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**CONTRIBUTIONS TO THE STUDY OF MANDIBULAR
ASYMMETRIES
SUMMARY OF PHD THESIS**

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Introduction

Facial symmetry refers to a state of balance in which the size, shape, and arrangement of tissue and facial structures correspond on the one hand and the other hand of the median-sagittal plane. On the other hand, facial asymmetry can be defined as a lack of correspondence and congruence of the shape, size and relative position of opposite parts of the face concerning the midline assessed both statically and dynamically (*Peck et al., 1991; Chia et al., 2008; Cheong and Lo, 2011*).

Elements of mandibular asymmetry are often found among patients requesting orthodontic treatment. These, according to the studies cited in the specialized literature (*Severt and Proffit, 1997; Cheong and Lo, 2011; Primožic et al., 2012*) are more frequently located in the lower third of the face and take on a wide variety of clinical forms, with a pathology diverse. The mandible forms the bony support of the soft tissues in the lower third of the figure, so the slightest change in its shape or position affects the facial appearance (*Ricketts, 1972; Haraguchi et al., 2008*).

Malocclusions present in the stages of growth and development can lead to the appearance of skeletal and functional mandibular changes. Mandibular bone asymmetry detected at the beginning of childhood must be evaluated and quantified, its early approach offering through growth redirection phenomena a remarkable therapeutic asset for stopping its anatomization.

Over time, panoramic radiographs were frequently used in dentistry and orthodontics, being an important complementary investigation, which can be found in the initial orthodontic record. Several researchers (*Larheim and Svanaes, 1986; Habets et al., 1987, 1988; Kjellberg et al., 1994; Simões, 2004*) have tried to use panoramic radiographs to diagnose early mandibular skeletal changes. Thus they developed measurement systems on these radiographs, to quantify the mandibular asymmetry with as few errors as possible.

Most of the studies in the specialized literature (*Larheim and Svanaes, 1986; Catić et al., 1998a,b; Liukkonen et al., 2005; Kambylařkas et al., 2006; Lim et al., 2018; Markic et al., 2022*) concluded that vertical measurements are reliable, compared to horizontal ones, which do not have the same relevance due to image distortions and the degree of magnification present on panoramic radiographs. In terms of measurement accuracy, CBCT offers superior acuity, but patient exposure must be taken into account, especially when addressing growing patients. From this perspective, the use of the panoramic radiographs for the assessment of

mandibular asymmetries is convenient, being a complementary routine investigation, which we find in the initial orthodontic records, not requiring an additional dose of irradiation to obtain it.

Most of the studies cited in the specialized literature (*Kecik et al., 2007; Sezgin et al., 2007; Kilic et al., 2008; Kurt et al., 2008; Kasimoglu et al., 2015*) were conducted on population groups with ethnic characteristics different from those in our country, hence the need to carry out a study on the growing age population in our country, the novelty of this research also due to the composition of the study group, selected from the population of Bucharest and its surrounding areas, the investigations analyzed in the research being carried out after 2015, when it is assumed that we have a standardization of radiological investigations. All radiographs analyzed were performed in the same radiology center with the same radiology machine settings to minimize the possibility of execution errors and to have some standardization.

I have focused my research on investigating simple and accessible methods of assessing mandibular asymmetries that can be successfully applied to growing children and that do not use elaborate investigations involving high radiation doses and the corresponding cost. In the last decades, studying more and more the effects of radiation, a series of rules have appeared that recommend limiting the dose of radiation to which the patient is subjected for medical investigations. Medical technology has indeed evolved a lot in recent years, and at present, we have new and new detailed investigation techniques, but parallel to this we must also develop our discernment in the use of these methods because, in addition to the financial cost, there is also a biological cost - patient irradiation. The information obtained by such methods is much more accurate, but the benefit and harm brought by their use must always be carefully weighed.

