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THE CONTRIBUTION OF COMPUTERIZED AXIOGRAPHY TO THE FUNCTIONAL EVALUATION OF THE TEMPOROMANDIBULAR JOINT: A CASE REPORT

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Abstract

The aim of this case report is to give comprehensive information on the clinical use of computerized axiography (CA) in the evaluation of temporomandibular joint (TMJ) mobility in a patient who undergoes orthognatic surgery. A 20-year-old female patient with class III skeletal anomaly and who underwent orthognatic surgery is presented. Pre- and postsurgical CA recordings for the patient are compared in order to evaluate the functional modifications that appear. The CA is a functional investigation of the TMJ and records the border movements of the mandible: protrusion, lateral movements and open/close. The starting point for every movement is the centric relation position. This allows for very high reproducibility of the CA and the data can later become available for comparison of examinations performed at different times. The CA can offer data to programme an articulator or to evaluate the functional evolution of the TMJs after various occlusal interventions (prosthodontic, orthodontic or orthognatic). After comparing the pre- and postsurgical CA recordings, a significant improvement of the TMJ function after the repositioning of the maxilla and mandible through orthognatic surgery was confirmed. In conclusion, our case confirms the results in literature that CA is a reproducible and reliable investigation method in the evaluation of TMJ function in orthognatic surgery patients, that it facilitates the monitoring of the evolution of the functionality of the TMJ ever time and that it allows for comparative evaluation of the two TMJs.

Keywords: computerized axiography, temporomandibular joint

Introduction

From an anatomical point of view, the temporomandibular joint (TMJ) is a small but very complex joint in the body [1,2]. It is a synovial, ginglymoarthrodial joint in which the main bone structures are the mandibular condyle, the mandibular fossa and the articular eminence on the squamosal part of the temporal bone of the skull [3,4]. Between the two bone structures we find the articular disc. The condyle and the fossa are covered by a cartilage which is thinner than the disc [5] and which also has a role in the absorption of compressive forces [6,7,8].

Because the TMJ disk is softer than the cartilage of the other load-bearing joints in the body, it is logical to assume that the plowing effect on the disc is likely more pronounced than in the other joints [9,10]. The TMJ can be transformed by both physiological and pathological situations [2,4] and have skeletal deformities, malocclusions, masticatory dysfunctions, or derangements of the articular disk appear [11,12].

The structural investigations of the TMJ today include radiographs, computed tomography (CT), cone beam computed tomography (CBCT), magnetic resonance imaging (MRI). But there can be discrepancies between the degree of the structural alteration and the actual functional

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alteration of the TMJ - the alterations are considered pathological only when accompanied by symptoms of pain or dysfunction [13].

For the competent and reproducible investigation of the mandibular movements, computerized axiography (CA) was confirmed as a valuable complementary examination [14-17]. The clinical daily use can be difficult because of time consumption and high acquisition costs [17], but its value is high in the functional analysis of temporomandibular disorder (TMD) [18] cases, in planning and following orthodontic patients [19,20] and for the programming of articulators based on the provided values.

Informed consent was obtained from the patient before performing the study. The procedures and protocol were approved by the institutional review board and by the ethic committee of the university.

The purpose of this case report is to 1) explain the recordings of the mandibular movements on CA; and 2) present the CA recordings of a case before and after orthognatic surgery in order to value the CA for the diagnostic and prognostic evaluation of patients.

Material and method

Interpretation of CA recordings

The CADIAX Compact (GAMMA, Vienna, Austria) records the movements of the mandible based on the registration of the movement of a stylus on an electromagnetically sensitive plate, elements which are placed in the area of the TMJ. The graphs are presented in Figure 1.

On a CA recording, the following can be examined

• **Quantitative values** – evaluation of the maximum amplitude of a recorded movement; the evaluation will be described as limited, average or hypermobile (Table I).

• **Qualitative assessment** – normal recordings are reproducible, clear and frictionless of the synovial joint. The quality can be excellent, average, or bad (Table II).

• **Aspect of trajectories** – concave, straight, convex or combined. Normal graphs have a concave to the anterior aspect (Table III).

• **Symmetry** – when comparing the right and left side graphs. Within symmetrical movements, the right and left graphs should be identical (Table IV).

