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RĪGAS STRADIŅA UNIVERSITĀTE

Zane Krišjāne

ASSESSMENT OF TEMPOROMANDIBULAR JOINT AND MANDIBLE IN IMAGE OF CONE BEAM COMPUTED TOMOGRAPHY IN PATIENTS WITH ANGLE CLASS II AND III DENTOFACIAL

Summary of Promotion Work for Acquisition of Scientific Degree of the Doctor of Medicine
Speciality – Orthodontics

Riga, 2012

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CONTENTS

1. INTRODUCTION

1.1. Topicality of the work

Incidence of severe dentofacial deformations among population of Latvia in the age group of 18 is averagely 5-7% of cases (Urtāne, 2006). As reasons of the development of such deformations are mentioned genetic factors, long-term parafunctional habits during the period of growth, functional disorders of facial soft tissues, traumas in the maxillofacial area, which may affect growth of facial and jaw bones. The disproportions and relations of jaws cause functional, aesthetic, as well as psychological disturbances. Treatment of deformations is usually combined and interdisciplinary, including orthodontic treatment with fixed bracket systems and orthognatic surgery. Though methods of treatment planning, as well as those of orthodontic and orthognatic surgery, are developing, risks of relapse cannot be excluded due to factors of osseous tissue, impact of facial soft tissue and remodelling disturbances related to damages in temporomandibular joint.

Adverse changes of osseous tissues in joint structures are most commonly related to inflammatory or degenerative processes, such as flattening, erosion, osteophytes, subchondral osseous sclerosis and cysts; they can be asymptomatic, and may be the reason of morphological and functional changes in the mandible (Dworkin, 1992).

Since growth and adaptive process involves not only condylar head, but mandible in general, it creates multi-dimensial growth capacity, reacting to changes of different character and developmental variations of dentofacial deformations (Shen, 2005).

As temporomandibular joint is the basis of occlusion correction, starting the treatment planning, it is important to determine its osseous structure, since the process of condylar remodelling, occurring during the treatment, can unfavourably affect stability of occlusion which may be followed by functional and aesthetic result (Arnett, 2004).

The complicated anatomy of skeletal structures of dentofacial deformations and perfection of treatment planning determine necessity of precise radiologic 3D diagnostics for the image of anatomical structures 1:1.

Different methods of radiologic examination reveal articulation structures in different image quality. The available literature reveals studies when temporomandibular joint has been examined using different methods, determining both parameters of anatomical structure of the joint, their relations and assessing morphology of the joint. Majority of studies deal with TMJ examination in symptomatic patients with temporomandibular disorders, as well as cross-sectional studies, where patients of different age groups with distinct signs of occlusion have been examined, determining only some of TMJ characterizing parameters.

Hence, results of the literature studies are difficult to compare, and they can only be generally related to the most common dentofacial deformations occurring in clinics – Angle Class II and III. The available literature does not give systematised studies in TMJ anatomy and morphology in asymptomatic 20-25 years old orthognatic surgery patients with Angle Class II and III dentofacial deformations. TMJ structural changes are usually related to the effect of ageing, therefore, basic population of these studies is people at the age of 40 with clinical signs and symptoms. However, orthognatic surgery most commonly is performed in younger patients after the end of active growth; stability of treatment results is also related to the condition of TMJ structures and processes ongoing in them.

Evaluating quality and quantity of TMJ articular surfaces in 3D reconstruction image, one can judge on structural changes that help to diagnose asymptomatic disturbances (Petersson, 2010).

Acquisition of research data with CBCT in the 3D image in patients with dentofacial deformities would systematise method of examination of TMJ osseous structures and mandible and data assessment for treatment planning of orthodontic and orthognatic surgery, as well as prognosis of results.

1.2. Novelty of the study

New data have been acquired on interrelation of linear parameters of temporomandibular joint and mandible, condylar position has been determined, as well as structural changes in osseous tissues in asymptomatic patients with Angle Class II and III dentofacial deformations, comparing to Angle Class I patients.

1.3. Aim of the study

Aim of the promotion work was to assess and compare radiologic morphology of the mandible and temporomandibular joint in asymptomatic patients with Angle Class II and III dentofacial deformations and with Angle Class I group, applying CBCT examination method.

1.4. Objectives of the study

1. To work out the algorithm for radiologic morphology examination of the mandible and temporomandibular joint with CBCT.
2. To assess linear parameters of osseous tissues of temporomandibular joint- condylar head and complex of fossa/eminence, as well as the mandible in patients with Angle Class II and III dentofacial deformations.
3. To assess condylar position and the form of condylar head in patients with Angle Class II and III dentofacial deformations.

4. To find out intensity of structural changes of osseous tissues of temporomandibular joint.

5. To evaluate existence of structural changes of osseous tissues of temporomandibular joint in relation to different linear parameters of the articulation and mandible, condylar position and form of the condylar head, type of growth.

6. To find out intensity of radiologic diagnoses – TMJ osteoarthritis and initial signs of osteoarthritis – in groups of Angle Class II and III dentofacial deformations.

7. To compare the acquired results with results in Angle Class I patients.

1.5. Hypothesis of the study

There exist differences in linear parameters of the mandible, temporomandibular joint and the intensity of structural changes in osseous tissues in patients with dentofacial deformations (Angle Class II and III) and patients with orthognatic jaw relations (Angle Class I).

2. MATERIALS AND METHODS

2.1. Study group

The study involved 142 patients, divided into 3 study groups: 1) 56 Class II patients; 2) 61 Class III patient with diagnosed dentofacial deformation and who needed combined orthodontic and orthognatic surgical treatment; 3) 25 Class I patients with diagnosed dental impaction or retention, so they needed to start orthodontic dental regulation with fixed systems or to perform surgical extraction of the tooth. The average age of the patients was 20.58 ± 4.27. Of all study group, 62 or 43.66% were males, 80 or 56.34% were females. Degree of severity of dentofacial deformity was determined making clinical examination of the patient, during which the patient was questioned on possible complaints regarding the function of temporomandibular joint, as well as by data of cephalometric analysis in CBCT images. Clinically signs of patient's occlusion were determined by Angle classification, which characterises the corresponding class. Relations of dental arches were determined by relations of the first permanent molars in sagital plane. In case of Class I maxillary mesiobuccal cusp of the first molar tooth was in contact with mandibular buccal sulcus of the first molar tooth (neutral or mesiodistal occlusion), in Class II situations, maxillary mesiobuccal cusp of the first molar tooth – with mandibular first molar tooth contacted mesially from buccal sulcus (distal occlusion), opposite to Class III situations, when mesiobuccal cusp of the maxillary first molar tooth contacted with mandibular first molar tooth distally from buccal sulcus (mesial occlusion).

In cephalometric analyses, two frequently used measurements were emphasized, which characterise jaw relations in sagital plane:

1. ANB angle, which forms between cephalometric anatomical points A (the most caudal point of the concavity of the maxillary frontal contour), N (anterior point of frontonasal seam) and B (the

most caudal point of the mandibular frontal contour concavity) and shows severity of skeletal jaw discrepancy.

2. Witts analysis – distance between perpendiculars drawn from points A and B to occlusion plane.

In patients of the Class I group, value of ANB angle was 0.0 – 2.8 degrees, Class II from 4.3 to 10.5 degrees, but in Class III from -7.5 to -0.3 degrees. Mean dentofacial skeletal indices in study groups were compared to dysgnatics characterizing values given in literature (Table 2.1).