The research aimed makes contributions to the statistical study of mandibular asymmetries, evaluated on a selected group of patients from our country, using simple investigation methods, which the orthodontist has at hand, the investigations used in this study being the panoramic radiographs, which is found in the initial orthodontic records and the quantification of the deviation of the lower dental midline on the study cast.

In this context, the topic of the doctoral thesis is a topical one, which falls into the concerns of both national and international researchers in the field of orthodontics and dentofacial orthopedics, which aims to evaluate mandibular asymmetries during prepubertal and pubertal growth.

The main objective of the research was to contribute to the study of mandibular asymmetry by evaluating the vertical asymmetry of the ascending mandibular ramus on the panoramic radiography and by analyzing on study cast, the displacement of the lower dental midline in a group of patients with different types of malocclusions.

The Study Group: To achieve the aforementioned objectives, a retrospective study was carried out, on a heterogeneous group consisting of 214 patients (134 females and 80 males), aged between 7 and 15 years (mean age being 9.5 years \pm 2), a selected group from Bucharest and its surrounding areas, who applied for an orthodontic consultation in the period 2015-2021.

Materials and Methods

For the subjects participating in the study, the panoramic radiographs, performed for diagnostic purposes, before the start of the orthodontic treatment (found in the initial orthodontic records) were evaluated, on which the vertical parameters of the ramus vertical height (RH), condyle height (CH), respectively total, ramus and condyle height (CH+RH) were measured, on the right and left side, and mandibular asymmetry indexes were calculated according to the formula from Habets method.

All necessary data were collected from the patient's records and initial orthodontic investigations (photographs, radiographs, and casts). The diagnosis was established based on the data from the patient's clinical records, corroborated with the data from the complementary investigations. The diagnostic protocol included the analysis of the initial orthodontic records, as well as the analysis of the study casts, made at the beginning of the orthodontic treatment. Initially, patients with unilateral posterior crossbite (UPC) were selected, considering that these patients show increased changes in the transverse plane. Subsequently, patients in the group that did not present unilateral posterior crossbite were divided into classes of anomalies according to Angle classification (Class I, Class II/1, Class II/2, Class III).

To determine the deviation mandibular midline, the study cast was used, positioned in the habitual occlusion, recorded clinically, and reproduced on the study models using the occlusion recording material.

The collected data were entered into Excel tables for the purpose of statistical analysis.

Independent samples Student's *t*-tests for paired measurements were used to test the significance of the difference between the mean of the right and left mandibular vertical linear parameters.

Independent samples Student's *t*-tests were used to test the significance of the difference in mandibular asymmetry index values according to sexual dimorphism.

The ANOVA test was used to independently analyze the differences between the data recorded in the groups of malocclusions evaluated.

The chi-square test was used to analyze the differences in the prevalence of parameters from two independent groups.

The statistical analyses had a reliability level of over 95% ($p < 0.05$).

The methodology and the statistical analysis used were different according to each research direction approached, this being described in the personal chapters.

The thesis was classically structured, into two main parts: the general part which was made up of 3 chapters, and the personal part which was made up of 4 chapters, organizing the three research directions.

Chapter 4

In the first chapter of personal contributions, the data collected from the studied batch were analyzed. Following the performance of reproducibility tests for the Habets method, the *t*-test for paired measurements, performed for the measured mandibular vertical parameters, showed the absence of systematic errors (bias). Statistically insignificant values were obtained for the *p* values. Lin's correlation coefficient of concordance (rc) showed a substantial correlation between the two measurements made, which justified the use of the data in this research. When calculating the reproducibility of the displacement of the mandibular midline validated by the *t*-test for paired measurements and the correlation coefficient Lin (rc), good values were also obtained that allowed the data to be used in the main studies.

Chapter 5

In the first direction of research, the asymmetry of the vertical mandibular parameters measured on the panoramic radiography was evaluated, in different groups of patients with malocclusion, considering the sexual dimorphism.

A comparative analysis was made of the linear values of the ramus vertical height (RH),

condyle height (CH), respectively ramus and condyle height (CH+RH) between the right side and the left side within the different types of malocclusions, taking into account the gender of the patients.

