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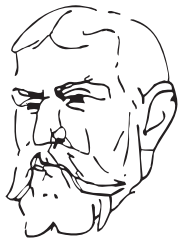

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ORIGINAL ARTICLE

RECIPROCAL CLICKING LOCATION ANALYSIS IN THE INTRAARTICULAR TEMPOROMANDIBULAR DISORDERS AFTER AXIOGRAPHY INVESTIGATION

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ABSTRACT

The aim: To investigate the peculiarities of hinge axis trajectories in patients with condyle-disc complex intraarticular Temporomandibular Disorders (TMD) and determine the average coordinates of the reciprocal clicking location by axiography.

Materials and methods: The results of axiographic examination of 151 patients (108 females and 43 males) with TMD confirmed by MRI were analyzed. This population included 44 persons with disc displacement with reduction (DDR), 45 persons with disc displacement with reduction and intermittent locking (DDRI), 62 persons with disc displacement without reduction (DDWR). Axiographic examination was carried out using CADIAX diagnostic device. Analysis of hinge axis movements was performed and the coordinates of articular disc reduction were determined.

Results: The quality of hinge axis trajectories in persons with DDR, DDRI was defined mainly as average and in patients with DDWR as poor. Quantitative indicators of trajectories during protrusion-retrusion movements were not beyond the average level. The length of the mouth opening-closing trajectory in patients with DDRI and DDWR has shown a tendency to decrease. We found that on average the reciprocal closing clicking (disc reduction) occurs at a distance of 0-1.4 mm on the X-axis, 0.1-2.9 mm on the Z-axis, and 0-0.85 mm on the Y-axis.

Conclusions: The obtained wide range of reciprocal clicking location parameters indicates the priority of a personalized approach when planning preliminary treatment in order to restore the disc-condylar complex of TMJ.

KEY WORDS: disc displacement, condylar position, axiography, intracapsular derangement

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INTRODUCTION

One of the most important and difficult approaches in the noninvasive treatment of TMD is the correction of articular disc position. In the pathogenesis of disc displacement, the main factors are adjacent structures influencing the changes in morphology and function of the retrodiscal zone and articular disc. Disorders of the disc-condylar complex are characterized by a number of symptoms, including clicking, popping, or crunching in the temporo-mandibular joint (TMJ), deviation, and deflection during opening and closing movements of the mandible. Limited mouth opening and pain symptoms in TMJ can be an indicator of some intra-articular pathology [1, 2].

Magnetic resonance imaging is usually used to confirm the presence and type of intra-articular disorders [3]. Axiographic examination of mandibular movement trajectories is useful in determining muscle discoordination, asymmetry of mandibular movements, hyper- and hypomobility of condyles and helps to assess the mechanisms of circumvention of occlusal obstructions and clarify the type of pathology of the disc-condylar complex. In comparison to other methods of TMJ functional examination, the axiography has some advantages: it's a non-invasive procedure, and it doesn't use any factors of pathological influence like radiation. The obtained results allow us to determine the functional state of the TMJ in real-time, use the data for analysis in various computer programs, and for adjusting the articulators to an individual function according to recorded parameters of jaw movements. The obtained data analysis significantly improves the differential diagnosis of both intra-articular and extra-articular disorders of TMJ based on the analysis of static and dynamic indicators of the trajectories of the mandible movements [4-6]. The high level of sensitivity and specificity of axiographic examination has been proved by several scientific studies and its capabilities can be compared with MRI, which is currently the main method for detecting morphological changes in the TMJ [7].

The recovery of the disc-condylar complex can be achieved by using repositioning and distraction occlusal splints [8, 9]. Thanks to the coordinates obtained by axiographic examination, the therapeutic position of

the mandible can be established while maintaining the disc-condylar interrelations on the custom-made splint, keeping the mandible in the therapeutic position, and preventing displacement of the articular disc [10].

The significant prevalence of intra-articular disorders of TMJ forms a need to determine the average values of reciprocal clicking coordinates in order to increase the efficiency of distraction and repositioning occlusal splints that confirm the relevance of this study.

