentoalveolar cephalometric parameters

Age group	Class III		Class I		Mean difference	P
	M	SD	M	SD		
∡I-F (°)						
AG1	106.27	4.92	105.15	3.96	1.13	0.397
AG2	114.81	6.74	107.00	4.67	7.81	0.218
AG3	115.60	7.36	115.00	1.20	0.60	0.457
AG4	119.60	4.88	112.65	3.53	6.95	0.153
∡I-NA (º)						
AG1	17.04	3.84	17.15	4.17	0.11	0.488
AG2	25.82	5.30	22.07	3.29	3.75	0.409
AG3	26.09	1.52	23.98	0.74	2.12	**0.049**
AG4	30.24	2.29	23.02	3.35	7.22	**0.033**
i-NA (mm)						
AG1	1.82	1.34	1.17	1.16	0.65	0.288
AG2	4.93	1.49	3.33	0.89	1.60	0.184
AG3	5.91	0.89	4.98	0.68	0.94	0.103
AG4	7.44	1.55	3.18	0.79	4.26	**0.027**
∡PrA-F (°)						
AG1	101.00	18.67	104.50	14.50	3.50	0.247
AG2	110.80	5.44	108.67	4.22	2.13	0.699
AG3	113.38	1.66	107.25	2.75	6.13	**0.016**
AG4	119.00	3.60	109.67	3.11	9.33	**0.026**

The statistical analysis of the values recorded for **∡I-F** found no significant differences between the two study groups. Nonetheless, from a descriptive point of view, although statistically insignificant, the mean values of ∡I-F for the Angle class III group of patients were higher than those for the Angle class I subjects.

The sagittal inclination of the maxillary incisors can also be assessed by their relation to ***I-NA(º) angle***. In Angle class III patients aged over 10 years, the ∡I-NA values were higher than in Angle class I patients, and statistically significant in patients aged over 13 years.

The results obtained for I to NA distance are similar to those obtained for the previous parameter, meaning higher values for Angle class III patients. The most important differences between the two groups were recorded for patients aged between 16 and 18, the differences (4.26 mm) being statistically significant.

Considering the role that the alveolar process plays in shaping the complex picture of mandibular prognathism, we used the cephalometric parameter **∡PrA-F(º)** to track changes in the vestibulo-oral inclination of the maxillary alveolar profile in the incisor area. When comparing the results between the two groups, the mean values of ∡PrA-F(º) were higher for class III patients over the age of 10, with statistically significant differences only for ages 13-18 (AG3 and AG4).

6.5. Discussions

As emerges from the results of my research, as well as from the review of the literature, Angle class III malocclusion appears as a dento-maxillary anomaly with a strong polymorphic character. The most severe forms of this dento-maxillary malocclusion are characterized by complex skeletal changes, which disrupt the functional balance of the dento-maxillary apparatus, also associating various dental and dentoalveolar changes. From this perspective, the dental and dentoalveolar changes can be aggravating or compensatory for the malocclusion.

Thus, for the variation of the mandibular dentoalveolar cephalometric parameters, the results of the statistical analysis of ***dentoalveolar changes in the mandibular incisors*** showed significant and highly significant differences between the two research groups.

In our research, the mean value of ***IMPA angle*** was lower in Angle class III patients, and statistically significant for those between 13 and 18 years of age. The mean values of IMPA angle for Angle class III patients in this age group were below the lower limit of the normal range described in the literature (85-95° according to the Ballard method quoted by Firu, 1983), thus indicating a lower retrodention.

Although the analysis of the IMPA angle is still a valuable diagnostic tool, some research has emphasized both the limitations of this parameter and the importance of associating the IMPA angle with other cephalometric parameters (Elfouly et al., 2019; Zhang et al, 2023). Among them are those of Steiner's cephalometric analysis which relates the mandibular incisors to the line joining the Nasion point to Downs B point. The sagittal inclination of mandibular incisors is assessed in relation to the NB line by angle i-NB (°), and the position of the incisors is assessed by measuring the distance between the incisal edge/most anterior coronal point of the mandibular incisor and the reference line (i to NB distance). It is important that both cephalometric parameters be interpreted together, as the use of only one of them may provide erroneous/insufficient information about the position of the incisors (Jacobson and Jacobson, 2006). The results of my research showed significantly lower values of the i-NB angle and i to NB distance in Angle class III patients older than 13 years, which indicates a posteriorward positioning and inclination of the mandibular incisors in patients with mandibular prognathism as compared to the control group.

