

**“CAROL DAVILA” UNIVERSITY OF MEDICINE AND
PHARMACY, BUCHAREST
DOCTORAL SCHOOL OF
DENTISTRY**



DOCTORAL THESIS

Conducător de doctorat:

PROF. UNIV. DR. DRAGOȘ STANCIU

Student - doctorand:

CRISTINA NICOLETA MIHAI

2024

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**CLINICAL AND IMAGING STUDIES ON THE ROLE OF THE ATM IN THE DIAGNOSIS AND
THERAPY OF DENTO-MAXILLARY ANOMALIES**

THESIS ABSTRACT

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Motto:

“NIHIL SINE DEO”

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INTRODUCTION

The increasing frequency of dento-maxillary anomalies has led to a growing number of patients seeking orthodontic treatment. Fixed appliances are more commonly used by adolescents and adults, while younger patients tend to opt for removable appliances.

Correcting dento-maxillary anomalies has local and regional benefits, improving the morphological and functional balance of the dento-periodontal structures, as well as enhancing the individual's overall health and comfort, thereby positively impacting their quality of life. Morphologically, orthodontic treatment can achieve favorable outcomes by aligning teeth and harmonizing dento-alveolar and intermaxillary relationships according to individual craniofacial characteristics. The success of the treatment depends on the quality of medical care, effective communication with the patient, and the patient's compliance with oral hygiene norms.

Epidemiological data on the prevalence of dento-maxillary anomalies vary across different European countries, but recent studies conducted in communities in Europe, the USA, and Asia show that 5% of the population suffers from skeletal dento-maxillary anomalies that require surgical treatment. In addition to achieving a long-term stable result, orthodontic treatment also aims to obtain multiple, stable, functional tooth contacts. At the end of the treatment, before removing the orthodontic appliance, a dynamic occlusal analysis must be performed to identify any premature contacts and interferences, which, if not detected and removed, could compromise the final treatment outcome.

The success and stability of orthodontic treatment with various types of appliances depend on the balance between the forces present before the treatment (perioral muscles, tongue muscles, etc.), during the treatment, and those created at the end, in the retention and stabilization phase. An essential element of balance and stability at the end of orthodontic treatment is dental occlusion. This represents the relationship between all components of the dento-maxillary apparatus during normal function (dysfunction or parafunction) and includes the morphological and functional characteristics of the contact surfaces of opposing teeth, the function of the temporomandibular joint (ATM), swallowing, and chewing. The general part of the thesis includes a description of the anatomy of the temporomandibular joint and its role in mandibular dynamics. It also describes the fundamental positions of the mandible and the reference intermaxillary relationships: centric relation (CR) and maximum intercuspation (MI).

The motivation for the research is presented in the second part, "Personal Contributions," and is linked to a clinical and statistical study on the involvement of orthodontists in the clinical and radiological evaluation of the temporomandibular joint. The second study focused on evaluating the correlations between TMJ changes in patients with Class II/2 Angle malocclusion and the need for

imaging examinations of the temporomandibular joint. The third study is related to the use and validation of the Helkimo index to establish correlations between various types of anomalies and ATM disorder signs.

The results obtained from the statistical data analysis were compared with the existing literature, and conclusions were objectively drawn for each of the three studies. The general conclusions were formulated in a separate chapter. The bibliography is presented at the end of the thesis, in the order of citation.

I extend my sincere gratitude to the Doctoral School of UMF Carol Davila Bucharest for all the support provided in the completion of this work. I would like to thank Prof. Dr. Dragoş Stanciu, the scientific supervisor of this work, for his trust, support, and guidance throughout the doctoral program. I express my deep gratitude and appreciation to Prof. Dr. Mariana Păcurar for her trust, support, and motivation during the entire doctoral journey and for demonstrating that professionalism and humanity can coexist in perfect harmony. I also thank my colleagues from the two departments: Dental Prosthetics and Orthodontics and Dento-Facial Orthopedics, for their case studies and statistical research. I thank my colleague Dr. Mirel Toma for the typesetting. I am grateful to my parents and friends for all the moral support during this period. Finally, I thank my husband, Marius, for his trust, support, and patience.

STATISTICAL STUDIES REGARDING ORTHODONTISTS' ATTITUDE TOWARDS COMPLEMENTARY TMJ EXAMINATIONS (CHAPTER 3)

Hypothesis/Objective

The aim of this study is to assess the clinical experience of orthodontic specialists within the national community in evaluating the temporomandibular joint (ATM) in patients with dento-maxillary anomalies. This study seeks to validate certain theoretical and practical aspects of orthodontics through an evidence-based analysis.

Material and Method

To achieve this, a newly designed questionnaire was developed using Google Forms, consisting of 11 questions: one single-choice question regarding the gender of the respondent, and 10 simple response questions rated on a scale from 1 to 5. These questions aimed to assess the advantages/disadvantages of corticotomy techniques, aspects related to ATM evaluation within orthodontic therapy, and the types of imaging examinations used prior to orthodontic treatment.

Cronbach's Alpha coefficient was calculated to validate the questionnaire. The statistical analysis included descriptive statistics (frequency, percentage, mean, median, standard deviation) and inferential statistics. The Shapiro-Wilk test was applied to determine the distribution of the analyzed data series.

The Mann-Whitney test was used for median comparisons, with a significance threshold of 0.05 for the p-value. Statistical analysis was performed using the demo version of GraphPad Prism. A total of 70 responses were recorded. The Cronbach's Alpha coefficient was 0.857, indicating good consistency among the questions in the applied questionnaire.

Results

The majority of the surveyed doctors (44.29%), although not having extensive experience in orthodontics, are up-to-date and apply modern techniques for evaluating dento-maxillary anomalies, depending on the complexity of the clinical case and the patient's availability (Fig. 3.1).