THE AIM

The aim of the study was to investigate the peculiarities of hinge axis trajectories in patients with condyle-disc complex intraarticular TMD and determine the average coordinates of the reciprocal clicking location by axiography.

MATERIALS AND METHODS

The retrospective study was conducted at the Dental Medical Center of Bogomolets National Medical University and covered the period from 2016 to 2020. The case histories of 573 patients (389 females and 182 males) who complained of pain in the TMJ, clicking, crunching in the TMJ, and limited mouth opening were analyzed. Considering the purpose of the study, the case histories and results of axiographic examination of 151 (108 females and 43 males; mean age 38.7±12.9 years) patients with condyle-disc complex intraarticular TMD confirmed by MRI were selected for further analysis.

The study excluded people with no signs of pathological changes in the TMJ, with signs of inflammation in the TMJ, patients with complete teeth loss, patients during splint therapy, psychologically unstable patients, patients during treatment of somatic pathology, and patients who underwent the specific treatment of TMD.

The selected population was divided into three groups according to The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) [2]. The first group (n=44) included patients with disc displacement with reduction (DDR). The second group (n=45) included patients with disc displacement with reduction and intermittent locking (DDRI). The third group (n=62) included patients with disc displacement without reduction (DDWR). The third group included individuals with and without limitation of mandibular movements due to certain problems of differentiating these conditions in a retrospective context.

Axiographic examination was carried out using CADIAX diagnostic device and GAMMA Dental Software Version 7.7.14 (GAMMA Medizinisch-wissenschaftliche Fortbildungs-GmbH, Austria). Analysis of hinge axis movements during symmetrical mandibular movements (opening-closing and protrusion-retrusion) was performed in three-dimensional space in the sagittal, transversal and cranial planes. The trajectories were analyzed from top to bottom in sagittal (x-z), frontal (y-z), and cranial (x-y) planes. Also, the coordinates of articular disc reduction were determined.

Statistical analysis of the results was performed by EZR v. 1.54 package (graphical user interface for R statistical software version 4.0.3, R Foundation for Statistical Computing, Vienna, Austria) [11]. For quantitative indicators in the case of normal distribution, the mean value of the indicator ± standard deviation (SD) was calculated, in the case of a distribution other than normal the median value of the indicator and the interquartile range (IQR) were calculated. The distribution was checked for normality by the Shapiro-Wilk test. The critical value for statistical hypotheses testing was taken at $p<0.05$.

The study was approved by the Bioethics Commission of Bogomolets National Medical University. All participants have signed informed consent for diagnostic and therapeutic procedures as well as for observation in accordance with the World Medical Association Declaration of Helsinki as a statement of ethical principles for medical research involving human subjects.

RESULTS

The analysis of hinge axis movement trajectories in the first group has determined that 36 patients (81.8%) had the intersections of trajectories during opening-closing and protrusion-retrusion movements, which are signs of bilateral displacement of the articular disc with reposition. In 8 patients (18.1%) the intersections of the trajectories were found unilaterally. Lateral translation during symmetrical mandibular movements was determined mainly in unilateral DDR. The average value of the trajectory length (Quantity) in patients with DDR was 12.9$\pm$1.6 mm during opening-closing movements and 10.3$\pm$1.7 mm during protrusion-retrusion movements. The Quality of trajectories values in most cases was average, in some patients with unilateral DDR a combination of poor and average values was observed. The shapes of the trajectories were variable with changing characteristics from convex to concave and with the intersection of lines. Hinge axis movement trajectories showed strong sagittal and transversal asymmetry in volume and direction of displacement during all symmetrical mandibular movements with different degrees of manifestations. The disc reduction clicking at the beginning of mouth opening and the reciprocal clicking at the end of mouth closing differed in amplitude and coordinates of the formation (Fig. 1).