Table 2.1

Mean cephalometric values in study groups

Class	ANB			Witt analysis		
	Mean value in degrees	SD	Class characterizing values (10-18 yrs)*	Mean value in degrees	SD	Class characterizing values (10-18 yrs)*
I	1,9	0,78	0,1-3,6	-0,48	0,92	-4 – 2,1
II	6,57	1,92	>3,6	7,73	4,05	>2,1
III	-3,52	2,54	<0,1	-11,28	5,79	< - 4

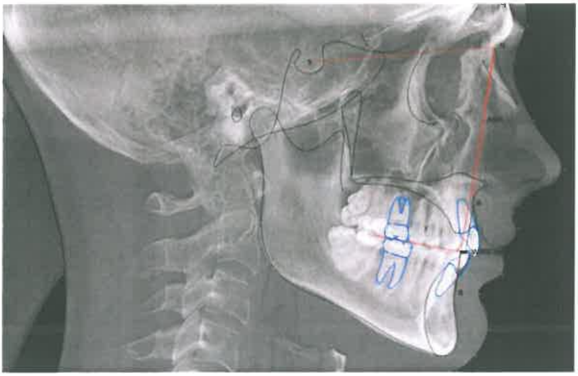
*Proffit, 2007

To assess relations of jaws with cranial basis, in Class II and III groups in cephalograms SNA and SNB angle values were determined; mean values are revealed in Table 2.2. All of the above mentioned cephalometric measurements are shown in Picture 2.1.

Table 2.2

Mean SNA and SNB angle values in Class II and III groups

Class	SNA				SNB			
	Mean value in degrees	SD	Min value	Max value	Mean value in degrees	SD	Min value	Max value
II	81,7	3,82	73,4	90,1	75,0	4,09	66	84,6
III	80,4	4,1	70,9	90,8	83,8	4,5	75,4	95,1



Picture 2.1 . Graphic image in CBCT of cephalometric measurements SNA, SNB, ANB and Witt analysis.

The study did not involve patients with:

- Congenital dentofacial syndromes (including labial and/or palatal cleft).
- Clinically visible skeletal face asymmetry.
- Rheumatoid or other arthritis forms in anamnesis.
- Trauma in maxillofacial area in anamnesis.
- Complaints about temporomandibular disorders, pain in maxillo-facial area, pronounced noise in temporomandibular joint.
- Previous orthodontic treatment with functional devices and/or fixed systems.

2.2. Subgroups of the study

2.2.1. Division of Class II in subdivisions

Basing on Angle classification, Class II can be divided into two subdivisions, determined by inclination of maxillary incisors. In case of subdivision 1 of Class II incisors are pro-inclined and sagital overjet is enlarged, opposite to Class II subdivision 2 situations when maxillary incisives are retroinclined and sagital overjet is markedly decreased. Of Class II patients, 42 corresponded to inclusion in II/1 subgroup (average age 21.08 ± 5.49), 14 in II/2 subgroup (average age 20.52±4.37). The mean age of the patients did not differ statistically significantly.

2.2.2. Division of groups by type of growth

Following the width of MM angle (the angle that forms between mandibular and maxillary plane and is one of characteristic cephalometric indices of facial growth types), the patients were divided into subgroups according to growth type. Neutral growth type is characterized by MM angle in the boundaries of 22^0- 32^0 or $27^0 \pm 5^{0.}$ An angle narrower than 22 degrees points to horizontal type of facial growth, but an angle wider than 32 degrees suggests vertical type of growth. Division of the patients by MM angle in classes can be seen in Table 2.3.

Table 2.3

Absolute and relative division of patients by growth type in study groups

Growth type	Class I		Class II		Class III	
	N	%	N	%	N	%
Neutral	25	100	18	32	34	56
Vertical	0	0	22	39	15	26
Horizontal	0	0	16	29	12	20
Totally	25	100	56	100	61	100

Division of Class II patients by growth type statistically did not differ. In Class III group, the most common was neutral growth type, number of patients with vertical and horizontal type were respectively 26% and 20%.

2.3. Description of the method

In all of the included patients, starting the treatment, for the purpose of diagnosis and treatment planning, computer tomography examination was performed in the maxillofacial area, using cone beam computed tomography apparatus iCAT (*iCAT* New Generation, Imaging Sciences International, Inc. Hatfield, PA, USA).

Computer tomography examination and usage for research purposes was performed in compliance with the permission of Ethics Committee of Riga Stradins University (Decision adopted on April 19, 2007).

2.3.1. Procedure of cone beam computed tomography examination

Within the period of examination the patient was in sitting position, with his head in natural position, vision directed ahead. Teeth were clenched, ensuring maximum intercuspidation.

A standardised work protocol was used for the equipment (voltage -120 KV, current – 38 mA, field of examination (FOV) -17 cm, resolution – 0.4 voxels, approximate dose of radiation =36 μSv.

2.3.2. Procession and analysis of cone beam computed tomography

The acquired examination data were processed and analysed applying the software corresponding to the equipment *iCAT Vision* (Imaging Sciences International, Inc. Hatfield, PA, USA).

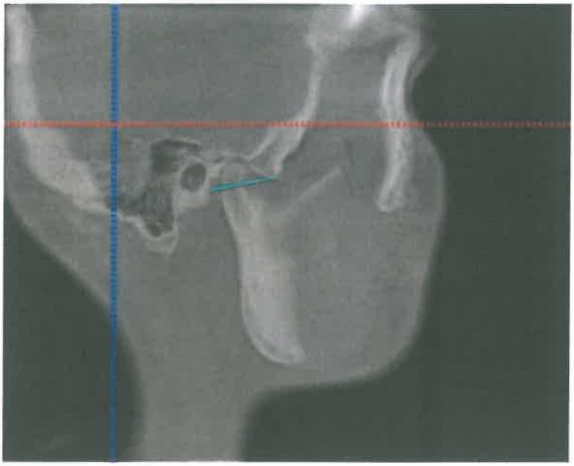
Basing on methodological descriptions of examination of temporo-mandibular joint in images of cone beam computed tomography, as well as applying standardised method for finding the optimum section, linear parameters of the articulation and mandible were analysed in sagital plane, intercondylar parameters – in axial plane, but presence of structural changes in osseous structures of the joint was assessed in coronary and sagital plane, basing on the system worked out by Dworkin (1992) for assessment of changes in temporomandibular joint (RDC/TMD).

To make cephalometric analyses with cone beam computed tomography data, *Dolphin* programme was used, version 11.0 (Dolphin imaging, CA, USA).

Analysis of all computed tomography data was made by the author of the work, for detection of the descriptive signs, an experienced maxillofacial radiologist was previously consulted.

2.3.2.1. Linear measures of temporomandibular joint

1. Width of articular fossa *(fossa mandibularis ossis temporalis)* – distance between the top of the articular tubercle and distal wall of articular fossa in the plane between the top of articular tubercle *and meatus acusticus externus* lower point.



Picture 2.2. Measurement – width of mandibular fossa

2. Depth of articular fossa (*fossa mandibularis ossis temporalis)* – perpendicular from the deepest point of mandibular fossa up to the plane between *tuberculum articulare* peak and *meatus acusticus externus* lower point.

Picture 2.3. Measurement – depth of articular fossa

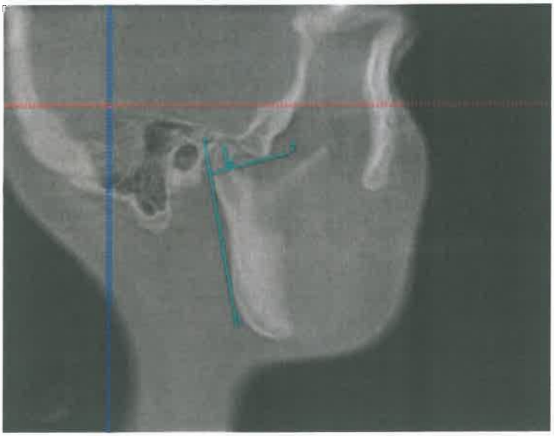
3. Width of temporomandibular joint spaces:
   a. Anterior joint space – the shortest perpendicular between the most forwardly pronounced point of condylar head and posterior wall of articular tubercle.

   b. Upper joint space – the shortest perpendicular between the highest point of condylar head and the deepest point of mandibular fossa.

   c. Posterior joint space – the shortest perpendicular between backwardly the most pronounced point of condylar head and back wall of mandibular fossa.