A percentage of 35.71% of the surveyed doctors are convinced that orthodontic treatment is lengthy, while 7.14% of them believe the duration is too long, and some patients may abandon the final retention stage or request the removal of the fixed orthodontic appliance before achieving all objectives.

Most respondents (48.57%) consider a clinical ATM investigation absolutely necessary. A small percentage (14.29%) consider both clinical and radiological investigations necessary, while 12.86% of those surveyed do not recommend ATM radiographs.

The highest percentage of respondents (82.86%) placed frontal telerradiography first, followed by panoramic radiography (60%) and simple radiography (48.57%). A smaller percentage is attributed to more expensive investigations: CBCT at 20% and ultrasonography at 7.14%.

The responses show a significant difference between the percentage of doctors who use articulators in their routine practice (31.43%) and those who focus only on classical techniques (68.57%). Of the 22 doctors who use articulators in their practice, 18 are male and 2 are female, once again demonstrating a greater interest among male doctors in modern investigation techniques (Fig. 3.6).

In a separate study conducted on 63 patients aged between 9-40 years regarding the use of articulators in orthodontic practice, carried out between 2019-2022 in two private clinics in Bucharest, it was found that the most common dento-maxillary anomaly was Class II/1, both in the 9-12 years age group and in the 12-18 years age group. The articulators were most frequently used for diagnosing and treating Class III anomalies, especially in the 19-40 years age group, where occlusal problems are more severe. More than half of the respondents (64.29%) consider radiological procedures for ATM examination to be costly, and 51.43% of those surveyed consider it an invasive procedure, given the intervention involved.

The largest percentage of respondent doctors (65.71%) believe the orthodontic objective for recommending ATM radiological evaluation would be joint pathology characterized by clicking, crepitus, and pain, followed by 44.29% of doctors who would recommend complementary ATM examinations in all cases of mandibular laterognathia. A smaller percentage of respondents (30%) recommend radiological examinations in cases of Class III anomalies, and 25.71% in Class II Angle cases.

As expected, the majority of respondent doctors (71.43%) reported that they recommend this procedure after the age of 40 in adult patients, where bone growth processes have concluded and joint ailments are more common, while 40% of respondents recommend this procedure between the ages of 25-40 (Table 3.10, Fig. 3.9).

More than half of the respondents (51.43%) reported a positive patient perception of radiological examinations, which provide additional information about craniofacial and joint bone structures.

Discussions

Orthodontic treatment for dento-maxillary anomalies has become a well-known therapeutic procedure, attracting an increasing number of patients. The reasons for seeking such treatment are diverse, but aesthetic concerns are the most prominent. Changes in one's smile are highly visible and easily noticed by both the patient and their social circle.

Additionally, the growing awareness of the necessity for orthodontic treatment has led to a shift in the demographics seeking care, with an increasing interest from adult patients. These patients often present with associated ATM pathology, such as pain, clicking, or crepitus. ATM pain can originate from the joint itself, the surrounding muscles, or be referred from another area.

Muscle pain can originate from superficial muscles, deep muscles, or the hyoid muscles. It manifests in various forms: burning, scratching, sharp, stabbing, or dull. Heikki monitored growth over a 12-year period in two groups of patients, some of whom had temporomandibular joint (ATM) dysfunction, and found an increase in facial asymmetry and sagittal step in patients who experienced facial pain.

Continuous or dull pain is often associated with muscle pain caused by hyperactivity. Sharp pain typically occurs in conditions of joint inflammation. Orthopedic instability due to dental occlusion is by far the main cause of joint pain in both children and adults. ATM dysfunctions can arise from disc displacements or ligament hyperlaxity.

Ligament hyperlaxity can be localized due to occlusion disorders or have a general cause. As a synovial joint, the ATM can be affected by the same diseases as other joints in the body. Ehler-Danlos Syndrome is a group of genetic disorders characterized by ligament hyperlaxity throughout the body due to genetic mutations in the *col5A* and *col3A* genes, which alter collagen structures.

Eagle's Syndrome is characterized by partial or complete calcification of the stylohyoid ligament. During speech and swallowing, pain may occur in the ATM, zygomatic region, tongue, and throat due to nerve irritation caused by this condition. ATM pain can be caused by nerve irritation or direct mechanical compression due to disc displacements. It can present as intense tooth pain, simulating pulpitis, and radiating to nearby regions.

The orthopantomogram, considered useful as a screening method for primary temporomandibular disorders with a sensitivity (the ability of the investigation to detect a morphological alteration when it is truly present) of 0.81 and specificity (the ability of the investigation to exclude the presence of bone pathology when it is not present) of 1.00, was indicated in 98.38% of patients. However, the temporal area of the ATM is less visible in these images. Lateral cephalometric radiography, necessary for establishing a complete orthodontic diagnosis, was recommended in 77.41% of cases, while anteroposterior cephalometry was indicated in 1.61% of patients with significant facial asymmetries.

Tipul investigației	Evidențierea morfologiei ATM		Aprecierea simetriei celor 2 ATM	Raporturi spațiale intraarticulare		Evidențierea proceselor adaptative	
	Condil/ fosă	Discul și zona bilaminară		Relația condil-fosă	Discul și zona bilaminară	Condil/ fosă	Discul și zona bilaminară
Ortopantomograma	Indicație relativă	Neindicată	Indicăță	Neindicată	Neindicată	Indicație relativă	Neindicată
Radiografie ATM	Indicație relativă	Neindicată	Indicăță	Neindicată	Neindicată	Indicație relativă	Neindicată
Incidența transcranială (Schüller)	Indicație relativă	Neindicată	Indicație relativă	Indicație relativă	Neindicată	Indicație relativă	Neindicată
Tomografie convențională	Indicăță	Neindicată	Indicăță	Indicăță	Neindicată	Indicăță	Neindicată
TC	Indicăță	Indicație relativă	Indicăță	Indicăță	Indicație relativă	Indicăță	Indicație relativă
Teleradiografie de profil	Indicație relativă	Neindicată	Neindicată	Indicație relativă	Neindicată	Indicație relativă	Neindicată
Teleradiografie posteroanterioară	Indicație relativă	Neindicată	Indicăță	Neindicată	Neindicată	Indicație relativă	Neindicată
IRM	Indicăță	Indicăță	Indicăță	Indicăță	Indicăță	Indicăță	Indicăță
Imagini dinamice IRM	Indicație relativă	Indicăță	Indicăță	Indicăță	Indicăță	Indicație relativă	Indicăță

Table 1 - Indications for Imaging Procedures in Diagnosing Temporomandibular Joint Pathology (modified from Bumann and Lotzmann 2002)¹.