Concerning the peculiarities of distribution in the population with DDR, the average indicators of the statistical analysis were presented by Me and IQR (Q_I-Q_{III}). During retrusion, according to the "X" axis, the displacement was 0.5 mm on the right and 0.7 mm on the left with IQR (Q_I-Q_{III}) 0.0-1.25 mm in right TMJ and 0.05-1.3 mm in left TMJ without statistically significant difference ($p>0.05$) in parameters of trajectories of hinge axis movements of the condyles outside the disc at the stage of jaws closing. During retrusion in the "Z" direction, Me was 1.45 mm on the right and 1.4 mm on the left with IQR (Q_I-Q_{III}) 0.0-2.0 mm on the right and 0.0-1.9 mm on the left without statistically significant difference ($p> 0.05$) between the

Table I. Comparative analysis of hinge axis movements parameters of TMJ condyles at the level of reciprocal clicking in patients with DDR according to the results of axiography (mm, Me (Q_I – Q_{III}))

Parameter	Right TMJ (n=44)	Left TMJ (n=44)	Level of significance of the difference, p
Retrusion (X)	0.5 (0.0-1.25)	0.7 (0.05-1.3)	0.2
Retrusion (Z)	1.45 (0.0-2.0)	1.4 (0.0-1.9)	0.441
Retrusion (Y)	0.35 (0.0-0.8)	0.25 (0.0-0.8)	0.381
Closing (X)	1.0 (0.6-1.4)	1.0 (0.25-1.4)	0.456
Closing (Z)	1.8 (1.2-2.9)	1.9 (1.0-2.4)	0.456
Closing (Y)	0.45 (0.2-0.85)	0.4 (0.0-0.7)	**0.016**

Note:
1. T-Wilcoxon criterion for related samples was used for comparison.
2. The directions of movements of the hinge axis are presented in coordinate system: "X" – forward-backward direction; "Z" – top-bottom direction; "Y" – left-right direction.

Table II. Comparative analysis of hinge axis movements parameters of TMJ condyles at the level of reciprocal clicking in patients with DDRI according to the results of axiography (mm, Me (QI – QIII))

Parameter	Right TMJ (n=45)	Left TMJ (n=45)	Level of significance of the difference, p
Retrusion (X)	0.7 (0.0-1.025)	0.7 (0,175-1.325)	0.295
Retrusion (Z)	1.0 (0.0-1.7)	1.2 (0,275-2,0)	0.555
Retrusion (Y)	0.3 (0.0-0.675)	0.3 (0.075-0.625)	0.939
Closing (X)	0.8 (0.3-1.3)	0.9 (0.2-1.425)	0.341
Closing (Z)	1.5 (0.925-2.275)	1.5 (1.0-2.4)	0.414
Closing (Y)	0.35 (0.15-0.65)	0.4 (0.075-0.825)	0.846

Note:
1. T-Wilcoxon criterion for related samples was used for comparison.
2. The directions of movements of the hinge axis are presented in coordinate system: "X" – forward-backward direction; "Z" – top-bottom direction; "Y" – left-right direction.

Table III. Comparative analysis of hinge axis movements parameters of TMJ condyles at the level of reciprocal clicking in patients with DDWR according to the results of axiography (mm, Me (QI – QIII))

Parameter	Right TMJ (n=62)	Left TMJ (n=62)	Level of significance of the difference, p
Retrusion (X)	0.25 (0.0-0.9)	0.15 (0.0-0.6)	0.695
Retrusion (Z)	0.8 (0.0-1.725)	0.35 (0.0-1.4)	0.823
Retrusion (Y)	0.05 (0.0-0.6)	0.0 (0.0-0.6)	0.27
Closing (X)	0.74 (0.2-1.4)	0.85 (0.1-1.5)	0.711
Closing (Z)	1.75 (1.0-2.5)	1.95 (0.66-2.8)	0.573
Closing (Y)	0.45 (0.2-0.8)	0.4 (0.1-0.6)	**0.037**

Note:
1. T-Wilcoxon criterion for related samples was used for comparison.
2. The directions of movements of the hinge axis are presented in coordinate system: "X" – forward-backward direction; "Z" – top-bottom direction; "Y" – left-right direction.

parameters in right and left TMJ. In the "Y" direction Me was 0.35 mm on the right and 0.25 mm on the left with IQR (Q_I-Q_{III}) 0.0-0.8 mm on the right and left without a statistically significant difference (p>0.05) between the parameters.