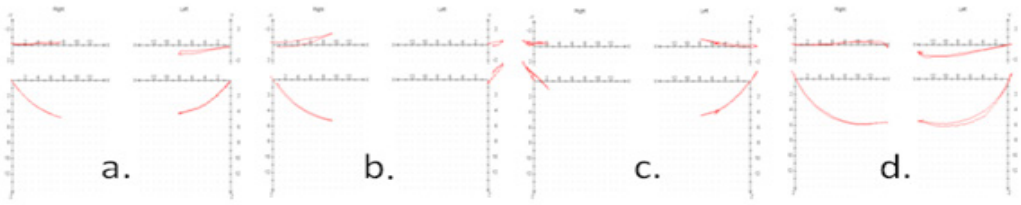


Figure 1. CA recordings within normal limits: a. protrusion b. left laterotrusion: c. right laterotrusion; d. open/close of the mouth.

Table I. Maximum amplitude values for the mandibular movements.

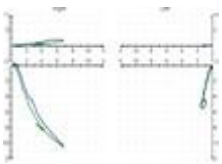
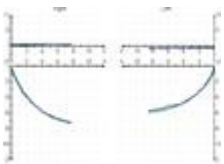
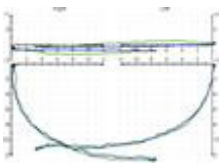
	Reduced	Average	Hypermobile
Protrusion	<= 8 mm	> 8 mm, < 12 mm	>= 12 mm
Mediotrusion	<= 9 mm	> 9 mm, < 14 mm	>= 14 mm
Open/Close	<= 10 mm	> 10, < 16 mm	>= 16 mm
	 Reduced amplitude left in Open/Close movement	 Average amplitude Protrusion	 Hypermobility by Opening/Closing of mouth

Table II. Quality assessment of mandibular movement graphs.

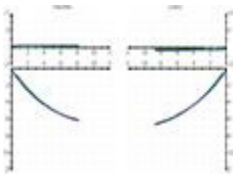
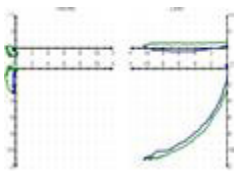
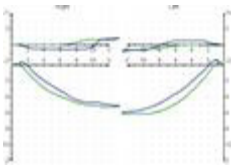
Excelent	Average	Bad
 Excelent quality of Protrusion/Retrusion	 Average Quality of left mediotrusion	

Table III. Aspect of trajectory of the CA graphs.

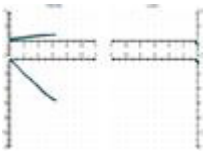
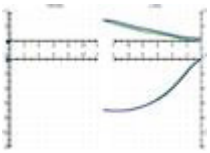
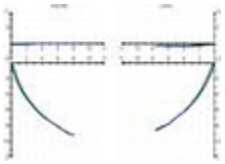
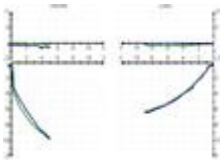
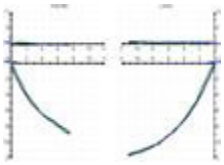
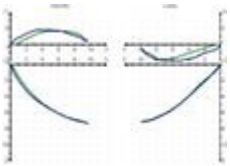
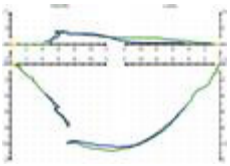
Anterior Concave	Straight	Combined convex/concave
		
Bilateral anterior concave protrusion graph	Right mediotrusion with straight aspect	Left mediotrusion with convex/ concave aspect

Table IV. Examples of movement symmetry.

Symmetrical graphs	Sagittal asymmetrical graphs	Quantitative sagittal asymmetry	Transversal asymmetry	Sagittal and transversal asymmetry
				
Symmetry in protrusion	Protrusion with extreme saggittal asymmetry	Longer trajectory of left graph in protrusive movement	Strong transversal asymmetry	

Case presentation

The case of a female patient, 20 years old, with a severe class III skeletal anomaly was analyzed. The treatment plan involved a complex orthodontic-orthognatic surgery. First, the patient was treated orthodontically to eliminate dental compensations; the second step was the surgical intervention; and the third step was the orthodontic finishing of the case after the completion of the orthognatic surgery. The surgical intervention was performed in the Department of Cranio-Maxillo-Facial Surgery, Cluj-Napoca, Romania.