In the context of any orthodontic treatment aiming to maintain the dental position within the bony envelope, it is important to relate the sagittal inclination of the incisors to the sagittal inclination of the alveolar process. The variation of the IdB-GoMe angle revealed lower values in Angle class III patients older than 10 years compared to the Angle class I group, indicating a compensatory lingual inclination of the alveolar process in this age group. It was only in Angle class III patients aged between 7 and 9 that the mean value of the idB-GoMe angle was above the normal variability described in the literature, suggesting the existence of proalveolia associated with the inferior prodention in this age group. For both dental changes and alveolar process, the result can be explained in terms of the patients' young age, in whom tooth eruption may still be incomplete. The results of our study are in line with those in the literature, showing that a dentoalveolar compensation phenomenon is observed in Angle class III patients with skeletal changes. (Yamada et al., 2007; Kim et al., 2014) These authors emphasize that the axis of the lower incisors and the related alveolar process varies with the facial pattern in an antero-posterior direction.

Three angular cephalometric parameters (∢I-F, ∢I-NA and ∢PrA-F) and one linear cephalometric parameter (I to NA) were used to emphasize ***the dento-alveolar changes in the maxillary incisor group.***

As regards the inclination of maxillary incisors with respect to the Frankfurt horizontal, my research revealed no statistically significant differences between the two study groups. However, on the whole, the mean values of ***∢I-F*** suggest a more accentuated maxillary incisor vestibulo-inclination in Angle class III patients compared to the Angle class I patients, albeit without statistical significance. When comparing the results obtained in our study with the mean normal values for this angular parameter provided by the literature (Rakosi, 1979; Firu, 1983; Milicescu, 2001), we found that the mean value of the I-F angle in Angle class III patients fell within the normal variability.

In my research, the mean values of I-NA angle and I to NA distance were higher for the sample of patients with Angle class III malocclusion. However, the differences between the two groups were statistically significant only for the age group 13-18 years (for ∡I-NA) and for the range 16-18 years (for I to NA distance), respectively. Literature data on dentoalveolar changes in Angle class III patients generally describe the presence of prodention and superior proalveolia as a compensatory mechanism for the skeletal intermaxillary discrepancy (Ellis and McNamara, 1984; Al-Balkhi and Al-Zahrani, 1994; Ishii, et al., 2002; Elfouly, 2019). The results of our study are similar to those published by Mouakeh et al. (2001), who found that, in the group of Syrian Angle class III children under examination, the maxillary incisors were not protrusive, as expected for typical dental compensation, but on the contrary, the upper incisors were excessively vertical (palatally inclined) while the mandibular incisors were only slightly lingually inclined. This finding emphasizes that the patient's age correlates with the degree of dentoalveolar compensation in Angle class III patients.

Considering how important it is to analyze dental changes in the context of the supporting bone substrate, I analyzed the variation **∡PrA-F(º)** in order to describe the vestibulo-oral inclination changes of the superior frontal alveolar profile. The results of my research showed that the mean values of PrA-F angle were significantly higher for class III patients aged 13 years and older compared to those with patients with Angle class I malocclusion. With respect to the limits of normal variability indicated by Firu for this parameter (105-115°), the mean values of the PrA-F angle recorded in my Angle class III group indicated the presence of superior retroalveolia in patients aged 7-9. For Angle class III patients, the PrA-F angle showed increasing values during growth, with the 16-18 age group showing superior proalveolia.