At the end of the mouth closing in the "X" direction Me was 1.0 mm on the right and left with IQR (Q_I-Q_{III}) 0.6-1.4 mm on the right and 0.250-1.4 mm on the left without statistically significant difference (p>0.05) between the parameters. In the "Z" direction Me was 1.8 mm on the right and 1.9 mm on the left with IQR (Q_I-Q_{III}) 1.2-2.9 mm on the right and 1.0-2.4 mm on the left without statistically significant difference (p>0.05) between the parameters. In the "Y" direction Me was 0.45 mm on the right and 0.4 mm on the left with IQR (Q_I-Q_{III}) 0.2-0.85 mm on the right and 0.0-0.7 mm on the left with statistically significant

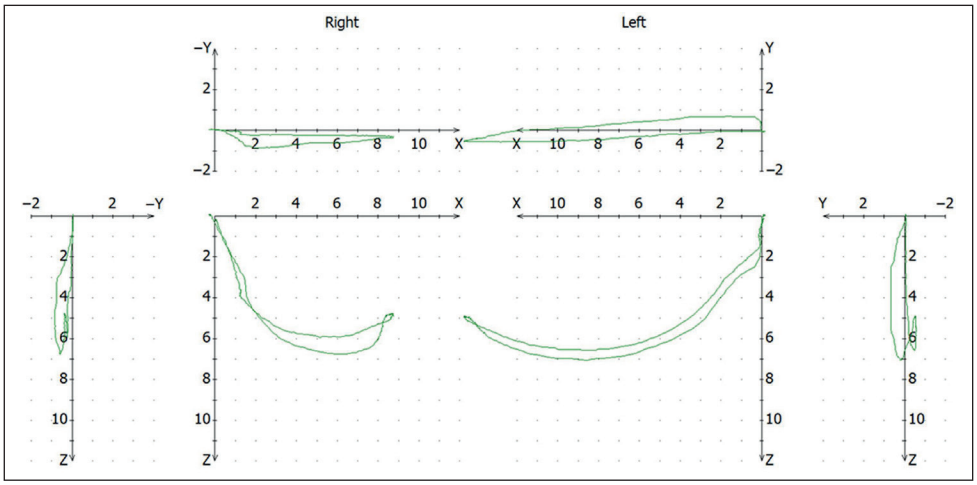

Fig. 1. Hinge axis movement trajectories at the axiogram of patient with DDR

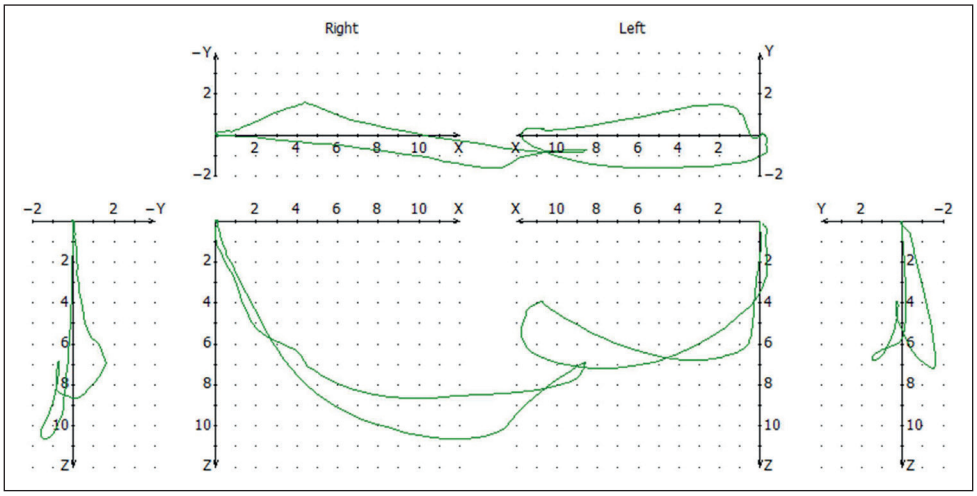

Fig. 2. Hinge axis movement trajectories at the axiogram of patient with DDRI

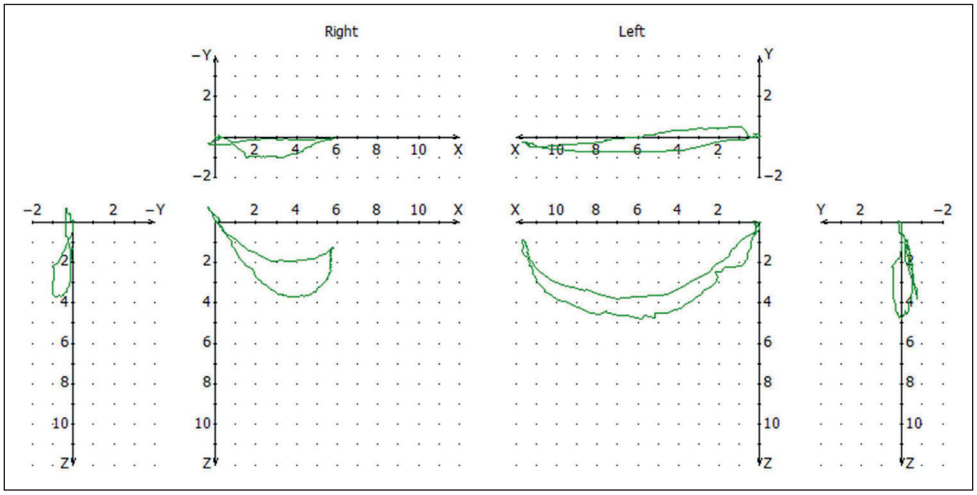

Fig. 3. Hinge axis movement trajectories at the axiogram of the patient with DDWR

(p=0.016) difference between ranges of movements on the right and left sides (Table I).

The main peculiarities of DDRI are intermittent limitations of condyles movements in TMJ during mouth opening and closing. The analysis of hinge axis displacement during mouth opening-closing and protrusion-retrusion movements has shown bilaterally asynchronous and asymmetric trajectories with different lengths and angulations in 45 patients with DDRI. The average length of the trajectory (Quantity) was 9.5±1.2 mm during mouth opening-closing and 10.1±1.3 mm during protrusion-retrusion movements. The signs of DDRI