Picture 2.4. Measurements of joint spaces

4. Height of condyle– distance from the top of condylar head up to the line which goes from its most pronounced point and is perpendicular to attachment of *ramus mandibulae*

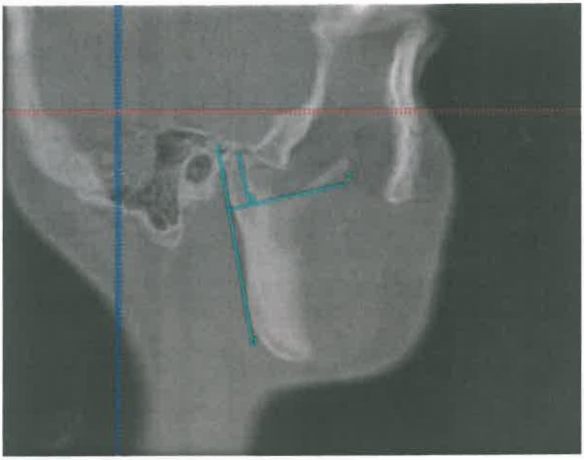


Picture 2.5. Measurement – height of condyle

5. Condylar sagital width – distance between anterior and posterior point of condylar head

Picture 2.6. Measurement - Condylar sagital width

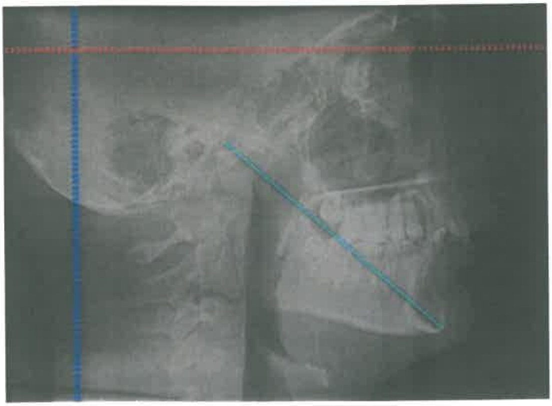
6. *Processus condylaris* height – distance from the top of condylar head to the line which goes through *incisura mandibulae* and is perpendicular to attachment of *ramus mandibulae*



Picture 2.7. Measurement - *Processus condylaris* height

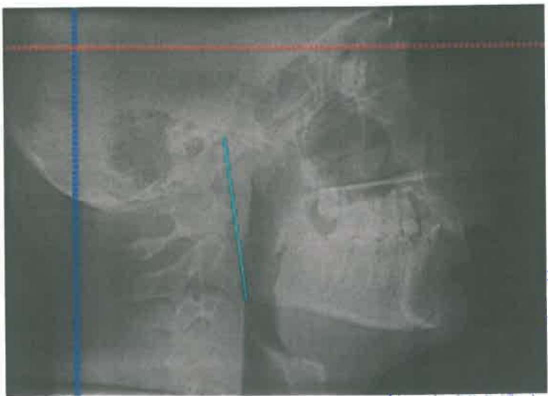
2.3.2.2. Measurements of mandible

1. Mandibular length – distance from the highest distal point of mandibular head (cephalometric anatomical point *Condilion*) to anterior lower chin point (cephalometric anatomical point *Gnathion*)



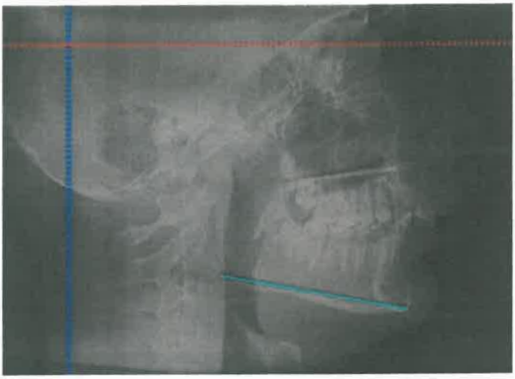
Picture 2.8. Measurement – mandibular length

2. Length of mandibular ramus- distance from the highest distal point of mandibular head to constructed point of intersection between posterior border of mandibular ramus and mandibular plane (cephalometric anatomical point *Gonion*)



Picture 2.9. Measurement – length of mandibular ramus

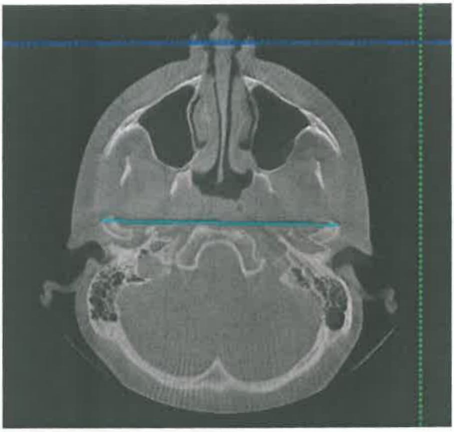
3.Mandibular body length – distance between constructed intersection between posterior border of mandibular ramus and mandibular plane (cephalometric anatomical point *Gonion*) and frontal lower chin point (cephalometric anatomical point *Gnathion*)



Picture 2.10. Measurement – mandibular body length

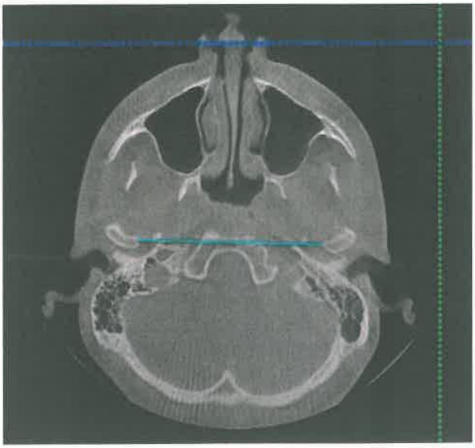
2.3.2.3. Intercondylar measurements

1. Maximum intercondylar distance between lateral poles – the greatest distance between lateral poles of condylar heads



Picture 2.11. Measurement – maximum intercondylar distance between lateral poles

2. Maximum intercondylar distance between medial poles – the greatest distance between medial poles of condylar heads



Picture 2.12. Measurement – maximum intercondylar distance between medial poles

2.3.2.4. Descriptive criteria of condylar head

1. Form of condylar head – descriptive evaluation of the form of mandibular head, that can be round, oval, flattened, triangular or sphenoidal (Katsavrias, 2006)

2. RDC/TMD criteria, which characterise volume of complex of mandibular head and fossa/eminence tubercle, surface quality and quantity, osseous structure:

   2.1. Condylar hypoplasia – condylar morphology is normal, but the size is small from all dimensions;

   2.2. Condylar hyperplasia – condylar morphology is normal, but the size is large in all dimensions;

   2.3. Articular surface flattening – a loss of the rounded contour of the surface;

2.4. Subcortical sclerosis – increased thickness of the cortical plate in the load-bearing areas relative to the adjacent non-load – bearing areas;

2.5. Subcortical cyst – a cavity below the articular surface that deviates from normal marrow pattern in the aspect of radiodensity;

2.6. Surface erosion – loss of continuity of articular cortex.

2.7. Osteophytes – marginal hypertrophy with sclerotic borders and exophytic angular formation of osseous tissue;

2.8. Generalised sclerosis – no clear trabecular orientation with no delineation between the cortical layer and the trabecular bone;

2.9. Loose joint body – a well defined calcified structure that is not continuous with the disc or osseous structures of the joint;

2.10. Deviation in form – a departure from normal shape, concavity in the outline of the cortical plate, not attributable to erosion, flattening and other above mentioned criteria;

2.11. Ankylosis;

2.12. Articular surface flattening – a loss of the rounded contour of the surface.

2.13. Subcortical sclerosis – increased sickness of the cortical plate in the load – bearing areas in comparison to the adjacent nonload-bearing areas.