Conclusions

1. Evaluation of Modern Therapeutic Methods: Online questionnaires provide feedback on tested practices and show that the majority of orthodontists prioritize clinical and radiological assessment of the temporomandibular joint (ATM).
2. Recommended Imaging Techniques: Among the imaging techniques recommended by orthodontists for ATM evaluation, panoramic radiography (OPT), cephalometric radiography, and simple radiography stand out.
3. Radiological Evaluation Indications: The highest percentage of respondents believe that the orthodontic objective for which a radiological evaluation of the ATM would be indicated is joint pathology characterized by cracking, crepitation, and pain, followed by mandibular laterognathia.
4. Use of Relaxation Splints: The majority of respondents (67.14%) use relaxation splints to reduce pain in the temporomandibular joint.
5. Use of Articulators: Articulators are used by a relatively small percentage of respondents (31.43%), even though the benefits of correctly mounting models and rigorous evaluation of the ATM are accepted by most orthodontists.
6. Less Common Techniques: Although CBCT, ultrasonography, and IRM provide additional information for evaluating the bony and soft tissues of the ATM, these techniques are less commonly indicated due to additional costs.

STUDIUL CLINICO-IMAGISTIV PRIVIND MODIFICĂRILE ATM LA UN LOT DE PACIENȚI CU MALOCLUZII CLASA II/2 ANGLE (CAPITOLUL 4)

Introducere

The possibilities for imaging exploration of the ATM are multiple: conventional radiology, computed tomography (CT), cone beam computed tomography (CBCT), magnetic resonance imaging (IRM), ultrasonography, and axiography. In this regard, we performed ATM radiographs in various projections and MRI to detect changes in the soft tissues.

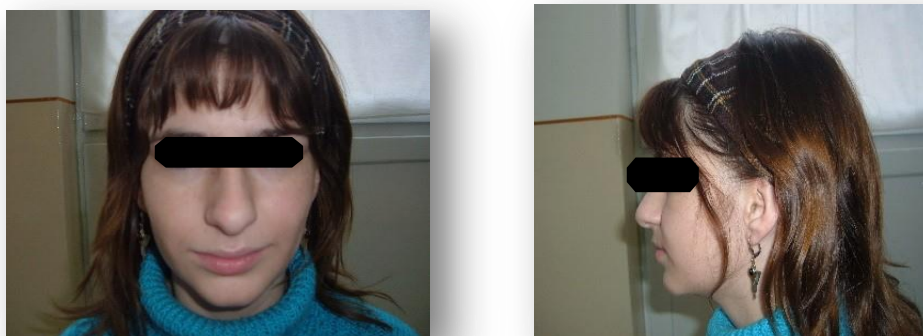


Fig. 1 - Facial appearance in Class II/2 malocclusion.

Complementary exams assist in diagnosing the two clinical forms: true deep bite and false deep bite. Among these, lateral cephalometric radiography illustrates the vertical and sagittal changes of the anomaly at the level of the maxillary bones, alveolo-dental arches, and soft tissues. This investigation allows us to determine whether there is a skeletal Class I or Class II. The lateral cephalometric radiograph reveals signs of anterior facial growth.

The possibilities for imaging exploration of the ATM are multiple: conventional radiology, computed tomography (CT), cone beam computed tomography (CBCT), magnetic resonance imaging (IRM), ultrasonography, and axiography

Material and Method

The study was conducted on a group of 52 patients, aged between 12 and 25 years, with dento-maxillary anomalies, who were undergoing fixed orthodontic treatment at the Orthodontics and Dento-Facial Orthopedics Department of the Faculty of Dental Medicine, UMFST G. E. Palade in Târgu Mureș, during the period 2018-2019. The initial group was divided into two subgroups based on gender: 22 male patients and 30 female patients.

The patients were categorized based on the type of anomaly, with each patient being clinically evaluated. The orthodontic file also included radiological examinations: panoramic radiography (OPT), lateral cephalometric radiography, and ATM examination in patients with Angle Class II/2 anomalies.

Results

Analyzing the distribution of patients with dento-maxillary anomalies, it is evident that Angle Class I anomaly has the highest distribution in both sexes and age groups. The least frequent was the Class III anomaly (Table 2).

Type of anomaly	Female 30-40	Female 40-50	Male 30-40	Male 40-50	p-value
Class I	6	5	2	3	0,9416
Class II/1	4	3	3	3	
Class II/2	5	6	3	3	
Class III	1	1	3	2	
TOTAL	16	14	12	10	

Table 2 - Distribution of Patients with Dento-Maxillary Anomalies

In the 17 patients with Angle Class II/2, the maximum mouth opening was measured using an electronic caliper, between the incisal edge of the upper incisors and the incisal edge of the lower incisors when the patient performed a maximum mouth-opening movement (Fig. 2). The measured value was then adjusted by adding the overbite value. In cases of anterior open bite, the value of the open bite was subtracted from the measured value.