6.6. Conclusions

From the results of this research we draw the following conclusions regarding the changes in dentoalveolar cephalometric parameters in Angle class III patients (from our population group):

- the cephalometric parameters evaluating the sagittal inclination (IMPA angle, i-NB angle) and the antero-posterior position (i to NB distance) of the mandibular incisors showed lower values in the Angle class III group, with statistically significant values at ages over 13 years;
- the inclination of the alveolar process in relation to the mandibular basal plane (assessed by the IdB-GoMe angle) correlated with that of mandibular incisors in Angle class III patients, regardless of the patient's age;
- the sagittal inclination of the maxillary incisors in relation to the Frankfurt horizontal was within normal variability, with no statistically significant differences in comparison with the group of Angle class I patients;
- I-NA angle (°) and I to NA distance (mm) revealed a significantly more anterior inclination and positioning of the maxillary incisors, respectively, in Angle class III patients aged 13 years and older compared to those with Angle class I malocclusion;
- the sagittal inclination of the alveolar process of the maxillary incisor group, as reflected by the PrA-F angle, follows the variation of the maxillary incisor axis for all age groups, maintaining an optimal position of the teeth in the supporting structures;
- the results obtained for all dentoalveolar cephalometric parameters varied according to the patients' age;
- the sagittal inclination of the alveolar process and mandibular incisors in relation to the mandibular basal plane decreases with increasing age (the lingual inclination of the incisors and of the mandibular alveolar process is accentuated), while in the maxillary arch the angle between the Frankfurt horizontal and the axis of the upper incisors and respectively of the alveolar process of the upper incisor group increases (the vestibulo-inclination of the incisors and of the maxillary alveolar process is accentuated), as a compensatory mechanism to maintain stable occlusal ratios during growth;

- the dentoalveolar changes that have a compensatory effect on the class III malocclusion with skeletal involvement (of the mandibular and maxillary base) occur predominantly in the mandibular incisor group, as compared to the maxillary incisor group.

In the light of these coordinates, the importance of evaluating changes in the inclination and position of incisors and alveolar processes for the diagnosis and planning of orthodontic treatment in Angle class III patients is evident.

GENERAL CONCLUSIONS

The results of the scientific research conducted as part of my doctoral thesis, corroborated with the data collected from the literature, demonstrate that mandibular prognathism (Angle class III malocclusion) is a distinct pathology, which takes many clinical forms, and is in fact a consequence of the association of multiple skeletal and dentoalveolar changes.

The variation of specific skeletal and dentoalveolar cephalometric parameters indicates the site, direction and extent of the changes, each of the affected morphologic components being responsible for the complex nature of this pathology.

From the critical review of the results of our scientific research, several conclusions having both a general but also a specific character for patients with mandibular prognathism stand out:

- **Skeletal changes**

Skeletal changes are found both in the sagittal and in the vertical plane, being representative for this type of dento-maxillary anomaly and significantly influencing its clinical expression. However, it should be noted that skeletal changes in the sagittal plane are the most evident and are actually pathognomonic.

- ***skeletal changes are predominantly localized to the mandible***, in the sense of overdevelopment (evidenced by increased Co to Gn) and a protrusive positioning (more anterior sagittal positioning) (∡SNB, B-N perp. and Pg-Nperp. with increased values);

- the ***size*** (assessed by Co to A) and the ***anteroposterior position of the maxilla*** (assessed by ∡SNA and A-N perp) ***do not show significant changes***;

- the ***sphenoidal angle*** (∡NSAr) and the ***articular angle*** (∡SArGo), describing changes in the skull base/ parameters related to the skull base, were within normal variability;

- the ***marked obliquity of the mandibular horizontal ramus*** relative to the anterior portion of the skull base and to the Frankfurt horizontal (evidenced by increased ∡SN-GoGn and ∡FMA) indicates a ***hyperdivergent facial growth pattern***;

- the ***gonial angle*** (∡ArGoMe) and, in particular, the ***lower gonial angle*** (∡NGoMe), displayed increased mean values suggesting a ***tendency to posterior mandibular rotation***, with a reduction in the frontal overcoverage as growth progresses, with the risk of association of mandibular prognathism with open occlusion;