2.14. Surface erosion – loss of continuity of articular cortex.

Summarizing the detected signs in articular osseous structures according to RDC/TMD (Research diagnostic criteria for temporomandibular disorders) described system; diagnosis of articular osseous tissues can be made:

1. No osteoarthritis

   a. Relatively normal size of condylar head

b. Flattening or subcortical sclerosis of the articular surface is not observed.
c. No deformations caused by subcortical cysts, surface erosion, osteophytes or generalised sclerosis.

2. Indeterminate for osteoarthritis (id OA)
   a. Relatively normal size of condylar head
   b. Observed subcortical sclerosis with or without flattening of articular surface, or
   c. Observed flattening of articular surface with or without sub-cortical sclerosis;
   d. No deformations caused by subcortical cysts, surface erosion, osteophytes or generalized sclerosis.
3. Osteoarthritis (OA)
   a. Observed deformations caused by subcortical cysts, surface erosion, osteophytes or generalised sclerosis.

3. RESULTS

3.1. Linear parameters of temporomandibular joint and mandible

Analysing the mean indices and looking for correlation between them, joints of each side were examined separately, since even clinically symmetric patients may have asymmetric joints.

Table 3.1

Comparison of linear parameters of temporomadibular joint and mandible in study groups

Measurement	Class I		Class II		Class III		p
	Mean value	SD	Mean value	SD	Mean value	SD	
Mandibular fossa width dx	19,89	1,43	20,31	1,95	21,89	2,08	**0.000**
Mandibular fossa width sin	19,33	2,3	20,49	1,93	21,29	1,99	**0.0003**
Mandibular fossa depth dx	8,38	1,09	8,19	1,12	8,61	1,1	NS
Mandibular fossa depth sin	8,06	1,13	8,31	1,04	8,4	1,02	NS
Anterior joint space dx	2,49	0,67	2,49	0,81	2,32	0,81	NS
Anterior joint space sin	2,60	0,77	2,44	0,83	2,27	0,67	NS
Upper joint space dx	2,65	0,96	2,44	0,84	2,03	0,81	**0.0033**
Upper joint space sin	2,7	0,91	2,48	0,87	2,18	0,78	NS
Posterior joint space dx	2,36	0,77	2,48	0,93	2,23	0,72	NS
Posterior joint space sin	2,54	0,67	2,55	1,06	2,52	0,68	NS
Height of condyle dx	8,49	1,52	8,2	1,55	8,6	1,55	NS
Height of condyle sin	8,01	1,53	8,27	1,74	8,31	1,52	NS
Condylar sagital width dx	10,39	2,04	10,66	1,9	10	1,75	NS
Condylar sagital width sin	9,81	1,58	10,32	1,87	9,55	1,39	NS
Processus condylaris height dx	21,72	2,79	19,09	2,83	23,92	3,22	**0.0000**
Processus condylaris height sin	21,38	2,82	19,28	3,05	23,9	3,35	**0.0000**

Table 3.1 (continued)

Mandibular length dx	115,1	6,39	108,93	7,14	125,8	7,73	**0.0000**
Mandibular length sin	115,76	7,53	109,09	7,37	123,3	8,31	**0.0000**
Mandibular body length dx	76,22	4,97	72,42	6,27	81,26	5,82	**0.0000**
Mandibular body length sin	77,08	6,22	70,52	10,63	79,49	6,23	**0.0000**
Mandibular ramus length dx	59,6	6,68	54,84	6,49	61,18	6,3	**0.0000**
Mandibular ramus length sin	59,52	6,34	56,08	6,1	61,02	9,36	**0.0000**
Maksimal intercom-dylar distance between lateral poles	117,39	5,97	113,40	7,37	116,35	6,1	NS
Maksimal intercondylar distance between medial poles	82,82	5	84,5	5,84	83,25	5,04	NS

P- significance level; NS- no statistical confidence; Dx- right side; Sin- left side

Width of the articular fossa on the right side significantly differed in study groups (p=0.0000), however, taking into account Bonferroni correction (Altman, 1999), such statistically significant difference was not detected between Class I and II groups.

Between measurements – depth of articular fossa on the right side and anterior joint space in the right side – statistically significant differences between study groups were not found.

Width of the upper joint space in the right side differed statistically significantly between study groups, but by Bonferroni correction statistical confidence, in comparison to measurements of Class I and II, was not found.

Statistically confident differences between all study groups were found in the following measurements: *processus condylaris* height in the right side, length of mandible (Co-Gn) in the right side; mandibular body (distance Go-Gn) in the right side, as well as length of mandibular ramus (Co-Go), however, for the latter, correcting by Bonferroni, confident difference between Class I and III groups was not found.

In the intercondylar distances in axial plane statistically significant differences between study groups were not found.

Comparison of TMJ linear parameters in the left side revealed statistically significant differences between measurements in the width of articular fossa (by Bonferroni correction confidence was not found between Class II and III groups), at the height of *processus condylaris*, at the length of mandible (distance Co-Gn), at the length of mandibular body (distance Go-Gn) (by Bonferroni correction differences were not found between Class I and III groups), as well as at the length of mandibular ramus (distance Co-Go). Between other measurements of the left side statistically significant differences were not found.

3.1.1. Linear parameters of temporomandibular joint and mandible in II class subdivisions

Basing on clinical and cephalometric differences in inclinations of maxillary incisors according to Angle classification, Class II group was analysed dividing it into two groups: subdivision 1 and 2. Though minor differences were observed between all parameters, as statistically significant were evaluated only two – length of mandibular body in the right side, which was bigger in Class II subdivision 2 group and condylar sagital width – also bigger in Class II subdivision 2 group.

3.1.2. Linear parameters of temporomandibular joint and mandible in relation to growth type

As it was mentioned in the description of the method of this study, growth type was determined evaluating the angle in cephalograms, which forms between maxillary and mandibular planes. In case of neutral growth type the angle varies between 22-32 degrees (27 ± 5^0), if the angle is narrower than 22 degrees, it suggests horizontal growth type, but if it is wider than 32 degrees – vertical growth type.

To determine differences in various linear parameters of TMJ and mandible between growth types, all of the patients depending on MM angle and not taking into account skeletal jaw relations, were divided into three groups. Mean indices and standard deviations, as well as differences between groups are revealed in Table 3.2.