Fig. 2 - Measuring Maximum Mouth Opening with an Electronic Caliper

Clinical examination detected 10 patients with normal TMJs and 5 patients (all female) with reducible disc displacement. For these patients, a TMJ radiograph was also taken. The specific conformational changes observed included a very steep articular tubercle, a high glenoid cavity, and a narrower, elongated condyle, along with a generally more delicate configuration of the ascending ramus. Regarding the relationships between these structures, in the initial phase, the condyle is positioned very close to the anterior wall of the glenoid cavity, and later, a widening of the joint space occurs(Fig.3, Fig.4).

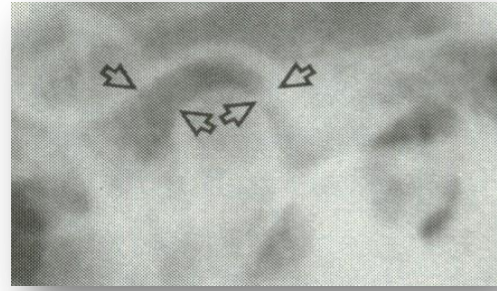


Fig. 3 - Clinical Appearance in Class II/2 Anomaly Fig. 4 - Radiologic Appearance in Class II/2 Anomaly

The modified radiologic appearance was observed only in the 5 patients (all female) with significant clinical signs of disc displacement. An MRI was also recommended for 2 of these patients to highlight changes in the soft tissues (Fig. 5a and 5b).

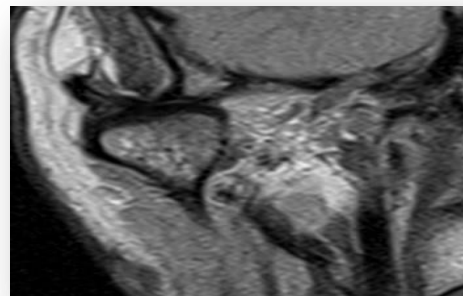
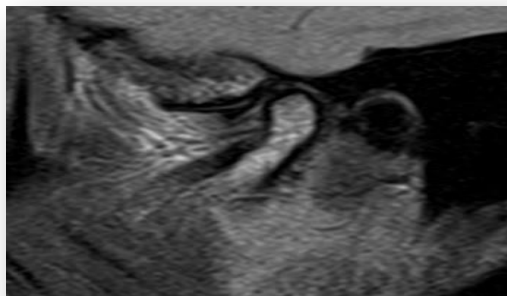


Fig. 5a - MRI, Oblique-Sagittal Section PD Fig. 5b - MRI, Oblique-Coronal Section PD

The IRM examination revealed a deformed disc, which appears inhomogeneous in structure with diffuse areas of high signal intensity within the disc on PD sequences. This investigation also has some drawbacks besides its high cost. For example, only the lateral aspect of the ATM is visible, while the medial surface remains inaccessible.

PARAMETRU STATISTIC	DEPLASARE DISCALĂ	OSTEOARTRITĂ
Sensibilitate %	93.1 (95 % CI 77.23-99.15)	38.24 (95% CI 22.17 - 56.44)
Specificitate %	87.88 (95 % CI 71.8-96.6)	92.98 (95% CI 86.64 - 96.92)
VPP %	87.1 (95 % CI 70.17-96.37)	61.9 (95% CI 38.44 - 81.89)
VPN %	93.55 (95% CI 78.58 - 99.21)	83.46 (95% CI 75.84 - 89.46)
RPP	7.68 (95% CI 3.05 - 19.35)	5.45 (95% CI 2.47 - 12.04)
RPN	0.08 (95% CI 0.02 - 0.3)	0.66 (95% CI 0.51 - 0.87)

Table 2 - IRM Examination of a Deformed Articular Disc

PARAMETRU STATISTIC	DEPLASARE DISCALĂ	OSTEOARTRITĂ
Sensibilitate %	82.5 (95% CI 72.38 - 90.09)	29.41 (95% CI 15.1 - 47.48)
Specificitate %	86.76 (95% CI 76.36 - 93.77)	100 (95% CI 95.25 - 100)
VPP %	88 (95% CI 78.44 - 94.36)	100 (95% CI 58.72 - 100)
VPN %	80.82 (95% CI 69.92 - 89.1)	82.61 (95% CI 75.24 - 88.53)
RPP	6.23 (95% CI 3.36 - 11.55)	Inf (95% CI NaN - Inf)
RPN	0.2 (95% CI 0.12 - 0.33)	0.71 (95% CI 0.57 - 0.88)
Acuratețe diagnostică %	84.46 (95% CI 77.6 - 89.89)	83.78 (95% CI 76.84 - 89.33)

Table 3 - Results of Clinical Examination Compared to IRM Investigation

Discussions

The study conducted by Unger and colleagues in 1989 on a group of 891 "healthy" French individuals revealed that 33.6% of men and 34.3% of women exhibited a clear sign of joint functional alteration without the need for treatment. Among them, 11.7% of men and 16.6% of women presented two or more signs of ATM dysfunction, including: a maximum mouth opening of less than 35 mm, muscle pain, clicking, and mandibular deviation during mouth opening.

It is noteworthy that, despite a high number of objective signs of temporomandibular dysfunction in children and young people, there are few subjective complaints among them. Similarly, patients over 60 years of age report fewer symptoms. The most significant symptomatology is reported by Dworkin and colleagues in individuals aged 20-40 years with Angle Class II/2 dento-maxillary anomalies.

Regarding gender differences, various authors report that women are affected by temporomandibular dysfunction 3 to 9 times more often than men (McNeill). This discrepancy is attributed to constitutional, psychological, psychosocial, and hormonal differences between the sexes. Other studies suggest that this discrepancy may not be real but rather due to a higher propensity of women to seek help for pain symptoms.

Clinical studies have suggested that certain types of orthodontic treatments may increase the risk of developing intracapsular disorders (Farrar and McCarty, Witzig and Yerkes), but long-term epidemiological research (Dahl et al., Henrikson and Nilner) on large patient groups after orthodontic treatment does not support these claims. These studies show that the prevalence of joint dysfunction signs is not higher among orthodontic patients compared to the general population.