were detected unilaterally with pronounced changes in hinge axis trajectories of the opposite joint and lateral translation during symmetrical mandibular movements in 17 (37.8%) patients. In 28 (62.2%) patients with bilateral DDRI, hinge axis movement was accompanied by asymmetric intersections of traces during mouth opening-closing and protrusion-retrusion movements of the jaw, its shapes varied from convex to concave. The quality of trajectories was average, the dis-

placements and intersections of the trajectories during clicking on the left and right were formed asynchronously in time. The reciprocal clicks at the end of mouth closing differed in amplitude and coordinates of formation (Fig. 2).

Concerning the peculiarities of distribution in the population with DDRI, the average indicators of the statistical analysis were presented by Me and IQR (Q_I-Q_{III}). During retrusion, according to the "X" axis, the displacement was 0.7 mm on the right and left with IQR (Q_I-Q_{III}) 0.0-1.025 mm in right TMJ and 0.175-1.325 mm in left TMJ without statistically significant difference (p>0.05) between the parameters of right and left TMJ. During retrusion in the "Z" direction Me was 1.0 mm on the right and 1.2 mm on the left with IQR (Q_I-Q_{III}) 0.0-1.7 mm on the right and 0.275-2.0 mm on the left without statistically significant difference (p> 0.05) between the parameters. In the "Y" direction Me was 0.3 mm on the right and left with IQR (Q_I-Q_{III}) 0.0-0.675 mm on the right and 0.075-0.625 mm on the left mm without a statistically significant difference (p> 0.05) between the parameters.