Table 3.2

Parameters of temporomandibular joint and mandible in relation to growth type

Measurement	Class I		Class II		Class III		P
	Mean value	SD	Mean value	SD	Mean value	SD	
Mandibular fossa width dx	20,83	2,31	20,69	1,76	21,43	1,89	NS
Mandibular fossa width sin	20,45	2,27	20,51	1,85	21,27	2,01	NS
Mandibular fossa depth dx	8,58	1,15	8,02	0,94	8,41	1,14	**0,0418**
Mandibular fossa depth sin	8,26	1,02	8,26	1,08	8,45	1,1	NS
Anterior joint space dx	2,34	0,68	2,53	0,91	2,47	0,87	NS
Anterior joint space sin	2,43	0,69	2,24	0,9	2,5	0,73	NS
Upper joint space dx	2,31	0,85	2,06	0,81	2,6	0,99	**0,0523**
Upper joint space sin	2,42	0,88	2,12	0,78	2,68	0,79	**0,0288**
Posterior joint space dx	2,34	0,77	2,3	0,74	2,45	1,04	NS
Posterior joint space sin	2,51	0,76	2,53	1,04	2,6	0,79	NS
Height of condyle dx	8,52	1,5	8,34	1,52	8,25	1,74	NS
Height of condyle sin	8,22	1,6	8,33	1,66	8,25	1,61	NS
Condylar sagital width dx	10,36	1,93	9,99	1,64	10,69	1,98	NS
Condylar sagital width sin	9,85	1,58	9,48	1,5	10,58	1,87	**0,0268**
Processus condylaris height dx	22,13	3,47	20,66	4,25	21,52	3,4	NS
Processus condylaris height sin	21,92	3,73	21,06	3,86	21,61	3,81	NS

Table 3.2 (continued)

Mandibular length dx	118,00	9,93	115,3	11,79	117,92	10,66	NS
Mandibular length sin	117,75	10,32	115,56	12,03	118,0	10,16	NS
Mandibular body length dx	77,81	6,87	73,71	7,46	78,54	6,0	**0,0052**
Mandibular body length sin	77,18	6,84	71,76	6,79	76,07	14,8	**0,0112**
Mandibular ramus length dx	58,66	6,17	54,95	7,53	62,27	6,63	**0,0001**
Mandibular ramus length sin	58,22	8,76	56,78	6,75	63,11	5,54	**0,0037**
Maximal interkondylar distance between lateral poles	116,27	6,65	112,94	6,54	116,12	6,81	**0,0378**
Maximal interkondylar distance between medial poles	83,58	4,86	84,16	6,04	83,24	5,93	NS

P- Significance level; NS- no statistical confidence; Dx- right side; Sin- left side

Several statistically significant differences were observed between measurements, majority of them manifestated symmetrically: upper joint space; length of mandibular body, length of mandibular ramus. In one side, differences were found in the following measurements: depth of articular fossa, sagital width of condyle.

In the measurement of the depth of the joint fossa in the right side, using Bonferroni correction, statistically significant difference was detected between neutral and vertical growth type, the same as for the measurement - upper joint space in the right side, where statistically confident difference was observed only between vertical and horizontal growth type (p=0.046).

Evaluating mean length of mandibular body in the right side in patients with different growth type, statistically significant difference was not found between groups of neutral and horizontal growth types, but rather pronounced they were comparing mean values of vertical growth type with neutral (p=0.01) and horizontal (p=0.017) type.

Measurement – length of mandibular ramus in the right side- statistically significantly differed between all groups, but maximum intercondylar distance between lateral poles by Bonferroni correction statistically significantly differed between neutral and vertical growth types only.

Also in the left side, for the upper joint space measurement statistically significant difference was observed only between vertical and horizontal growth type (p=0.026), exactly the same as for measurement of condylar sagital width (p=0.023).

The length of the left side mandibular body statistically significantly differed between neutral and vertical growth types only; comparing length of mandibular ramus, such confidence was observed between neutral and horizontal type, as well as between vertical and horizontal growth types.

Dividing Class II and III groups into subgroups of growth types and evaluating mean indices, only some statistically confident differences were found.

Table 3.3

Comparison of mean values of linear measurements of subgroups of Class II growth type

Measurement	Neutral growth type		Vertical growth type		Horizontal growth type		p
	Mean value	SD	Mean value	SD	Mean value	SD	
Mandibular body length dx	70,96	5,01	70,57	6,58	76,6	5,38	**0,0049**
Mandibular ramus length dx	54,90	5,17	50,85	5,13	60,27	5,68	**0,0000**
Mandibular ramus length sin	10,46	1,79	9,53	1,57	11,24	1,98	**0,0163**
Condylar sagital width sin	53,99	4,13	53,55	5,27	61,92	5,24	**0,0000**

P- Significance level; Dx- right side; Sin- left side;

For Class II group measurement of mandibular ramus in both sides statistically significantly differed between all growth types; length of mandibular body in the right side – only between neutral and horizontal (p=0.019) and between vertical and horizontal (p=0.008). Condylar sagital width measurement – in the left side statistically confident difference (p=0.014) was detected between vertical and horizontal growth type.

Table 3.4

Comparison of mean values of linear measurements of subgroups of Class III growth type

Measurement	Neutral growth type		Vertical growth type		Horizontal growth type		p
	Mean value	SD	Mean value	SD	Mean value	SD	
Mandibular body length dx	82,62	5,16	78,3	6,33	81,12	6,02	**0,0448**
Maksimal interkondylar distance between lateral poles	117,18	5,65	112,98	5,58	118,22	6,79	**0,0396**
Mandibular fossa width sin	21,34	1,98	20,32	1,75	22,36	1,81	**0,0275**

P- Significance level; Dx- right side; Sin- left side

Also in Class III group, making Bonferroni correction for the acquired results, statistical differences were found only between some of the growth types. Measurement for the length of the mandibular body differed only between vertical and neutral growth type (p=0.049); maximum intercondylar distance between the lateral poles – between vertical and horizontal growth type (p=0.045) and width of the joint fossa in the left side – between vertical and horizontal growth type (p=0.023).

3.2. Assessment of condylar position of temporomandibular articulation and the form of condylar head

Condylar position was evaluated by equation:

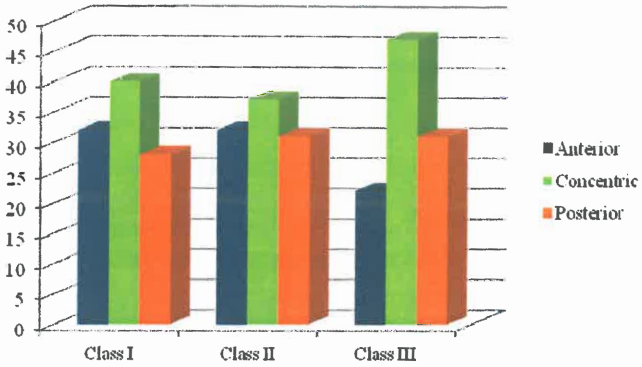
$$\text{Linear ratio} = \frac{P-A}{P+A} \times 100$$

where **P** means posterior articular space or the shortest perpendicular between backwardly the most pronounced point of the mandibular head and posterior wall of the articular fossa, but **A** – anterior articular space or the shortest perpendicular between the forwardly most pronounced point of the mandibular head and the posterior wall of the articular tubercle. If the calculated proportion is less than minus 12, condylar position can be characterised as posterior; if it is from minus 12 to 12, it is concentric, but if the index is bigger than 12, position is evaluated as frontal (Pulinger, 1987).

Also in this case joint of each side was evaluated separately. In both right and left side joints statistically significant differences were not observed in condylar position between Class I, II and III groups. In the right side joints in Class I group, most commonly anterior condylar position was observed (n=10 or 40%), followed by concentric (n=8 or 32%) and posterior position (n=7 or 28%). In almost half, or 48%, of the left side joints centric position was observed; division between posterior and anterior position was similar: 28% and 24% respectively.

In Class II group division between right and left side was more even. In both sides the most common was concentric condylar position (34% in the right side and 40% in the left side); posterior position was observed respectively in 32% and 30% of cases, similarly to the anterior – 34% and 30%.

In Class III group, significantly more frequently concentric position was observed (46% in the right side and 48% in the left side), posterior position more frequently was found in the left side joints (36% in the left side against 26% in the right side), also in the intensity of frontal position differences between the sides appeared (28%in the right and 16% in the left side). Picture 3.1 reveals common incidence of condylar positions in study groups.