A literature review published in 2009 by Manfredini indicated that the diagnostic accuracy of ultrasound ranges from 54-100% for disc displacements and 56-93% for degenerative changes. The authors concluded that ultrasound is a useful method for ATM evaluation but that better standardization of the examination technique and normality parameters is needed. Standardization of examination and interpretation criteria is also essential for IRM, which is used as the reference standard in most ultrasound studies.

Conclusions

1. Angle Class II/2 anomalies are more frequent in females and lead to facial changes (gingival smile), mandibular dynamics alterations (crunching movements), as well as periodontal and joint changes.
2. ATM changes can be detected both clinically and radiologically, with radiologic examination and IRM being particularly useful for adult patients with complex joint pathology.
3. Radiologic changes are characterized by a steep articular tubercle and widening of the joint space.
4. Magnetic Resonance Imaging (IRM) is currently considered the gold standard for evaluating the soft tissues of the ATM (disc, synovial membrane, ligaments), but this investigation is recommended only in severe cases with significant ATM involvement.
5. The use of IRM is sometimes limited due to high costs and availability issues, leading to a growing need for alternative techniques.
6. Ultrasound (US) is reported in the literature as a simple, non-invasive, dynamic, and cost-effective technique for evaluating ATM pathology regarding disc position and degenerative changes. High-resolution US has demonstrated high sensitivity, specificity, and diagnostic accuracy in identifying disc displacements in patients with Angle Class II/2 malocclusion.

EVALUATION OF CRANIO-MANDIBULAR DYSFUNCTION IN PATIENTS WITH DENTO-MAXILLARY ANOMALIES USING THE HELKIMO INDEX (CHAPTER 5)

Introduction

Created by Swedish researcher Marti Helkimo in 1972 to investigate the prevalence and severity of temporomandibular dysfunction signs and symptoms among the Lapp population in northern Finland, the Helkimo classification represents a turning point in the objective assessment of joint suffering. The classification includes three indices: anamnestic (Ai), clinical (Di), and occlusal (Do), which are currently used in clinical and epidemiological studies to facilitate the statistical processing of the obtained data.

Materials and Methods

The study was conducted on a group of 82 patients from the personal cases of Prof. Dr. Dragoş Stanciu, with various dento-maxillary anomalies and ATM dysfunction. The data obtained from the clinical examination of 78 patients in the study group were statistically processed to provide a comparative description of patients with temporomandibular dysfunction versus those without joint disorders at the time of the initial examination.

The muscle groups investigated bilaterally through palpation according to Helkimo include: masseter muscles, anterior and posterior regions of the temporal muscles, external pterygoid muscles, and the area of insertion of the temporal muscle on the coronoid process, intraorally. We analyzed the joint regions and recorded with 0 points the absence of sensitivity to palpation, with 1 point the uni- or bilateral sensitivity to palpation of the lateral joint area, and with 5 points the onset of pain uni- or bilaterally upon palpation of the posterior joint pole inside the external auditory canal.

Results

The study group is heterogeneous in terms of age and sex. Analyzing the frequency of dento-maxillary anomalies in the study group, we found a higher prevalence of Angle Class I malocclusion, followed by Class II/1, then Class II/2, and Class III Angle. Among all types of anomalies, females have a higher prevalence.

Regarding Angle Class II/2 anomaly, it has a higher prevalence of 47.62% in the 12-18 age group, followed by the 18-28 age group with a percentage of 28.57%, and the 28-40 age group with a percentage of 23.81%.

For Angle Class III anomaly, it has a higher prevalence of 41.67% in the 18-28 age group, followed by the 28-40 age group with a percentage of 33.33%.

Analyzing Angle Class II/2 anomaly, it is found to be more frequent in males, but there is no statistically significant association between sex and Class II/2 Angle. In our study, Angle Class III malocclusion is more frequent in males, but there is no statistically significant association between sex and Class III Angle. 4.03% of patients in the 12-18 age group presented unilateral clicks (Fig. 6).

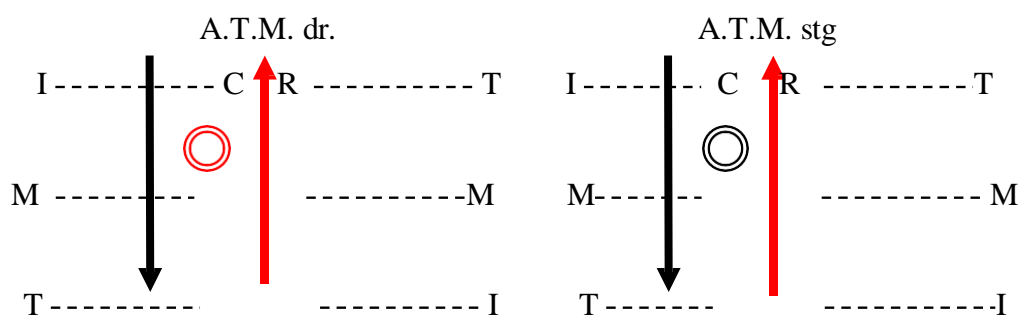


Fig. 6 - Distribution of Clicks During Mouth Opening

In the 18-28 age group, 5.45% of patients had unilateral clicks, and 1.4% had bilateral clicks (Fig. 7). In the 28-40 age group, 7.25% of patients had unilateral clicks, and 3.6% had bilateral clicks.