The obtained results were compared with the existing data in the specialized literature, obtained from similar studies, carried out on different population groups.

Conclusions

The condyle height (CH) on the panoramic radiography is modified, both in females and males, with a higher value in females (0.3 mm). At the same time, it was highlighted that the linear parameter CH was predominantly higher on the left side in both genders, with a statistically significant difference between females and males ($p=0.03$).

The condyle height measured linearly on the panoramic radiography, as well as entered into the formula of the condylar asymmetry index (by the Habets method) revealed significant differences between females and males. Thus, the height of the condyle shows that the results obtained by the two methods were similar.

Ramus Vertical Height (RH) was modified in both genders on the right side, with a higher linear value being highlighted in the male's group (2 mm) compared to the female's group, by comparison with the normal values, analyzed between 7-15 years, when the growth phenomena are more favorable rather the female gender.

Analyzing the bilaterally measured values of the ramus vertical height, a significant difference ($p=0.02$) in favor of the right ramus vertical was recorded in the group of females, while for the group of males, no significant differences were recorded.

From the comparative analysis of the linear parameters measured (on the panoramic radiography) within the studied group, during the growth period, it emerged that females are more prone to mandibular vertical asymmetries than males, this asymmetry predominantly occurs based on the right ramus vertical mandibular. In the analysis carried out by entering the ramus vertical height in Habet's formula, no significant differences were recorded in the level of the ramus vertical between the two genders.

Compared to the groups of malocclusions analyzed in the total group (OIU, Class I, Class II/1, Class II/2, and Class III), we recorded no significant differences between the right and left sides, except for the anomaly Class III ($p=0.02$).

The ramus and condyle height (CH+RH), recorded in the comparative linear analysis significant differences related to sexual dimorphism, with higher values in the group of males compared to that of females (1.4 mm; $p=0.004$), with a preponderance on the right side in both genders, in the same sense as the ramus vertical height values.

In the linear study, the total asymmetries of the vertical ramus and condyle were insignificant, probably due to the larger adaptive growth of the left condyle compared to the smaller growth of the left vertical ramus, thus achieving a compensation between the ramus-condyle relationship. When the linear values were entered into the calculation of the total asymmetry index of the condyle and ramus, it was revealed that the asymmetry was also insignificant (being below the limit value cut-off of 6%).

Regarding the type of anomalies, we observed greater asymmetries of the ramus and condyle height of the right/left in the Class III anomaly, with significant differences ($p=0.03$), and in the other groups of malocclusions analyzed (OIU, Class I, Class II/1, Class II/2) no significant differences were appreciated.

Chapter 6

In the second direction of research, the degree of vertical mandibular asymmetry was investigated by calculating the mandibular asymmetry indexes (IAC, IAR, IAT) according to the formula from Habets' method, in the children and adolescents from the researched group. A comparative analysis was carried out within the studied group according to sexual dimorphism and according to the malocclusion studied, then the prevalence of vertical mandibular asymmetry was determined using the asymmetry indexes of the condyle, of the ramus vertical, respectively of the condyle and ramus. Afterward, the results obtained were compared with similar studies, cited in the specialized literature, carried out on different population groups.

Conclusions

The Condylar Asymmetry Index (CAI), calculated by the formula of the Habets method reports

$$IAC = \left| (CH_{\text{Right}} - CH_{\text{Left}}) / (CH_{\text{Right}} + CH_{\text{Left}}) \right| \times 100\%.$$

percentage and confirms the presence of asymmetry at the level of the condyle with values over 3%, within the studied group, registering significant differences ($p=0.023$) between females (9.3%) and males (11.2%), in favor of males.

Concerning the groups of malocclusions, the condylar asymmetry index did not record statistical differences, except for unilateral posterior crossbite, in which case significant differences were observed between females (8.7%) and males (11.8%) with the value of $p=0.018$.