Picture 3.1. Relative division of condylar positions by Class

The form of condylar head was assessed in sagital and coronar image reconstructions and characterised as round, oval, flattened and triangular or sphenoidal. For this index, the same as for condylar position, statistically significant differences were not found between Class I, II and III groups. Data analysis enables us to conclude that incidence of different forms in Class I and III groups was similar, opposite to Class II group, where most commonly flattened form of condylar head occurred. Assessing data of the left and right side, differences appeared in indices of incidence, which points to asymmetric, in the aspect of form, temporomandibular joints of both sides in clinically symmetric patients.

3.3. Assessment of structural changes of osseous tissues of temporomandibular joint

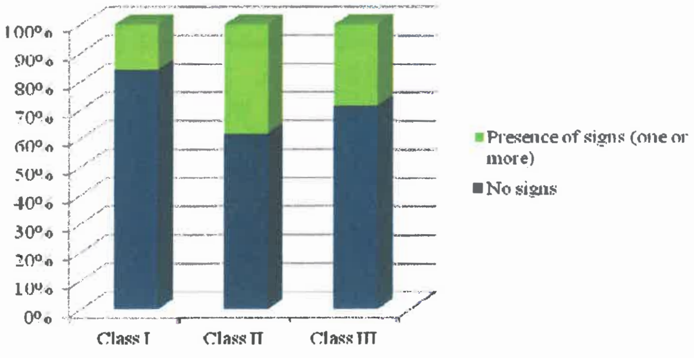
Osseous structures of the joint – complex of condylar head and articular fossa/eminence was assessed basing on first part (Axis I) criteria of temporomandibular disturbances worked out by Dworkin (Dworkin, 1992).

This paragraph describes analysis of TMJ osseous structures, made evaluating condylar head and structural quality and quantity of articular fossa/eminence complex by existence of above mentioned signs (See chapter Material and methods).

3.3.1. Intensity of signs in study groups

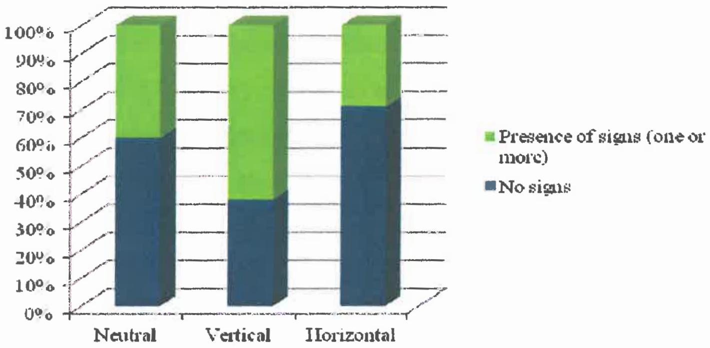
Presence of signs was determined and calculated separately for each joint, therefore, comparatively frequently for both temporomandibular joints of the same patient different diagnoses were made.

Presence of signs in Class I, II and III groups is revealed in Picture 3.2. Statistically significant difference was found ($p=0.014$) in the aspect of existence of signs between study groups. None of the destruction signs was found in 84% of joints in Class I group; 61.6 % of joints in Class II group and 71.3% of joints in Class III group. One or several signs of destruction were determined in 16% of joints in Class I group, 38.4% in Class II group and 28.7% in Class III group.



Picture 3.2. Presence of signs in study groups

Statistically significant differences were not found in incidence of signs between Class II subdivisions, almost equally divided number of the joints in which none of the signs of destruction was found and those, in which at least one of the signs was detected. Frequency of existence of signs most markedly differed in groups which were divided basing on MM angle or groups of growth types. Here, statistically significant differences were found in both separately for each side (right side indices are shown in the table) and totally. The common trends are shown in the picture – in vertical growth type group in 62% of joints at least one sign of destruction was found in comparison to 40% in neutral and 29% of horizontal growth type.



Picture 3.3. Intensity of signs in relation to growth type in joints of both sides

3.3.2. Differences in number of signs in study groups

Comparing number of the determined destruction signs in Class I, II and III groups, only in the left side joints statistically significant differences were found in the aspect of number of signs – more than two signs in one joint were determined only in Class II group. Informative description of intensity of signs among classes with skeletally different jaw relations is seen in Table 3.5

Table 3.5

Number of destruction signs in the left side joints by Class (p=0.024)

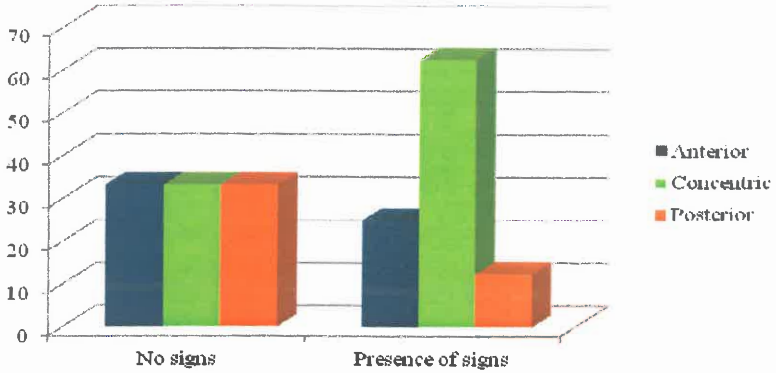
Number of signs	Class I		Class II		Class III		Total
	N	%	N	%	N	%	
0	20	80	34	60.71	38	62.3	92
1	5	20	10	17.86	21	34.43	36
2	0	0	8	14.29	2	3.28	10
3	0	0	2	3.57	0	0	2
4	0	0	2	3.57	0	0	2
Total	25	100	56	100	61	100	142

In Class II subdivisions, too, differences in number of signs were not determined. Four and more signs were found only in Class II subdivision 1. Analysing number of the destruction signs in joints and their relation to the growth type, in the right side joints statistically significant difference (p=0.033) was determined in the aspect of number of signs – the greatest number of joints with one or two signs occurred in the group of vertical growth type.

3.3.3. Presence of signs in relation to condylar position and form of condylar head

Looking for relation of condylar position with presence of destruction signs in temporomandibular joint, statistically significant differences in the framework of one group were not found.

In Class II group too, similarly to Class I group, incidence of positions in the joints without changes was approximately the same, but among joints, in which changes were detected, most commonly condylar head was in the concentric position. Different tendencies were observed in Class III group, where, regardless of presence of signs, position of condylar head most commonly was concentric.



Picture 3.4. Condylar position of Class I group and presence of TMJ destruction signs

Similarly to condylar position, in Class I and II groups relation between the form of the mandible and existence of destructive signs in TMJ bones was not found. Only in Class III group in left side joints this relation was found (p=0.000) (See Table 3.6)

Table 3.6

Presence of destruction signs in relation with the form of condylar head

Form of condylar head	No signs		Sign		Total
	N	%	N	%	
Round	22	57.89	4	17.39	26
Oval	14	36.84	8	34.78	22
Flattened	2	5.26	9	39.13	11
Triangular or sphenoidal	0	0	2	8.7	2
Total	38	100	23	100	61

3.3.4. Intensity of type of signs in study groups

In Class I group the signs were detected in small number of joints (4 joints in the right side, 6 – in the left side); only two types of signs were observed – flattening of articular surface of condylar head and changes of the form of condylar head, in majority of the cases one-sidedly. In Class II group signs of different types were determined more frequently, most commonly one-sidedly, however in rare cases also in joints of both sides. The following signs were found most commonly – flattening of the articular surface of condylar head, condylar hypoplasia, osteophytes, changes in the form of condylar head. Surface erosion, subcortical sclerosis in the condylar head was found in few cases only (See Table 3.7). In Class III group common tendencies were more similar to Class I group – mainly one-sidedly found changes, as the most common should be mentioned flattening of the particular surface of the articular head, changes of the form of articular head and subcortical sclerosis in head of the joint.