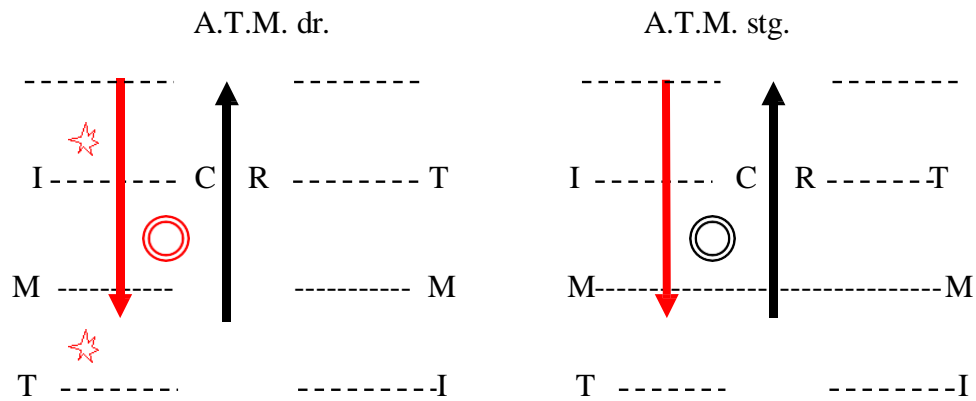


Fig. 7 - Distribution of Clicks During Mandibular Depression

The Helkimo Clinical Dysfunction Index (Di) is summarized as follows:

-0 or 1 point for the amplitude of mandibular movements. In 2.4% of patients (female, over 18 years old), limitations in mandibular mobility were observed, resulting in 5 points.

-0 points were awarded in most cases for sensitivity to palpation of the joint structures. 4.76% of patients received 1 point, and 2.38% received 5 points, all of whom were female and over 18 years old (Table 4).

Indice Helkimo	Total	Clas a I sex M	Clas a I Sex F	% din total	Clas a II/1 sex M	Clas a II/1 sex F	% din total	Clasa II/2 Sex M	Clas a II/2 sex F	% din total	Clasa III Sex M	Clasa III Sex F	% din total
Anamnestic	23	16	14	39,9	12	11	39%	14	13	46	19	16	37%
	3	8,2	31,7	%	13,7	46,3	%	31,7%	30,2	%	34%	21%	
		%	%		%	%			%				
Clinic	12	20	25	37%	15	9	61,	26	24	54	27	22	28%
	7	15,7	21,3		27,5	35,4	%	22,3%	20,4	%	24%	32%	
		%	%		%	%			%				

Tabel 4 - Helkimo Clinical Dysfunction Index

Discussions

Hansson et al. were the first to advocate for the inclusion of orthopedic and alternative medicine examination methods in the clinical evaluation of the temporomandibular joint (ATM). Subsequently, other authors have adopted various orthopedic diagnostic procedures, describing their potential benefits (Magnusson).

In Helkimo's initial research, 75% of individuals whose questionnaires were classified in group Ai II had at least one severe sign of joint impairment, and 44% had two or more severe signs. Only 21% of subjects without anamnestic symptoms were diagnosed with severe dysfunction. In this study, the occlusal index was not evaluated, as several authors have demonstrated that there is no correlation between this index and the occurrence of ATM dysfunction.

Currently, prosthodontists and orthodontists are focused on the early identification of Class II/1 and II/2 malocclusions, both associated with deep occlusion (especially in individuals with excessive overbite), resulting from the loss of cusp teeth, which causes "occlusal collapse" and can lead to cranio-mandibular disorders. Other studies have reported a higher percentage (41.12%) of ATM dysfunction in patients with maxillary anomalies, particularly deep and open occlusions.

In Class II/1 malocclusions, A.H. Owen emphasizes that the sagittal occlusal space must be correctly interpreted considering the nature and position of the mandibular condyles to facilitate therapeutic intervention. If this space results from maxillary protrusion with the mandible in its normal position, mechanical retraction of the maxilla is recommended.

In children and adolescents, the progressive remodeling capability of bone structures allows for adaptive changes in the ATM during active orthodontic treatment and retention.

Orthodontic treatment in adulthood should be concluded with the achievement of a stable maximum intercuspatation position, coincident with the centric occlusion (CO), as further adaptation of the stomatognathic system structures cannot be expected after the growth processes have ended. Correctly mounted articulator models are useful in many of these cases.

Our study highlighted greater ATM impairment in adult patients with Class II/2 and Class III Angle anomalies.

Conclusions

1. The most crucial examination for ATM pathology is a thorough clinical assessment, which, when conducted according to well-established criteria, has high diagnostic accuracy.
2. The presence of anamnestic signs and symptoms of joint dysfunction is higher in Class II/2 dento-maxillary anomalies, followed by Class II/1 and Class III Angle anomalies.
3. The Helkimo anamnestic index showed the highest scores in Class II/2 anomalies in females, followed by Class II/1 anomalies in males. This index correlates better with the clinical index in females for all types of anomalies.
4. The Helkimo clinical index had the highest scores in a small percentage for Class III malocclusion in males and a score of 1 for Class II/2 Angle anomalies.
5. Regarding the clinical examination of patients, the most frequent parameter was the deviation of the menton during mouth opening, the presence of crackling sounds, and muscle pain.
6. Among the crackles, reciprocal sounds during rotational movement were most common in most patients with Class III anomalies.
7. With advancing age, the severity of joint dysfunction signs (evidenced by Helkimo scores of 1 and 5) increases.

MODERN TECHNIQUES FOR EVALUATING THE TEMPOROMANDIBULAR JOINT (ATM): MODJAW VERSUS CADIAX (CHAPTER 6)

Introduction

Over the years, various techniques have been developed to accurately capture and analyze jaw movements, including Electromyography (EMG), kinesiography, ultrasonography, magnetic resonance imaging (IRM), cone-beam computed tomography (CBCT), mechanical and electronic axiography, and optical motion capture systems.

Modern dentistry presents numerous challenges, reflecting both advancements in the field and evolving patient expectations. Virtual planning has revolutionized dentistry by integrating advanced technology, enhancing precision, efficiency, and treatment outcomes.