The evaluation of the orofacial muscles did not reveal any tension or pain, before or after the surgery, as patients undergoing orthodontic treatment present a certain muscle relaxation due to the orthognatic treatment.

The presurgical clinical investigation revealed bilateral cracking sounds during protrusion and opening of the mouth, hypermobility of the mandible in the opening movement, a deviation of the mandible to the left during protrusion, sagittal and transversal asymmetry of all movements, but with no accused pain. The mandible presented a deviation with reduction of the trajectory during opening of the mouth.

The postsurgical clinical evaluation, one year after the surgery, revealed improved sagittal and transversal symmetry, normal range amplitude of the opening of the mouth and no cracking sounds. The movement of the mandible during protrusion had no deviation; during opening of the mouth, a deviation of the mandible to the left remained.

No occlusal evaluation was recorded, as it has been demonstrated that occlusal status has negligible influence on the TMJ function [15].

CA was performed before the orthognatic surgery and one year after the surgery in order to evaluate the modifications that appear in the function of the TMJs between the two moments.

The CA recordings for the patient were collected from the CADIAX Compact database in order to illustrate the modifications that appear following an intervention – in this case the orthognatic surgery – at the level of the TMJs from a functional point of view (Figure 2).

The presurgical graphs indicated amplitude of movement for the protrusion and laterotrusion within normal limits and hypermobility of the TMJ in the opening of the mouth. They also showed variable amplitude between the symmetrical movements and little symmetry of the right and left joints. In the movement of the opening of the mouth, there was no overlap of the excursion/incursion graphs, with both saggittal and transverse asymmetry.

The postsurgical recordings that were taken at a distance of one year (one year after the surgery) show the reduction of amplitude for the protrusion and mediotrusion movements and the reduction of the amplitude for the open/close movements. For protrusion and mediotrusion the postsurgical amplitude was reduced compared to

previous and normal values; the amplitude for the open/close movement decreased and was within normal limits after surgery. Also, the trajectories for the open/close movements had an improved overlap after the surgery.

The transverse asymmetry which was present in both protrusion and opening of the mouth before the surgery disappeared almost completely in the postsurgical recordings.

The aspect of the curves was convex and convex/concave presurgically and they changed to either straight or convex after surgery.

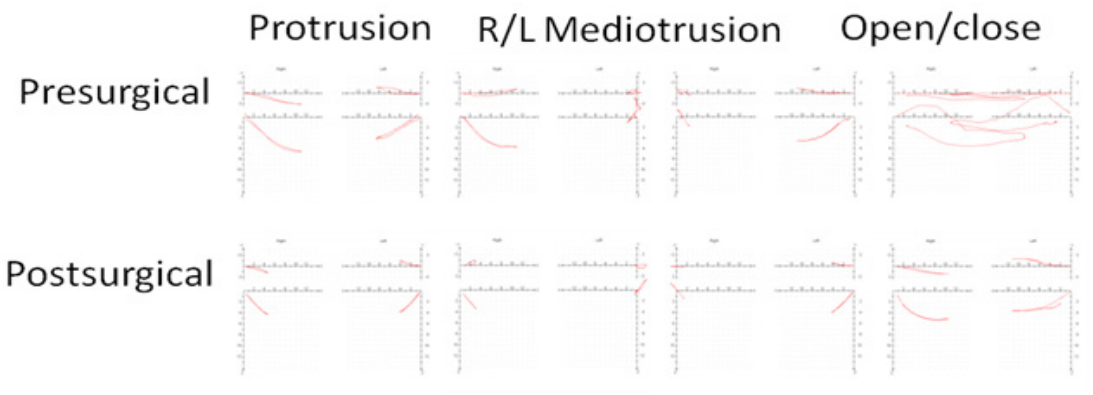


Figure 2. Pre- and postsurgical recordings for the mandibular movements.

Discussion

Assessment of favorable or unfavorable evolution of TMJ symptoms may be difficult to perform along the same evaluation criteria at different times and it is highly dependent on the examiner's experience [21-25]. That is why objective examination methods are more reliable and as often as possible preferred over clinical examination [18,25].