Table 3.7.

Destruction signs of condylar head and fossa/eminence complex in Class II individuals

Criteria	Right		Left		Both	
	N	%	N	%	N	%
None	21	37,5	22	39,29	16	14,29
Condylar hypoplasia	7	12,5	6	10,71	5	4,46
Condylar hyperplasia	0		0		0	
Flattening of articular surface	10	17,86	13	23,21	8	7,14
Subcortical sclerosis of condylar head	2	3,57	5	8,93	1	0,89
Subcortical cyst of condylar head	0	0	0	0	0	0
Surface erosion of condylar head	2	3,57	2	3,57	1	0,89
Osteophytes	3	5,36	7	12,50	1	0,89
Generalised sclerosis of condylar head	0	0	0	0	0	0
Loose joint body	0	0	0	0	0	0
Deviation in form of condylar head	4	7,14	3	5,36	0	0
Ankylosis	0	0	0	0	0	0

Table 3.7 (continued)

Articular surface flattening of fossa/eminence	2	3,57	4	7,14	2	1,79
Subcortical sclerosis of fossa/eminence	0	0	0	0	0	0
Surface erosion of articular fossa/eminence	0	0	0	0	0	0
Joints together	56	100	56	100	112	100

3.3.5. Intensity of skeletal diagnoses in study groups

Skeletal diagnoses, following RDC/TMD instructions, were calculated by both analysing each joint separately and examining temporomadibular joints of both sides together.

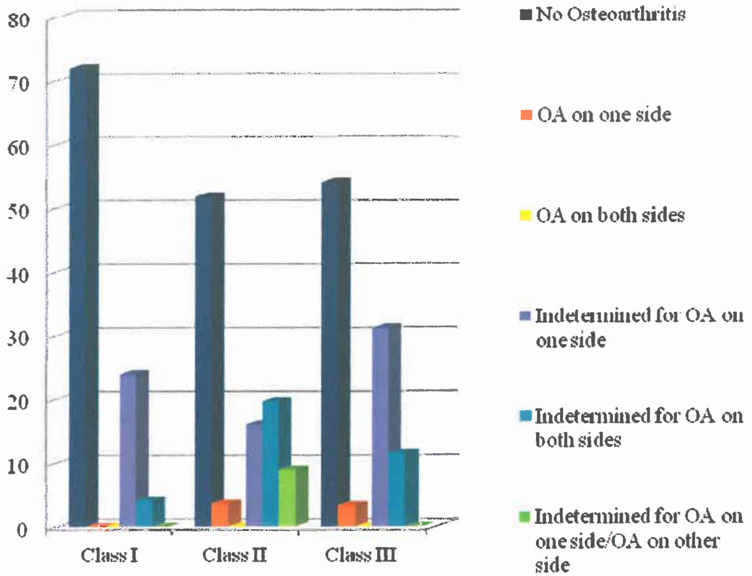
Intensity of indeterminate for osteoarthritis and osteoarthritis diagnoses in study groups are shown in the table 3.8. Though, statistically significant differences were not found, results show that in Class II group osteoarthritis diagnosis occurred more frequently than in other groups, similarly to diagnosis of indeterminate for osteoarthritis. The biggest proportion of healthy joints was found in Class I group.

Table 3.8.

Intensity of skeletal diagnoses in study groups

Diagnosis by RDC/TMD	Class I		Class II		Class III		Total
	N	%	N	%	N	%	
No signs of osteoarthritis	42	84	69	61,6	87	71,3	106
Indeterminate for osteoarthritis	8	16	36	32,1	33	27,0	31
Osteoarthritis	0	0	7	6,3	2	1,7	5
Total	50	100	112	100	122	100	142

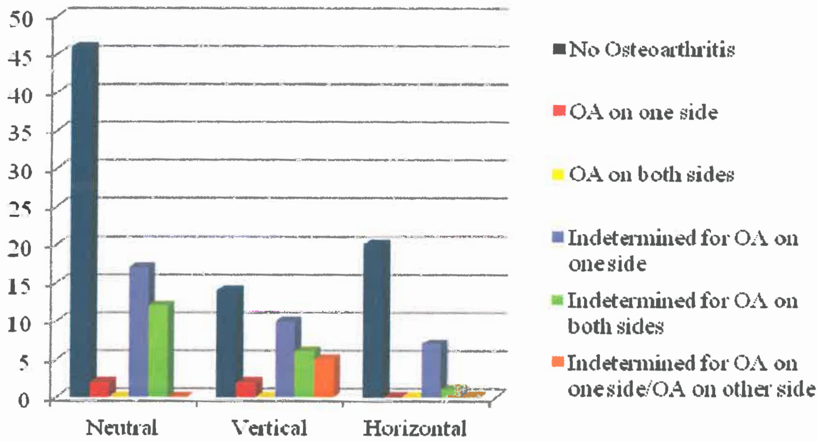
Analysing intensity of diagnoses in joints of both sides, it is possible to conclude that healthy joints most commonly occur in Class I group, intensity of osteoarthritis in one side is approximately similar in Class II and III groups, one-sided indeterminate for osteoarthritis most commonly are characteristic to Class III individuals (See picture 3.5)



Picture 3.5 Intensity of skeletal diagnoses by Class in both temporomandibular joints

Between Class II subclasses also significant differences in intensity of diagnoses were not found, percentage of indeterminate for osteoarthritis diagnoses was greater in Class II subdivision 1 group, but osteoarthritis in II/2 group.

Assessing intensity of skeletal diagnoses in both joints in relation to the growth type it was found that most frequently indeterminate for osteoarthritis and osteoarthritis in both temporomandibular joints were detected in the group of vertical growth type (See picture 3.6).



Picture 3.6. Intensity of skeletal diagnoses in both joints in relation to growth type

4. SUMMARY

Analysing our study, we conclude that CBCT is an optimal method of examination in order to assess, in three dimensions, quality and quantity of osseous structures of temporomandibular joint, as well as to measure precisely parameters of the joint and mandible; it is financially available and biologically acceptable (considering radiation dose) method for a patient. The acquired data are easy to analyse and interpret even for medical personnel without education in diagnostic radiology.

The acquired data prove asymmetric TMJ structures, different condylar positions and different TMJ osseous morphology in clinically symmetric patients, which may suggest ability of mastication system to adjust to different situations in joints of both sides, continuing ensuring of a good function.

The results of our study do not show significant differences in TMJ parameters between Angle Class I, II and III groups. Changes mainly are observed comparing the length of anatomical structures of mandible. Similar conclusions should be made assessing condylar position and the form of condylar head in different dentofacial anomalies – significant differences have not been found also here. Statistically significant differences between above mentioned study groups are found, evaluating structural changes in osseous tissues of the joint - most commonly in the joints of Angle Class II group, suggesting the role of occlusion in the development of structural changes.

Intensity of osteoarthritis, too, is higher in groups of dentofacial deformations, which allows us to presume that loads, caused by occlusion, affect TMJ structures and their remodelling.

More significant changes are observed, comparing linear parameters of the joint and mandible in different growth type groups, which suggests effect of facial growth type on the development of anatomical structures of the joint and mandible. Changes in osseous structures more frequently were observed in the

group of vertical growth type, long-term observations would let us understand whether mandibular rotation, which is characteristic to vertical growth type, is the cause or consequence of TMJ destruction. Similarly to data reported in literature, our results as well confirm more pronounced osteoarthritis intensity in vertical growth type group.