At the end of the mouth closing in the "X" direction Me was 0.8 mm on the right and 0.9 mm on the left with IQR (Q_I-Q_{III}) 0.3-1.3 mm on the right and 0.2-1.425 mm on the left without statistically significant difference (p>0.05) between the parameters. In the "Z" direction Me was 1.5 mm on the right and left with IQR (Q_I-Q_{III}) 0.925-2.275 mm on the right and 1.0-2.4 mm on the left without a statistically significant difference (p>0.05) between the parameters. In the "Y" direction Me was 0.35 mm on the right and 0.4 mm on the left with IQR (Q_I-Q_{III}) 0.15-0.65 mm on the right and 0.075-0.825 mm on the left without statistically significant difference (p>0.05) between the parameters (Table II).

The analysis of hinge axis movements trajectories in the group with DDWR has shown a reduction of movement trajectories parameters in 42 (67.7%) patients. The typical trajectories of hinge axis movements were found in 30 (48.4%) patients bilaterally and in 32 (51.6%) patients unilaterally. Qualitative characteristics of hinge axis trajectories were evaluated as poor. In all cases, an asymmetry, intersections of trajectories in the vertical, sagittal, and transversal directions were observed, as well as no coincidence of the lines and extreme differences between the right and left sides during mouth opening-closing were found. The average length of the trajectory (Quantity) was 9.8±11.6 mm during mouth opening-closing and 9.3±1.4 mm during protrusion-retrusion movements of the jaw (Fig. 3).

Concerning the peculiarities of distribution in the population with DDWR, the average indicators of the statistical analysis were presented by Me and IQR (Q_I-Q_{III}). During retrusion, according to the "X" axis, the displacement was 0.25 mm on the right and 0.15 mm on the left with IQR (Q_I-Q_{III}) 0.0-0.9 mm in right TMJ and 0.0-0.6 mm in left TMJ without statistically significant difference (p>0.05) in parameters of trajectories of hinge axis movements. During retrusion in the "Z" direction Me was 0.8 mm on the right and 0.35 mm on the left with IQR (Q_I-Q_{III}) 0.0-1.725 mm on the right and 0.0-1.4 mm on the left without statistically significant difference (p> 0.05) between the parameters in right and left TMJ. In the "Y" direction Me was 0.05 mm on the right and 0.0 mm on the left with IQR (Q_I-Q_{III}) 0.0-0.6 mm on the right and left without statistically significant difference (p>0.05) between the parameters.

At the end of the mouth closing in the "X" direction Me was 0.74 mm on the right and 0.85 mm on the left with IQR (Q_I-Q_{III}) 0.2-1.4 mm on the right and 0.1-1.5 mm on the left without statistically significant difference (p>0.05) between the parameters. In the "Z" direction Me was 1.75 mm on the right and 1.95 mm on the left with IQR (Q_I-Q_{III}) 1.0-2.5 mm on the right and 0.66-2.8 mm on the left without statistically significant difference (p>0.05) between the parameters. In the "Y" direction Me was 0.45 mm on the right and 0.4 mm on the left with IQR (Q_I-Q_{III}) 0.2-0.8 mm on the right and 0.1-0.6 mm on the left with statistically significant (p=0.037) difference between ranges of movements on the right and left sides (Table III).

DISCUSSION

Qualitative assessment of hinge axis trajectories in the study in patients with DDR and DDRI has shown mainly average and in some cases poor values. Various deviations and intersections of lines were observed along the entire path of hinge axis movements. The number of deviations and intersections was determined from one to four. Such results may emphasize the changes in disc-condyles complex of TMJ. Qualitative characteristics of patients with DDWR were defined as poor.

The study included more female patients than male and bilateral manifestations of TMJ disorders were observed in $^4/_5$ of the first group, $^2/_3$ of the second group and ½ of the third group. The obtained data confirm the typical for women bilateral manifestations of TMJ pathology revealed in previous studies [12]. However, possibility to determine certain peculiarities of hinge axis trajectories is an advantage of axiography during early preventive and treatment procedures [13].