Recently, certain systems that involve computerized data collection and analysis have proven to be user-friendly and non-invasive for tracking jaw movement. These include the French company Modjaw, launched in 2019 with a 4D dental concept that uses real jaw movement and dynamic occlusion alongside 3D modeling, and Cadiax, introduced by Gamma GmbH, Klosterneuburg, Austria in 1999 as a computerized axiography for the electronic recording of mandibular movements.

ModJaw (TWIN IN MOTION) is a medical software device designed to record and analyze mandibular kinematics to aid in diagnosing, characterizing, and planning therapeutic interventions for occlusal patterns. It is recommended for edentulous patients or those with dentition at an age allowing understanding and cooperation during the recording protocol.

The use of the TWIN IN MOTION device is contraindicated in patients with pathologies that prevent accurate digital dental model recording, those who cannot follow the necessary procedure instructions, or those who cannot maintain proper posture during the examination.

The aim of this study is to highlight the novel aspects represented by the use of digital tools in diagnosing and developing treatment plans.

Materials and Methods

A literature search was conducted to identify articles describing the use of Modjaw and Cadiax systems for measuring ATM kinematics. Articles were identified through a systematic search in the PubMed database using the keywords "Modjaw," "Cadiax system," "jaw motion analysis," and "jaw tracking system." Only studies published in the last 10 years were considered to ensure current and relevant data. The results were analyzed, and the selection criteria for articles related to the study topic

are presented in Table 5.

Inclusion Criteria

- Articles studying the capability of tracking jaw movements using Cadiax or Modjaw systems.

- Use of the Cadiax or Modjaw device for evaluating ATM, SCI, BA, or bite recording.

- Studies reporting quantitative results such as accuracy, reliability, ease of use, patient outcomes, cost-effectiveness, and clinical relevance of measurements provided by both systems.

Exclusion Criteria

- Articles studying jaw movement tracking that do not use Cadiax or Modjaw systems.

- Evaluation of SCI, BA, bite, or ATM without using the Cadiax or Modjaw device.

- Studies lacking clear measures of performance and effectiveness of the Modjaw or Cadiax systems.

Results

Out of a total of 586 articles found in the PubMed database using the specified keywords, 18 of these publications were relevant to the study topic. After a thorough review, only 8 articles were selected as eligible, meeting the selection criteria. The workflow of the study is presented in Figure 8. Out of the 18 articles reviewed for eligibility, 10 described dental techniques and workflows using either Cadiax or Modjaw, but did not provide precise information regarding the accuracy of the measurements provided by the two systems.

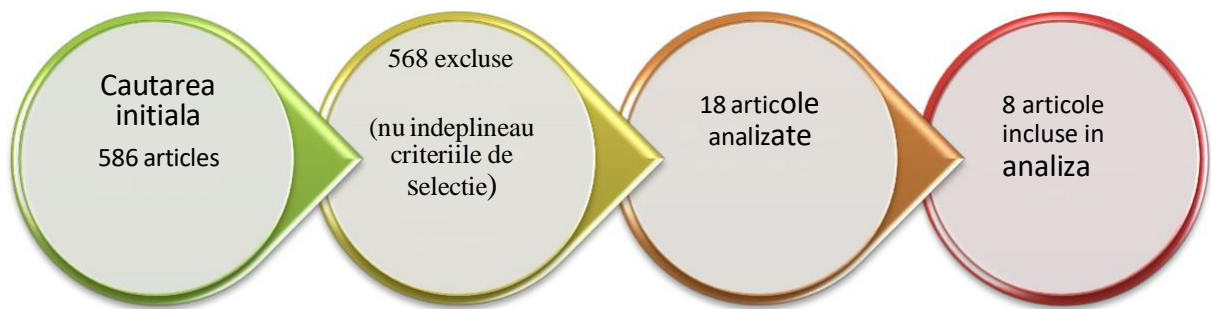


Figure 8 - Study Selection Workflow

Discussion

Regarding the use of the Cadiax system, only two PubMed articles from the past 10 years specifically assess and compare the accuracy of measurements obtained using the Cadiax system with other clinical recording methods. In November 2014, Kianoosh Torabi et al. conducted a comparative clinical study between Cadiax Compact II and intraoral wax and addition silicone recordings. The results showed significant differences for all measurements between Cadiax and intraoral recordings, with Cadiax measurements demonstrating a stronger correlation with silicone recordings.

In other studies published during this period, Cadiax is often used as a reference tool, demonstrating its reliability in the medical field over time. In November 2021, Bapelle et al. investigated the use of the Modjaw device to determine the repeatability and kinematic data of Modjaw recordings in a group of 22 asymptomatic patients. The study indicated good to excellent repeatability, concluding that the Modjaw device reliably records the kinematics of the patient's actual joint axis during functional mandibular movements.

Compared to previous studies, Modjaw demonstrated accuracy values approximately 40 times greater than the pure accuracy obtained in an in vitro study by Zsolt Nagy et al., indicating the extent of IOS uncertainty. In 2023 and again in 2024, two different research groups compared condylar inclination values obtained using the Cadiax Compact 2 and Modjaw devices. Both groups measured SCI and BA values at 3 and 5 mm of condylar displacement. The results were similar for both research groups, concluding that Modjaw measurements for SCI and BA were higher than those obtained with Cadiax.

Conclusions

1. Both systems can detect subtle changes in mandibular kinematics and are useful in orthodontic diagnosis.
2. The Cadiax device is a reliable tool with high recording repeatability and low average error, proven over time.
3. Recently, the Cadiax system is used as a reference among researchers.
4. Modjaw is a promising tool that can provide useful information, but additional studies are needed to confirm its accuracy.