- ***increased anterior facial height*** (N to Gn distance) and ***reduced Jaraback index values*** (S-Go/N-Me %) support the skeletal changes in the vertical plane revealed by the parameters mentioned above;

- ***skeletal changes do not display sexual dimorphism***, with a few exceptions *concerning the position and size of the mandible* (in some of the female subjects under 13 years of age, the increase in Co to Gn indicates a more developed mandible in terms of size, while the increase in the Pg-N perp. and B-N perp. indicate a more anterior position of the mandible. However, these differences become insignificant after this age) and, respectively, the obliquity of the horizontal ramus of the mandible (some of the male subjects aged over 16 years show increased values of ∡SN-GoGn and ∡FMA, which indicate a more accentuated obliquity of the horizontal ramus of the mandible);

- **Dentoalveolar changes**

The variation in dentoalveolar changes is lower than in skeletal changes, it is generally compensatory in nature, and not as clinically expressive as skeletal discrepancies:

- ***compensatory dentoalveolar changes occur predominantly in the mandibular incisor group*** as opposed to the maxillary incisor group;

- the ***mandibular incisors display a lingual inclination*** and/or ***lingual positioning*** whose severity increases as the intermaxillary sagittal discrepancy increases, whereas the maxillary incisors generally maintain an antero-posterior inclination within the limits of normal variability;

- the ***inclination of the alveolar process was correlated with the inclination of the incisors***, both in the mandibular and in the maxillary arch, regardless of the patient's age, thus maintaining an optimal position of the teeth in the supporting structures;

Both ***skeletal and dentoalveolar changes*** vary depending on the patients' ***age***.

Thus:

- the mandibular skeletal changes in the sagittal plane (emphasized by Co to Gn distance, ∡SNB, Pg-N perp. and B-N perp.), the skeletal changes in the vertical plane (revealed by ∡FMA, ∡gonial and anterior facial height), as well as the sagittal intermaxillary skeletal discrepancy (as measured by ∡ANB, Ao to Bo distance and maxillomandibular gap) became more pronounced with age. As for the dentoalveolar changes, the lingual inclination of the alveolar process and mandibular incisors was seen to increase with age;

- ***the changes indicated by specific cephalometric parameters generally begin to take shape after the age of 10 (for skeletal changes) and respectively 13 (for dentoalveolar changes)***, but their maximum expression is emphasized for the 16-18 age group;

- although the clinical picture of mandibular prognathism is especially evident after the age of 16, there are ***a number of cephalometric parameters*** (∡SNB, maxillomandibular difference, gonial angle and anterior facial height) ***that indicate a tendency towards a certain skeletal pattern as early as 7-9 years of age***, which underlines the high practical usefulness of analyzing these cephalometric parameters in establishing the early diagnosis of this dento-maxillary malocclusion.

Summarizing, the interpretation of cephalometric parameters described a phenotypic diversity of mandibular prognathism, with multiple changes, the most representative being the skeletal ones, while the dentoalveolar changes are secondary in terms of expression of this pathology. Sagittal skeletal discrepancies are generally the consequence of (positional and dimensional) mandibular changes and less so of maxillary changes, to which a hyperdivergent vertical growth pattern is associated. As far as the dentoalveolar changes are concerned, the compensation of the malocclusion was mainly due to the lingual inclination of the mandibular incisors and alveolar process. Both the skeletal and the dentoalveolar changes became more marked with age, an observation that emphasizes the importance of early detection and appropriate therapeutic intervention.

Supporting the importance of the integrated analysis of specific cephalometric parameters describing the skeletal and dentoalveolar changes that provide a complete picture of mandibular prognathism, the results of my research have applicability in the current practice of the specialists who deal with this type of pathology, being known that establishing a correct diagnosis allows the approach and the initiation of orthodontic treatment at the optimal time, as well as its individualization according to the various skeletal and dentoalveolar manifestations of mandibular prognathism.