In the majority of patients (81.8%) we identified the signs of bilateral DDR with strong sagittal and transversal asymmetry in volume and direction of displacement during symmetrical movements of the mandible and varying degrees of manifestation. In contrast, the prevalence of unilateral manifestations in patients with DDRI was 37.8% compared to 18.2% in patients with DDR. Also, the disc reduction clicking and reciprocal clicking differed significantly in the coordinates of formation.

The signs of asymmetry during symmetrical movements of the mandible has been widely discussed in the literature. And as it has been already proven it can be observed in a significant amount even if the person has no TMJ pathology [13]. According to our observations, asymmetric trajectories can be formed due to both morphological peculiarities and translations in the sagittal, transversal, and vertical directions in patients with the condyle-disc complex intraarticular TMD. In our study, the transversal

asymmetry and, especially, its initial component (lateral translation) during symmetrical mandibular movements prevailed in patients with unilateral DDR and DDRI. Sadao Sato et al. suggested that the lateral translation of the condyle occurs in the lower joint when the lower joint is loosened with disk displacement, and the analysis of condylar tracking is probably useful for the early detection of dysfunction [14].

Quantitative parameters of trajectories during protrusion-retrusion movement in all study groups were within the average level. The length of the mouth opening-closing trajectories in patients with DDRI and DDWR has shown a tendency to decrease, which can be the result of condyle movement blocking. The possibility to determine the peculiarities of condyle movement trajectories confirms the benefit of axiography for the diagnostics of certain types of TMJ pathology [5].

Intra-articular disorders DDR and DDRI, which are characterized by certain clinical symptoms and morphological changes, have been described by numerous MRI studies [4]. When the jaws are closed, the disc occurs in an altered position, in most cases being displaced forward and medially. During the mouth opening movement, as well as during protrusion and mediatrusion, the restoration of normal disc-condyle interrelation occurs. DDWR clinically manifests itself by limitation of jaw movement, often without any noise. But among typical manifestations, there are always some changes in jaw movement trajectories during mouth opening-closing, protrusion, and mediotrusion which can be assessed by axiography. According to the recommendations of several authors, the therapeutic position of the mandible should be achieved before reaching the closing clicking and then fixed by occlusal splint [15]. Common pivoting splints for the distraction of the TMJ condyles are made with flat stops in the area of upper second molars which have 5 mm in diameter with a height of 1.5 mm [16, 17].

The analysis of obtained parameters of reciprocal clicking during symmetrical movements of the mandible (retrusion, mouth closing) shows that Me of reciprocal clicking coordinates are not significantly different in all groups of patients. There were no statistically significant differences between the movements in right and left TMJs, except for the transversal shift in "Y" direction in the first and third groups. With some limitations, it can be suggested that the average coordinate of reciprocal clicking in the "Z" direction is slightly increased during mouth closing movements in all groups of patients in the range from 1 to 2 mm. In the "X" direction during mouth closing movements the average displacement of the hinge axis was determined within 1 mm. Considering the IQR values in majority of all patients the average reciprocal closing click occurs at the distance of 0-1.4 mm on the "X"-axis, 0.1-2.9 mm on the "Z"-axis and 0-0.85 mm on the "Y"-axis. The determined values of reciprocal clicking coordinates significantly differ from the recommended average distraction parameters, which are used in the pivoting splints for condyle distraction. In his recommendations for the pretreatment of patients with TMJ disorders, Meyer suggested the use of individual parameters recorded by axiography as the best option for the formation of personalized approach in the rehabilitation of such patients [10]. At the same time, considering our average reciprocal clicking coordinates, it is possible to improve the characteristics of distraction splints and increase the efficiency of preliminary treatment of disc pathology.

CONCLUSIONS

The study of peculiarities of hinge axis trajectories in patients with disc-condylar disorders has shown qualitative and quantitative changes. The obtained wide range of reciprocal clicking location parameters indicates the priority of a personalized approach in planning the parameters of distraction occlusal splints. Common in the recommendations average parameters of distraction need to be revised in order to establish the optimal therapeutic position of the mandible considering the displacements in the vertical, sagittal, and transversal directions. Further research is required.