The case we presented confirms the clinical contribution of the CA to the functional evaluation of the TMJ over time. In this case, the CA recordings confirmed an improvement of the TMJ situation after orthognatic surgery; bone pieces were repositioned and, as a consequence of bone remodeling and muscle reattachment, occlusion improved. This is visible in the better symmetry, amplitude within normal limits, and better overlap of excursion/incursion movements described.

All postsurgical modifications indicated an improvement of the TMJ status by the reduction in amplitude of the mandibular movements as compared to the presurgical situation, by a better overlap of the excursion/incursion movements of the mandible and by an increased transverse and sagittal symmetry of the movements on the right and left sides, thus confirming the benefits of orthognatic surgery on TMJ functionality.

From a clinical point of view, the patient's clinical examination improved. Due to better bone relationship, the opening of the mouth was reduced in amplitude in order to reach normal values; the right and left TMJs worked more symmetrical after the orthognatic surgery, especially during opening of the mouth; and the symmetry during excursion/incursion of the movements improved significantly, again especially during open/close of the mouth.

Obviously, the modifications that appear in the TMJ dynamics widely differ among patients and thorough analysis is required for each of them.

The recordings of the mandibular movements documented with the CADIAX Compact (GAMMA, Vienna Austria) can be kept and reviewed as frequently as needed, can be compared with recordings performed at different times, and can provide details for the programming of articulators, as confirmed by recent studies [26,27]. The data can at any times be used to make measurements and assess evolution. The recordings can also be used to diagnose TMD, because of the pathological elements that can be identified on the graphs. The evolution under treatment of the pathological elements (hypermobility, limitations, disk displacement) can be monitored on subsequent recordings.

It was shown that the morphology of the TMJ is correlated with the occlusal morphology and tooth position in balanced patients with no treatment needs [28]. The functional evaluation of the TMJ is more reliable when objectively recorded [18,25]. This way, the CA recordings help with the interpretation and evaluation of TMJ function in patients that either need or have had done prosthodontic reconstructions [28-31].

This case confirmed the results we found in literature. Given that this was a case presentation, studies that involve more patients would be needed in the future in order to confirm the already published results.

Conclusions

In conclusion, based on our case one can say:

The CA is a valuable investigation that allows for a

reproducible and objective assessment of the functionality of the TMJ;

The CA facilitates monitoring over time the evolution of the functionality of the TMJ structures;

The CA allows for comparative evaluation of the function of the two TMJs.