Looking for relation of linear parameters of mandible and TMJ with existence/intensity of destruction signs, relations in parameter indices and existence of signs were not observed, suggesting that the size of articular anatomical structure is not the determining factor in the development of destruction signs

5. CONCLUSIONS

1. The worked out examination algorithm, using CBCT for examination of radiologic morphology of mandible and TMJ, provides acquisition of 2D and 3D information on condition of osseous tissue structure and linear parameters.

2. Comparing dentofacial deformations of Angle Class II and III, minor differences are observed in size of TMJ structures and pronounced differences in size of mandibular anatomical structures

3. Analysing condylar position and the form of mandibular head in patients with Angle Class II and III dentofacial deformations, significant differences have not been found, which, possibly, suggests the minor role of these factors in the development of deformations.

4. In Angle Class I jaw relations, markedly different TMJ linear parameters, condylar positions and differences in the form of articular head have not been found, comparing to results of Angle Class II and III.

5. Structural changes in osseous tissues of temporomandibular joint most commonly are observed in patients with Angle Class II dentofacial deformations.

6. In cases of Angle Class I jaw relations as well, structural changes in osseous tissues of temporomandibular joint are observed; more of those that characterize remodelling process

7. Study results do not reveal relation of different TMJ and mandibular parameters, condylar position or form of the condylar head with existence of structural changes in osseous tissues of the joint.

8. The acquired data prove relation of vertical growth type of the jaws with more frequent intensity of structural changes in osseous tissues of the joint, comparing to neutral or horizontal growth type.

9. Diagnoses as indeterminate for osteoarthritis and osteoarthritis in temporomandibular joint most often are found in cases of Angle II jaw deformations.

10. Slightly asymmetric TMJ structures are frequently observed in patients with facial and occlusion symmetry.

11. There exists remarkable TMJ morphology variability – in patients with similar skeletal cephalometric measurements, condition of TMJ osseous structure can be markedly different, which suggests possible effect of growth, load, parafunctions, stress, general health condition and some other factors, determining structural quality and quantity of osseous tissue of temporo-mandibular joint.

6. PUBLICATIONS AND REPORTS ON THE TOPIC OF THE STUDY

6.1. Publications

1. Krisjane Z, Urtane I, Krumina G, Bieza A, Zepa K, Rogovska I. Condylar and mandibular morphological criteria in the 2D and 3D MSCT imaging for patients with Class II division 1 subdivision malocclusion// Stomatologia, 2007; 9: 67-71
2. Krūmiņa G, Urtāne I, Biezā A, Krišjāne Z, Zepa K. Temporomandibulārās locītavas un apakšžokļa kompjūtertomogrāfijas izmeklēšanas algoritms// RSU Zinātniskie raksti, 2007: 374-379
3. Zepa K, Urtāne I, Krūmiņa G, Biezā A, Krišjāne Z. Magnētiskās rezonanses 3D attēlu izmantošana Musculus masseter un Musculus pterygoideus medialis mērījumu algoritma izstrādē pacientiem ar apakšžokļa retrognātiju// RSU zinātniskie raksti, 2007:324-327
4. Zepa K, Urtāne I, Krišjāne Z. Apakšžokļa laterālās digitālās cefalometrijas un 3D datortomogrāfijas attēla lineāro mērījumu salīdzinājums// RSU zinātniskie raksti, 2008: 398- 402
5. Krisjane Z, Urtane I, Krumina G, Zepa K. Three- dimensional evaluation of TMJ parameters in Class II and Class III patients// Stomatologia, 2009; 11: 32-36
6. Zepa K, Urtane I, Krisjane Z, Krumina G. Three- dimensional assessment of musculosceletal features in Class II and Class III patients// Stomatologia, 2009; 11: 15-20
7. Krišjāne Z, Urtāne I, Krūmiņa G, Neimane L, Zepa K. TML morfoloģijas izmaiņu novērtējums konusstara datortomogrāfijas attēlos pacientiem ar dentofaciālām deformācijām// RSU Zinātniskie raksti, 2010: 313-317

8. Krisjane Z, Urtane I, Neimane L, Krumina G, Ragovska I. The prevalence of TMJ osteoarthritis in asymptomatic patients with dentofacial deformities: a cone- beam CT study// Int J Oral Maxillofac Surg, 2012; 41 (6): 690-95

6.2. Reports in congresses and conferences

1. Krisjane Z, Urtane I, Krumina G, Neimane L. The assessment of TMJ osseous morphology for osteoarthritic features in patients with dentofacial deformities/ Apvienotais pasaules latviešu zinātnieku 3. kongress un Letonikas 4. kongress/ tēzes/ 24.- 27. oktobris 2011; 53. (Rīga, Latvija)
2. Krisjane Z, Urtane I, Neimane L. Assessment of condylar morphology using cone beam computed tomography in patients with dentofacial anomalies/ 87th congress of the European orthodontic society/ abstract/19- 23 jūnijs, 2011; 150 (Stambula,Turcija)
3. Krisjane Z. Assessment of TMJ skeletal morphology in orthognatic patients/ 7th congress of the Baltic orthodontic association/ mutiska prezentācija /27- 28. maijs, 2011 (Kauņa, Lietuva)
4. Krisjane Z, Urtane I, Zepa K, Neimane L. Assessment of TMJ osseous morphology in orthognatic patients related on iCAT data/ 110th Annual session of American orthodontic society/ abstract/ 30. aprīlis- 4. maijs 2010; 150 (Vašingtona, ASV)
5. Zepa K, Urtane I, Krumina G, Krisjane Z. Musculoskeletal features in patients with skeletal Class I, Class II and Class III malocclusions/ abstract/ 110th Annual session of American orthodontic society/ 30. aprīlis-4. maijs 2010; 150 (Vašingtona, ASV)
6. Krišjāne Z, Urtāne I, Zepa K, Neimane L. Kondilārā morfoloģija ortognātiskās ķirurģijas pacientiem/ RSU zinātniskā konference/ tēzes/18.- 19. marts, 2010; 300 (Rīga, Latvija)

7. Zepa K, Urtāne I, Krišjāne Z, Krūmiņa G, Pavaine J. Muskulo-mandibulāro struktūru īpatnības pacientiem ar skeletālu Angle I klases sakodienu/ RSU zinātniskā konference/ tēzes/18.- 19. marts, 2010; 301 (Rīga, Latvija)

8. Krisjane Z, Urtane I, Zepa K. Morphological assessment of TMJ parameters in Class II and Class III patients/ 85th congress of the European orthodontic society/ abstract/ 10- 14 jūnijs, 2009; 74 (Helsinki, Somija)

9. Zepa K, Urtane I, Krisjane Z. Three- dimensional assessment of musculoskeletal features in Class II and Class III patients/ 85th congress of the European orthodontic society/ abstract/ 10- 14 jūnijs, 2009; 73 (Helsinki, Somija)

10. Krišjāne Z, Zepa K, Urtāne I. Kondiļa pozīcijas salīdzinājums pacientiem ar skeletālām II un III klases žokļu attiecībām/ RSU zinātniskā konference/ tēzes/ 2.-3. aprīlis, 2009;202 (Rīga, Latvija)

11. Zepa K, Krišjāne Z, Urtāne I, Krūmiņa G. 3D skeletālo un muskuļu struktūru īpatnības pacientiem ar skeletālu Angle II un III klases sakodienu/ RSU zinātniskā konference/ tēzes/ 2.-3. aprīlis, 2009;203 (Rīga, Latvija)

12. Krisjane Z, Urtane I, Zepa K, Krumina G. MSCT parameters of TMJ in patients with mandibular retrognathia and prognathia/ 6th congress of the Baltic orthodontic association/ mutiska prezentācija/ 22.-24. maijs, 2008; 8 (Rīga, Latvija)

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