REFERENCES

1. Manfredini D. Etiopathogenesis of disk displacement of the temporomandibular joint: a review of the mechanisms. Indian J Dent Res. 2009;20(2):212-221. doi:10.4103/0970-9290.51365.
2. Schiffman E., Ohrbach R., Truelove E. et al. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. J Oral Facial Pain Headache. 2014;28(1):6-27. doi:10.11607/jop.1151.
3. Santos K.C., Dutra M.E., Warmling L.V., Oliveira J.X. Correlation among the changes observed in temporomandibular joint internal derangements assessed by magnetic resonance in symptomatic patients. J Oral Maxillofac Surg. 2013;71(9):1504-1512. doi:10.1016/j.joms.2013.04.033.
4. Tanteri G., Tanteri E., Tanteri C., Slavicek G. TMJ Dynamics. MRI of the Temporomandibular Joint. Correlation Between Imaging and Pathology. "Springer Nature", Switzerland AG. 2020, 90 p. doi:10.1007/978-3-030-25421-6_4.
5. Botos A.M., Mesaros A.S., Zimbran A.I. The contribution of computerized axiography to the functional evaluation of the temporomandibular joint: a case report. Clujul Med. 2016;89(3):438-442. doi:10.15386/cjmed-618.
6. Buduru S., Balhuc S., Ciumasu A. et al. Temporomandibular dysfunction diagnosis by means of computerized axiography. Med Pharm Rep. 2020;93(4):416-421. doi:10.15386/mpr-1754.
7. Kobs G., Bernhardt O., Meyer G. Accuracy of Computerized Axiography Controlled by MRI in Detecting Internal Derangements of the TMJ. Stomatologija, Baltic Dental and Maxillofacial Journal. 2004; 6:7-10.
8. Liu M.Q., Lei J., Han J.H. et al. Metrical analysis of disc-condyle relation with different splint treatment positions in patients with TMJ disc displacement. J Appl Oral Sci. 2017;25(5):483-489. doi:10.1590/1678-7757-2016-0471.
9. Chen H.M., Liu M.Q., Yap A.U., Fu K.Y. Physiological effects of anterior repositioning splint on temporomandibular joint disc displacement: a quantitative analysis. J Oral Rehabil. 2017;44(9):664-672. doi:10.1111/joor.12532.

10. Meyer G.B., Asselmeyer T., Bernhardt O. Basics of functional clinical and instrumental diagnostics and pretreatment before final oral rehabilitation. Stoma Edu J. 2015;2(2):120-131. doi:10.25241/stomaeduj.2015.2(2).art.4.
11. Kanda Y. Investigation of the freely available easy-to-use software 'EZR' for medical statistics. Bone Marrow Transplant. 2013;48(3):452-458. doi:10.1038/bmt.2012.244.
12. Witzel A.L., Costa J.E.S., Bolzan M.C. et al. Correlation between gender, temporomandibular joint disc position and clinical findings in patients with temporomandibular disorder. MedicalExpress (São Paulo, online). 2015; 2(4). doi: 10.5935/MedicalExpress.2015.04.02.
13. Kondrat W., Sierpińska T., Radke J. Axiographic assessment of masticatory system function in healthy volunteers. Dentistry. 2018;(8):1-6. doi:10.4172/2161-1122.1000504.
14. Mito T., Ishizaki K., Suzuki K., Sato S. Mandibular lateral translation during symmetric mandibular movement. J. Stomat. Occ. Med. 2009;(2):24-31. doi:10.1007/s12548-009-0004-1.
15. Suzuki K., Mito T., Ishizaki K., Sato S. Mandibular lateral translation during symmetric mandibular function in relation to patterns of intracapsular derangement of TMJ. J. Stomat. Occ. Med. 2009;(2):16-23. doi:10.1007/s12548-009-0003-2.
16. Moncayo S. Biomechanics of pivoting appliances. J Orofac Pain. 1994;8(2):190-196.
17. Wu J.-H., Kao Y.-H., Chen C.-M. et al. Modified mandibular splint therapy for disc displacement with reduction of the temporomandibular joint. J Dent Sci. 2013;8:91-93. doi:10.1016/j.jds.2012.09.010.

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