Selective bibliography

1. Al-Balkhi, K., și Al-Zahrani A. The pattern of malocclusions in Saudi Arabian patients attending for orthodontic treatment at the College of Dentistry, King Saud University, Riyadh. Saudi Dent J, 6(3), (1994): 138-44.
2. Al-Shamout, R., Ammoush M., și Al-Habahba A. Age and gender differences in gonial angle, ramus height and bigonial width in dentate subjects. Pak Oral Dent J. 32(1), (2012).
3. **Aristide, Andrei Sorin**, Anca-Oana Dragomirescu, Elena-Claudia Coculescu, Maria-Angelica Bencze, și Ecaterina Ionescu. Morphological characteristics of mandibular symphysis and sagittal inclination of lower incisors in class III malocclusion according to facial divergence pattern. Romanian Journal of Oral Rehabilitation,15(4):19-27 (2023); https://rjor.ro/morphological-characteristics-of-mandibular-symphysis-and-sagittal-inclination-of-lower-incisors-in-class-iii-malocclusion-according-to-facial-divergence-pattern/ ; indexare ISI cu FI 0.6; (lucrare realizată din capitolul 6 al tezei de doctorat)
4. **Aristide, Andrei Sorin**, Anca-Oana Dragomirescu, Maria-Angelica Bencze, Andreea Băluță, și Ecaterina Ionescu. Vertical Cephalometric Characteristics in Class III Malocclusions. Current Health Sciences Journal, 48(4):446-453 (2022); https://www.chsjournal.org/CHSJ/papers/CHSJ.48.04.12.pdf ; indexare PubMed, BDI (lucrare realizată din capitolul 5 al tezei de doctorat).
5. Baccetti, T. F. Growth in the untreated Class III subject. Seminars in orthodontics, 13(3), (2007): 130-142.
6. Berger, O. P. D. A., Marchioro E. M., Rizzato S. M. D., și Lima E. M. S. D. Comparative study of linear and angular measures of the cranial base in skeletal Class I and III malocclusion. Rev Odonto Ciên, (2011), 26, (2), 126-132.
7. Björk, A. Variations in the growth pattern of the growing mandible. JDent Res (1963); 42:406-32.
8. Björk, A. Facial growth in man, studied with the aid of metallic implants. Acta Odontol Scand. (1955), 13, (1), 9-34.
9. Capelozza, Filho L.: Diagnóstico en Ortodontia, Dental Press, Maringá, (2004).
10. Dhopatkar, A., Bhatia S., și Rock P.: An investigation into the relationship between the cranial base angle and malocclusion. Angle Orthod. (2002), 72, (5), 456-463.
11. Elfouly, Dina, Marzouk, Eiman, Ismail, și Hanan. Cephalometric Features Of Angle Class III Malocclusion With Different Dentoalveolar Compensation (Retrospective Study). Egyptian Orthodontic Journal. 55. 25-38. 10.21608/eos.(2019), 77125
12. Ellis, E (3rd), și McNamara JA Jr. Components of adult Class III open-bite malocclusion. Am J Orthod. (1984), Oct;86(4):277-90. doi: 10.1016/0002-9416(84)90138-6. PMID: 6592976.
13. Ellis, E., și McNamara Jr. J. A.: Components of adult Class III malocclusion. J Oral Maxillofac Surg. (1984), 42(5), 295-305.doi: 10.1016/0278-2391(84)90109-5. PMID: 6585502.
14. Farias, V. C., De Souza Tesch, R., Victor, O., Denardin, P., și Ursi W. Early cephalometric characteristics in Class III malocclusion. In Dental Press J Orthod (Vol. 17, Issue 2). (2012).
15. Firu, P. Stomatologie infantilã. Ed. Didactică şi Pedagogică. București. (1983).
16. Guyer, E. C., Ellis III E. E., McNamara Jr J. A., și Behrents R. G.Components of Class III malocclusion in juveniles and adolescents. Angle Orthod. 56, (1), (1986): 7-30.
17. Hashim, Hayder, AL-Sayed, Najat, Gsouma, Imen, Hashim, și Mohamed. Bjork-Jarabak Analysis in Different Anteroposterior Skeletal Relationship: A Comparative Study. Oral Health and Dental science. 7. 10.33425/2639-9490.1135. (2023).
18. Ishii, N., Deguchi T., și Hunt NP. Craniofacial differences between Japanese and British Caucasian females with a skeletal Class III malocclusion. Eur J Orthod. (2002) Oct;24(5):493-9.