Regarding the total groups, the condylar asymmetry index revealed a more obvious asymmetry of the condyle above the 3% threshold in Class I anomalies (12.3%), followed by similar percentages in value in Class II/1 anomalies (10.8%), OIU (10.1%), Class III (9.1%) and Class II/2 (8.9%), different from the results of international studies, where the higher values were for Class III. This increased percentage of the Class I anomaly reveals that the neutrality of the sagittal molar relations is due to the compensatory adaptive phenomena of the mandibular structures, especially those at the level of the mandibular condyles.

The most obvious asymmetry was registered at the level of the condyle, with a percentage of 99.3% of the researched group, at a limit value (cut-off) recorded at 3%, this fact indicates an asymmetry of the condyle present in almost all patients from the researched group. The same trend of asymmetry was also observed when the limit value (cut-off) was fixed at 6%, but percentage values of asymmetry of 67.7% were recorded in the total research group. The percentage of the condyle asymmetry index was higher in the group of males corresponding to the limit of 6% (75%) compared to the group of females (63.4%).

The Ramus Asymmetry Index (RAI), evaluated in the total group, does not statistically support the presence of asymmetries at this level, the values obtained being below the threshold of 3%. Asymmetry of the ramus vertical height greater than 6% was present only in 6% of the patients of the studied group.

Regarding sexual dimorphism, the ramus asymmetry index highlighted the fact that the asymmetry is higher in the group of males compared to the group of females, at both limit points (cut-off 3% and 6%).

About the groups of anomalies, the ramus asymmetry index highlighted a percentage of asymmetry close to the threshold of 3% in Class III anomalies (2.8%), followed by a similar value of the percentage in OIU, Class II/1, Class I, and Class II/2.

The Total Asymmetry Index (TAI) did not register percentage values that statistically attest to the presence of asymmetries at this level within the total group, most of the values obtained being below the threshold of 3%. When the cut-off point was fixed at 6%, the percentage of the presence of asymmetry was 2.8%.

Depending on the sexual dimorphism, the value of the total asymmetry index does not indicate statistically significant differences, even about the groups of anomalies studied. The closeness of the asymmetry percentage to the 3% threshold was observed in Class III anomalies, followed by a significantly similar percentage value in OIU, Class II/1, Class I, and Class II/2.

Therefore, most patients presented an asymmetry of the condyle height, this being significantly affected in all types of malocclusions. This situation can be explained on the one hand to the continuous condylar movements and displacements in the glenoid fossa, correlated with the occlusion disorders that can occur during the growth period, inducing the differential growth of the condyles, or, on the other hand, it can be related to strong forces affecting the articular surfaces of the temporomandibular joint.

The consecutively generated forces affect the skeletal and ligamentous components of the temporomandibular joint by reactively increasing the thickness of the tissue on their surfaces. Thus, the value of the condylar asymmetry index could increase, and this process could continue as the adaptation capacity of the articular surfaces would allow.

The greatest therapeutic difficulty occurs when there is desynchronization between the dento-osseous support and the soft parts (in the sense that either the soft parts compensate for the mandibular asymmetry, or the soft parts suffer a marked asymmetry that does not follow the underlying dento-alveolar and skeletal pattern). The vertical ramus compensates to a large extent the individual asymmetry at the level of the condyle, due to the adaptation of the corresponding lifting muscles and the need for the most appropriate functioning of the dental-maxillary apparatus.

Chapter 7

The study described in the third research direction aimed to establish the prevalence of lower dental midline displacement in growing patients with mixed and permanent dentition from the analyzed group.

Three other study groups were formed: the first, with patients who had the lower dental midline shifted by less than 2 mm, the second group, with patients in whom a deviation of

the mandibular midline was recorded between 2-4 mm and the third group, with a deviation of more than 4 mm.

The results obtained were compared within the studied group according to sexual dimorphism and compared with similar studies cited in the specialized literature, carried out similarly, but on different population groups.