References

1. Su N, Liu Y, Yang X, Luo Z, Shi Z. Correlation between bony changes measured with cone beam computed tomography and clinical dysfunction index in patients with temporomandibular joint osteoarthritis. J Craniomaxillofac Surg. 2014;42(7):1402-1407.
2. Walter E, Huls A, Schmelzle R, Klose U, Kuper K, Kalender WA. CT and MR imaging of the temporomandibular joint. Radiographics. 1988;8(2):327-348.
3. Reed DA, Scapino RP, Ross CF, Chen D, Diekwisch TGH. Developmental and Evolutionary perspectives on TMJ tissue engineering. In Greene CS, Laskin DM (eds). Treatment of TMDs. Bridging the gap between advances in research and clinical patient management. Chicago: Quintessence; 2013: 167-176.
4. Marques AP, Perella A, Arita ES, Pereira MF, Cavalcanti Mde G. Assessment of simulated mandibular condyle bone lesions by cone beam computed tomography. Braz Oral Res. 2010;24:467-474.
5. Hansson T, Öberg T, Carlsson GE, Kopp S. Thickness of the soft tissue layers and the articular disk in the temporomandibular joint. Acta Odontol Scand. 1977;35:77-83.
6. Kuroda S, Tanimoto K, Izawa T, Fujihara S, Koolstra JH, Tanaka E. Biomechanical and biochemical characteristics of the mandibular condyle cartilage. Osteoarthritis Cartilage. 2009;17:1408-1415.
7. Lu XL, Mow VC, Guo XE. Proteoglycans and mechanical behavior of condylar cartilage. J Dent Res. 2009;88:244-248.
8. Tanaka E, Yamano E, Dalla-Bona DA, Watanabe M, Inubushi T, Shirakura M, et al. Dynamic compressive properties of the mandibular condyle cartilage. J Dent Res. 2006;85:571-575.
9. Kober C, Hellmich C, Stubinger S, Zeilhofer HF, Sader R. "Anatomical simulation" of the biomechanical behavior of the human mandible. Int J Comput Dent. 2015;18:333-342.
10. Almarza AJ, Athanasiou KA. Design characteristics for the tissue engineering of cartilaginous tissues. Ann Biomed Eng. 2004;32:2-17.
11. Gaivoronskaya MG, Gaivoronskiy IV, Nikolenko VN. Morphometric characteristics of the articular surfaces of the temporomandibular joint in different types of occlusion in adult persons. Morfologiia. 2015;148:32-36.
12. Brooks SL, Brand JW, Gibbs SJ, Hollender L, Lurie AG, Omnell KA, et al. Imaging of the temporomandibular joint: a position paper of the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1997;83:609-618.
13. Barghan S, Tetradis S, Mallya S. Application of cone beam computed tomography for assessment of the temporomandibular joints. Aust Dent J. 2012;57 suppl 1:109-118.
14. Ahangari AH, Torabi K, Pour SR, Ghodsi S. Evaluation of the Cadiax Compact® II accuracy in recording preadjustable condylar inclinations on fully adjustable articulator. J Contemp Dent Pract. 2012;13(4):504-508.
15. Schierz O, Klinger N, Schön G, Reissmann DR. The reliability of computerized condylar path angle assessment. Int J Comput Dent. 2014;17(1):35-51.
16. Cimic S, Simunkovic SK, Badel T, Dulcic N, Alajbeg I, Catic A. Measurements of the sagittal condylar inclination: intraindividual variations. Cranio. 2014;32:104-109.
17. Frisoli M, Braidot A, Nicolet J, Edelhof J, Gersdorff N, Engelke W. Biostatistics applied to comparison of jaw movement measurement methods. IFMBE Proceedings. 2015;49:67-70.
18. Manfredini D, Guarda-Nardini L, Winocur E, Piccotti F, Ahlberg J, Lobbezoo F. Research diagnostic criteria for temporomandibular disorders: a systematic review of axis I epidemiologic findings. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;112(4):453-462.
19. Reverdito M, Piancino MG, Frongia G, Bracco AA, Fresi MG, Debernardi CL, et al. Functional cephalometry analysis and computerized axiography before and after therapy with "Function Generating Bite" in a deep bite patient. J Stomat Occ Med. 2011;4:67-71.
20. Dos Santos PF. Correlation between sagittal dental classes and sagittal condylar inclination. J Stomat Occ Med. 2013;6:96-100.
21. Anders C, Harzer W, Eckardt L. Axiographic evaluation of mandibular mobility in children with angle Class II/2 malocclusion (deep overbite). J Orofac Orthop. 2000;61:45-53.
22. Siegmund T, Harzer W. Orthodontic diagnostics and treatment planning in adults with temporomanidbular disorders a case report. J Orofac Orthop. 2002;63:435-445.
23. Currie P. Age and gender as factors in temporomandibular joint movement in adolescents, as determined by computerized 3D electronic condylography. J Stomat Occ Med. 2010;3:76-82.
24. Takada J, Miyamoto JJ, Yokota T, Ono T, Moriyama K. Comparison of the manidbular hinge axis in adult patients with facial asymmetry with and without posterior unilateral crossbite. Eur J Orthod. 2015;37(1):22-27.
25. Manfredini D, Ahlberg J, Winocur E, Guarda-Nardini L, Lobbezoo F. Correlation of RDC/TMD axis I diagnoses and axis II pain-related disabiliry. A multicenter study. Clin Oral Investig. 2011;15:749-756.
26. Torabi K, Pour SR, Ahangari AH, Ghodsi S. A clinical comparative study of Cadiax Compact® II and intraoral records using wax and addition silicone. Int J Prosthodont. 2014;27:541-543.
27. CADIAX® Compact Benutzerhandlung. 5. GAMMA GmbH, 1999.
28. Reusch D, Lenze PG, Fischer H. Rekonstruktion von Kauflächen und Frontzähnen. Hachenburg GmbH, 1990.
29. Kano P. Chalenging nature. Wax-up techniques in aestetics and functional occlusion. Quintessence, New Malden, UK, 2011.
30. Rosenstiel S, Land M, Fujimoto J. Contemporary fixed prosthodontics. Mosby, Inc, 2006.
31. Dawson P. The concept of complete dentistry. Dawson Center for Advanced Dental Study. St. Petersburg, Florida, 2003.