19. Jacobson, A., Evans W. G., Preston C. B., și Sadowsky P. L. Mandibular prognathism. *Am J Orthod*. 66, (1974): 140-171.
20. Jacobson, A., și Jacobson R. L. Radiographic Cephalometry. From Basics to 3D Imaging. 2nd edition. Quintessence Publishing Co, Chicago, (2006).
21. Jieni, Zhang, Yuqi Liang, Rui Chen, și Si Chen. Inclination of mandibular incisors and symphysis in severe skeletal class III malocclusion. Head & Face Medicine. (2023), 19:16
22. Kim, SJ, Kim KH, Yu HS, și Baik HS. Dentoalveolar compensation according to skeletal discrepancy and overjet in skeletal Class III patients. Am J Orthod Dentofacial Orthop. (2014) Mar;145(3):317-24. doi: 10.1016/j.ajodo.2013.11.014. PMID: 24582023.
23. Korkhaus, G. Entwicklungsstörungen des Oberkiefers und des Mittelgesichts, *J Orofac Orthop/Fortschritte der Kieferorthopädie*, 18, (1), (1957): 23-54.
24. Leversha, J, McKeough G, Myrteza A, Skjellrup-Wakefiled H, Welsh J, și Sholapurkar A. Age and gender correlation of gonial angle, ramus height and bigonial width in dentate subjects in a dental school in Far North Queensland. *J Clin Exp Dent. (*2016);8:e49–e54. doi: 10.4317/jced.52683.
25. Lewis, A. B., și Roche A. F. The saddle angle constancy or changes, *Angle orthod*, (1997), 1, 46-54.
26. Milicescu, V., și Duduca-Milicescu I. Creşterea şi dezvoltarea generală şi cranio-facială la copii. Ed. Viaţa Medicală Românească, Bucureşti, (2001).
27. Mitani, H. S. Growth of mandibular prognathism after pubertal growth peak. American Journal of Orthodontics and Dentofacial Orthopedics. 104(4), (1993):330-336.
28. Miyajima, K, McNamara JA Jr, Sana M, și Murata S. An estimation of craniofacial growth in the untreated Class III female with anterior crossbite. Am J Orthod Dentofacial Orthop. (1997) Oct;112(4):425-34. doi: 10.1016/s0889-5406(97)70051-9. PMID: 9345155.
29. Moon, J. H. Evaluation of an individualized facial growth prediction model based on the multivariate partial least squares method. The Angle Orthodontist, 92(6), (2022): 705-713.
30. Mouakeh, M. Cephalometric evaluation of craniofacial pattern of Syrian children with Class III malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics, 119(6), (2001): 640-649.
31. Petersen, P. E. Continuous improvement of oral health in the 21st century-the approach of the WHO Global Oral Health Programme. (2003).
32. Proff, P. W. Cranial base features in skeletal Class III patients. The Angle Orthodontist, 78(3), (2008): 433-439.
33. Rakosi, T. Atlas und Anleitung zur praktischen Fernröntgenanalyse, Hanser Verlag, München, Wien, (1979).
34. Rakosi, T. An Atlas and Manual of Cephalometric Radiography. Munich: Wolfe Medical Publications; (1982).
35. Ramezanzadeh, B., Pousti M., și Bagheri M. Cephalometric Evaluation of Dentofacial Features of Class III Malocclusion in Adults of Mashhad, Iran. J Dent Res Dent Clin Dent Prospects.;1(3) (2007): 125–30.
36. Reyes, BC, Baccetti T, și McNamara JA Jr. An estimate of craniofacial growth in Class III malocclusion. Angle Orthod. (2006) Jul;76(4):577-584. doi: 10.1043/0003-3219(2006)076[0577:AEOCGI]2.0.CO;2. PMID: 16808562.
37. Rodriguez-Cardenas, YA., Arriola-Guillen LE., și Flores-Mir C. Björk-Jarabak cephalometric analysis on CBCT synthesized cephalograms with different dentofacial sagittal skeletal patterns. Dent Press J Orthod. (2014);19(6):46–53.
38. Rubika, J., Felicita AS., și Sivambiga V. Gonial Angle as an Indicator for the Prediction of Growth Pattern. World J Dent. (2015) Sep;6(3):161–3.
39. Sargod, Sharan, Shetty, N, Shabbir, și A. Early class III management in deciduous dentition