Conclusions

The lower dental midline was displaced more than 2 mm in a large percentage of the studied group (75.7%). The value of the displacement of the mandibular midline was most frequently in the range of 2-4 mm (59.8%). This high percentage must also be correlated with the age of the research group, as it is known that the changes that occur during dental permutations influence the position of the upper and lower dental midlines.

The value of $p=0.98$ within the researched group, obtained with the chi-square test for assessing the deviation of the lower dental midline, showed that from a statistical point of view, there are no significant differences in this situation for the group of females, respectively the group of males. In this context, a shift of the lower dental midline predominantly to the right side was observed in both groups.

Concerning the type of malocclusions in the total group, the marked displacement of the mandibular midline (with a value over 4 mm), had the highest prevalence in unilateral posterior crossbite (5.6%). Regarding the groups of anomalies analyzed, the displacement of the mandibular midline in the range of 2-4 mm values was recorded higher in the Class II/1 anomaly (18.2%), in the unilateral posterior crossbite (15%) and the Class II anomaly II/2 (13.1%).

Relative to age, the highest frequency of displacement of the lower dental midline was recorded at 7-8 years, possibly due to dental displacements that accompany the eruptive process.

General conclusions and personal contributions

The comparative analysis of the vertical linear parameters measured on the panoramic radiographs recorded significant differences only at the level of the mandibular vertical ramus, between the right and left sides, while based on the formula from the Habets method and calculating asymmetry indexes at the level of the three studied areas: condyle, ramus

vertically, respectively ramus and condyle, a statistically significant asymmetry was revealed only at the level of the condyle.

Although there was an asymmetry of the condylar index, in all analyzed groups, when this index was compared with the total asymmetry index of the condyle and ramus, we observed low values of the total asymmetry (ramus and condyle). This attests to the fact that functional adaptive compensatory processes occur at the height of the vertical mandibular ramus reducing the asymmetry at the level of the entire ascending mandibular ramus.

The lack of correspondence of the upper and lower dental midline can be found in all types of malocclusions. This inconsistency of the upper and lower dental midlines can appear temporarily, during dental permutations, or it can become permanent and generate disorders of the temporomandibular joints, dento-alveolar, and periodontal suffering.

Finding this displacement from an early stage can orient the doctor on the therapeutic attitude, prevention, and interception being extremely important, it is known that a functional displacement can anatomize, subsequently generating major occlusion and functional disorders, with consequences on the mechanics of the temporomandibular joint.

Habets' method, applied to children and adolescents aged between 7-15 years, proved effective. This study showed the importance of this method in the percentage assessment of mandibular vertical asymmetry, providing information with increased relevance in the prepubertal and pubertal periods.

An increased condylar asymmetry index is a sign of atypical skeletal changes, which deserves to be considered in the diagnostic process and the elaboration of the therapeutic approach.

Condylar asymmetry, associated with unilateral posterior crossbite, suggests according to this method that orthodontic treatment should be instituted early, an aspect confirmed by important studies similarly designed on radiological investigations (*Vig and Hewitt, 1975; Larheim and Svanes, 1986; Peck, 1991; Melnik, 1992; Pirttiniemi and Kantomaa, 1994; Kjellberg et al., 1994; Severt and Proffit, 1997*).

From the perspective of these results, in future studies, one can continue the research through the Habets method developed on panoramic radiography and make it a useful investigative tool for the patient, widening the age range to which it is addressed. Likewise, the doctor is at an advantage, taking into account the speed of application of the technique. This method announces possible directions of growth, depending on the age at which the

patient is surprised, respectively the treatment begins. Habets brings additional elements to the investigation of panoramic radiography, making possible the presumptive diagnosis regarding the growth trends that define the evolution towards the vertical facial pattern.

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List of the published scientific papers:

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<https://rjor.ro/the-prevalence-of-mandibular-midline-deviation-in-children-and-adolescents-with-different-types-of-malocclusions/>

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