General Conclusions

1. Evaluating modern therapeutic methods through online questionnaires provides feedback on tested practices and shows that most orthodontists prioritize clinical and radiological assessment of the ATM.
2. Among the imaging techniques recommended by orthodontists for ATM assessment are OPT, lateral cephalometric radiography, and plain radiography.
3. The highest percentage of responding physicians considers the orthodontic objective for recommending radiological evaluation of the ATM to be joint pathology characterized by clicks, crepitations, and pain, followed by mandibular laterognathia.
4. The majority of respondents use relaxation splints for reducing pain in the ATM, with a percentage of 67.14%.
5. Articulators are used by a relatively small percentage (31.43%), even though the benefits of correctly mounting models and thorough ATM assessment are acknowledged by most orthodontists.
6. Although CBCT and ultrasonography, and MRI provide additional data for assessing bone and soft tissue parts of the ATM, these techniques are less indicated due to additional costs.
7. Class II/2 Angle anomalies are more frequent in females and cause facial changes (gingival smile), mandibular dynamics (chopping motion), periodontal, and joint changes.
8. ATM changes can be detected both clinically and radiologically, with radiological and MRI examinations being particularly useful in adult patients with complex joint pathology.
9. Radiological changes are indicated by a steep slope of the articular tubercle and widening of the articular interspace.
10. Magnetic resonance imaging (MRI) is currently considered the gold standard for evaluating soft tissues of the ATM (disc, synovial membrane, ligaments), but this investigation will be recommended only in severe cases with major ATM involvement. The use of MRI is sometimes limited due to high costs and lack of availability, increasing the need for alternative techniques.
11. Ultrasound (US) is reported in the literature as a simple, non-invasive, dynamic, and cost-effective technique for evaluating ATM pathology, including disc position and degenerative changes. High-resolution US has demonstrated high sensitivity, specificity, and diagnostic accuracy in identifying disc displacements in patients with Class II/2 Angle malocclusion.
12. The most frequent anomaly is Class I Angle malocclusion, followed by Class II/1 in age groups 9-12 and 12-18.
13. The Helkimo anamnestic index had the highest scores in Class II/2 anomalies in females, followed by Class II/1 anomalies in males. This index correlates better with the clinical index in females for all

types of anomalies.

14. The Helkimo clinical index had the highest scores in a small percentage of Class III malocclusion in males and a score of 1 for Class II/2 Angle anomalies.

15. In the clinical examination of patients, the most frequent parameter was chin deviation during mouth opening, the presence of crackling noises, and muscle pain.

16. Among crackling noises, reciprocal noises during rotation movements were the most frequent in most patients with Class III anomalies.

17. With advancing age, the severity of joint dysfunction signs (evidenced by Helkimo scores of 1 and 5) increases.

18. Both systems (Cadiax and ModJaw) can detect subtle changes in mandibular kinematics and are useful in orthodontic diagnosis.

19. The Cadiax device is a reliable tool with high recording repeatability and low average error, proven over time.

20. Recently, the Cadiax system is used as a reference among researchers.

21. ModJaw is a promising tool that can provide useful information, but additional studies are needed to confirm its accuracy.

Originality of the Thesis

The doctoral thesis titled "Clinical and Imaging Studies on the Role of ATM in the Diagnosis and Therapy of Dento-Maxillary Anomalies" addresses an interdisciplinary subject with clear practical applications, highlighting the importance of evaluating the temporomandibular joint (ATM) before starting orthodontic treatment to detect potential issues caused by dento-maxillary malocclusion.

The originality of this work lies in emphasizing the role of imaging evaluation of the ATM before orthodontic treatment, as well as the statistical analysis of the use of articulators for assessing centric relation and maximum intercuspation.

The first study of the personal research focused on evaluating orthodontists' perceptions of ATM assessment. This study was conducted using a newly developed Google Forms questionnaire comprising 11 questions: one single-choice question regarding the respondent's gender, followed by 10 simple response questions using a scale from 1 to 5 to assess aspects related to ATM evaluation in orthodontic therapy and the types of imaging examinations used before orthodontic treatment.

The second study was a clinical-imaging study on ATM changes in a cohort of patients with Class II/2 Angle malocclusions. The clinical study focused on evaluating the presence of joint noises (clicks or crepitations) in a sample of 52 patients aged 12-25 years. Imaging examination was performed using ATM radiography and MRI. MRI findings revealed a deformed disc with an inhomogeneous structure and diffuse intradiscal hyperintensity zones. These changes were infrequent, demonstrating the adaptive capacity of the joint to deep occlusion syndrome.

The third study, titled "Evaluation of Cranio-Mandibular Dysfunction in Patients with Dento-Maxillary Anomalies Using the Helkimo Index," was a clinical-statistical study analyzing correlations between the anamnestic and clinical Helkimo index values related to various dento-maxillary anomalies. The anamnestic Helkimo index scored highest for Class II/2 anomalies in females, followed by Class II/1 anomalies in males. This index correlates better with the clinical index in females for all types of anomalies.

Planning orthodontic treatment for an adult population must consider both the aspects of articular structures, which may suffer degenerative changes related to age or consequent to dento-maxillary anomalies, as well as the acceptance of potential adverse effects on periodontal structures. Orthodontic biomechanics should employ light forces and be complemented by an analysis of the type of articular kinematics. Mounting models in an articulator adds accuracy to diagnosis by establishing occlusal dynamics.

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Lista cu lucrările științifice publicate

LUCRĂRI PUBLICATE IN EXTENSO

1. **Mihai C.**, Bud E, Hancu V, Chibeleian M, Salcudean A, Rusu E, et al. Evaluation of crano-mandibular dysfunction in patients with dento-maxillary anomalies using the Helkimo index. Ro J Stomatol. 2023;69(4):242-55. doi:10.37897/RJS.2023.4.10 (Anexa nr. 1, Capitol 5, pag. 75-95)
2. **Mihai C.**, Mihai L, Pacurar M, Dumitrescu I, Ganga A, Pacurar C, et al. Clinical-statistical study on the use of articulators in orthodontic practice. Ro J Stomatol. 2023;69(1):32-42. doi:10.37897/RJS.2023.1.6 (Capitol 3, pag. 50)
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