using reverse twin block. Journal of the Indian Society of Pedodontics and Preventive Dentistry. 31. 56-60. 10.4103/0970-4388.112418. (1955).

40. Sato, S. Case report: developmental characterization of skeletal Class III malocclusion. Angle Orthod.; 64(2)(1994): 105-11; discussion 111-2. doi: 10.1043/0003-3219(1994)064<0105:CRDCOS>2.0.CO;2. PMID: 8010518.
41. Singh, GD, McNamara JA Jr, și Lozanoff S. Morphometry of the midfacial complex in subjects with class III malocclusions: Procrustes, Euclidean, and cephalometric analyses. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists, Clin Anat, 11(3), 162-170, doi: 10.1002/(SICI)1098-2353(1998)11:3<162::AID-CA3>3.0.CO;2-V. PMID: 9579588. (1998).
42. Tahmina K., Tanaka E., și Tanne K. Craniofacial morphology in orthodontically treated patients of class III malocclusion with stable and unstable treatment outcomes. Am J Orthod Dentofac Orthop Off Publ Am Assoc Orthod Its Const Soc Am Board Orthod. (2000) Jun;117(6):681–90.
43. Usman, Amina, Hegde, Amitha, Shetty, Rajmohan, R., și Manju. Effectiveness of Management of Skeletal Class III Malocclusion during Primary, Mixed, and Permanent Dentition Period – A Literature Review. Journal of Health and Allied Sciences NU. 13. 10.1055/s-0042-1755351. (2022).
44. Vasconcelos, MB., Pinzan-Vercelino CRM., Gurgel J de A., și Bramante F da S. Cephalometric characteristics of Class III malocclusion in Brazilian individuals. Braz J Oral Sci. (2014) Dec;13(4):314–8.
45. Vela, K. C. Phenotypic characterization of class CIII malocclusion [University of Iowa]. (2012). https://doi.org/10.17077/etd.3j7sxe1m
46. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Jahrbuch Für Wissenschaft Und Ethik, 14(1), (2009): 233-238.
47. Yamada C, Kitai N, Kakimoto N, și Murakami S. Spatial relationships between the mandibular central incisor and associated alveolar bone in adults with mandibular prognathism. Angle Orthod. (2007) ;77(5):766–72. https:// doi. org/ 10. 2319/ 072906- 309.

LIST OF PUBLISHED SCIENTIFIC WORKS

1. Andrei Sorin Aristide, Anca-Oana Dragomirescu, Elena-Claudia Coculescu, Maria - Angelica Bencze, Ecaterina Ionescu. *Morphological characteristics of mandibular symphysis and sagittal inclination of lower incisors in class iii malocclusion according to facial divergence pattern*. Romanian Journal of Oral Rehabilitation, 2023, 15(4):19-27; indexare ISI, FI 0.6; https://rjor.ro/morphological-characteristics-of-mandibular-symphysis-and-sagittal-inclination-of-lower-incisors-in-class-iii-malocclusion-according-to-facial-divergence-pattern/ (lucrare realizată din capitolul 6 al tezei de doctorat)

2. Andrei Sorin Aristide, Anca-Oana Dragomirescu, Maria-Angelica Bencze, Andreea Băluță, Ecaterina Ionescu. *Vertical cephalometric characteristics in class III malocclusions* Current Health Sciences Journal, 2022, 48(4):446-453; indexare PubMed, BDI; https://www.chsjournal.org/CHSJ/papers/CHSJ.48.04.12.pdf (lucrare realizată din capitolul 5 al tezei de doctorat)