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Evaluation of mandibular dynamics and bite force in myofascial pain follow-up

S. de Quadros Uzêda[1], L. Garcia Alonso[1], A. Sergio Guimarães[2] and R. Luiz Smith[1]

1- Disciplina de Anatomia Descritiva e Topográfica, Departamento de Morfologia, Universidade Federal de São Paulo-Escola Paulista de Medicina, São Paulo, Brasil
2- Instituto da Cabeça, Universidade Federal de São Paulo-Escola Paulista de Medicina, São Paulo, Brasil

SUMMARY

The purpose of this study was to assess clinically and through electronic axiography the changes in mandibular dynamics in the symptomatic and asymptomatic phases occurring in patients with a diagnosis of myofascial pain. From October 2003 through December 2004, a sample of 10 cases (all female aged, 20-50 years old) clinically diagnosed of myofascial pain were followed up to identify changes in mandibular movements. The patients were interviewed, and anamnesis and a clinical examination were performed. Patients with a diagnosis of myofascial pain were recorded with an electronic axiograph (Kavo, model Arcus digma™) and their bite force was measured (Kratos™ digital dynamometer). The patients were then instructed about treatment and follow-up was carried out. After the remission of symptoms, a new axiography and determination of bite force was performed. Axiograph analysis showed significant changes in the mandibular dynamic pattern between the symptomatic and asymptomatic phases and a statistically significant ($p<0.001$) increase in bite force in 100% of the patients after pain remission was verified. The changes in mandibular dynamics were: an increase in maximum jaw opening without pain in 100% of the sample and a decreased mandibular deviation in opening and closing jaw movements in 70% of the patients. The present study suggests that axiographic study of mandibular movements and the determination of bite force can contribute to a better understanding of temporomandibular disorders, and an improvement in diagnostic criteria and the follow-up of therapeutic procedures.

Key words: Mandibular dynamics – TMD – Myofascial pain – Axiography – Bite force

INTRODUCTION

Temporomandibular dysfunction (TMD) is a set of signs and symptoms involving the masticatory system and leading to changes in mandibular dynamics. Its signs and symptoms include altered articular and muscular function in the orofacial region accompanied by pain in the masticatory muscles and/or temporomandibular joints (TMJ), TMJ sounds, headache, and limitation and poor coordination of mandibular movements (Dworkin and LeResche, 1992; Okeson, 1998; Stohler and Mann, 1999).

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Correspondence to:
Luís Garcia Alonso. Disciplina de Anatomia Descritiva e Topográfica, Departamento de Morfologia, Universidade Federal de São Paulo-Escola Paulista de Medicina, Rua Botucatu, 740 – Edifício Leitão da Cunha, Vila Clementino – São Paulo – SP – Brasil 04023-900. Phone: (55-11) 5576-4261; Fax: (55-11) 5571-7597.
E-mail: luisalonso.morf@epm.br / sandrauzeda@yahoo.com.br

The patient's history and a complete clinical examination are fundamental for the correct diagnosis and TMJ assessment cannot be overlooked. A good understanding of TMJ movements as well as of alterations in their patterns is essential for improving the diagnostic criteria and treatment currently used (Dworkin et al., 1990; Airoldi et al., 1994; Ash and Ramfjord, 1995; Lindauer et al., 1995). A number of studies have investigated mandibular dynamics in an attempt to elucidate the mechanisms causing disorders associated with masticatory movements, thus helping with their treatment (Peck et al., 1997; Lewis et al., 2001; Huang et al., 2002; Ioi et al., 2003).

A device that records the movements of the mandible three-dimensionally, the kinesiograph, has been developed. It electronically records the excursion of a point in the lower incisor teeth to which a minute magnet is attached (Jankelson, 1980; Palla and Salaorni, 1994; Sato et al., 2003). Using this device, Nielsen et al. (1990) studied the patterns of mandibular movement in 24 normal individuals and in 26 patients with muscular pain associated with craniomandibular disorders. The control group showed harmonious patterns for the lateral, protrusive and vertical mandibular excursion, whereas the experimental group had asymmetric latero-protrusive movements, and a differing mandibular lateral excursion with respect to an initial and final intercuspal reference positioning. Other asymmetric patterns were also observed for lateral, protrusive and retrusive movements in the experimental group, although both groups showed similar mandible displacement during speaking.

The aim of the present study was to investigate the mandibular dynamics and bite force of patients with myofascial pain in the symptomatic and asymptomatic phases.

Materials and Methods

Female patients of 20 to 50 years old with complaints of TMD had their history taken and were examined clinically for muscular and articular conditions according to the *Research Diagnostic Criteria for Temporomandibular Disorders* (RDC/TMD) validated by Dworkin and LeResche (1992). Patients lacking their lower teeth, either partially or totally, as well as those with a history of degenerative joint dis-

Table 1. Maximum non-painful mouth opening (mm) in patients before and after treatment and the corresponding time interval between recordings.

Patient	Before treatment	After treatment	Time elapsed (months)
1	39.3	47.0	1
2	36.0	50.0	2
3	30.0	40.0	2
4	29.7	39.9	1
5	24.0	30.0	10
6	34.0	38.6	1
7	34.7	40.0	1
8	25.4	41.0	11
9	30.2	35.5	1
10	42.5	50.1	2

Wilcoxon test: *p<0.01

Table 2. Bite force magnitude (Newtons) in patients with myofascial pain on the right and left sides during symptomatic and asymptomatic phases.

Patient	Before treatment (right side)	After treatment (right side)	Before treatment (left side)	After treatment (left side)
1	173.4	200.9	187.2	252.8
2	23.5	245.9	12.7	170.1
3	84.3	196.0	84.3	98.0
4	108.8	196.9	96.0	138.2
5	13.7	284.2	22.5	230.3
6	178.4	196.0	141.1	175.4
7	13.7	171.5	22.5	199.9
8	121.5	230.3	102.9	223.4
9	44.1	139.1	44.1	87.2
10	63.7	220.5	107.8	185.2

Wilcoxon test: *p<0.01

Table 3. Mandibular deviation during maximum mouth opening recorded on the median sagittal plane.

Patient	Before treatment	After treatment
1	+	-
2	+	-
3	-	-
4	+	-
5	+	-
6	+	-
7	+	-
8	+	-
9	+	+
10	+	+

With deviation (+); without deviation (-)

Table 4. Restriction to lateral mandible excursion on right and left sides.

Patient	Before treatment (right side)	After treatment (left side)	Before treatment (left side)	After treatment (left side)
1	+	-	+	-
2	-	-	+	-
3	+	-	-	-
4	+	-	-	+
5	+	-	+	-
6	-	-	+	-
7	+	-	+	+
8	-	-	-	-
9	+	+	+	-
10	+	+	-	-

With restriction (+); without restriction (-)

ease were not included in the present study. The study was approved by the Ethics Committee for Research of the Federal University of São Paulo. The experiments were undertaken with the understanding and written consent of each subject. The participating patients (n=10) diagnosed with myofascial pain had the excursion of their mandible recorded using a Kavo gnatograph model Arcus Digma™. This device was suitably adjusted for each patient and set up for recording. The patients were asked to open and close their mouth, move their mandible laterally and in protrusion, and to chew raw carrot cubes of approximately 1 cm^3. The patients' bite force between the corresponding molars on both left and right sides was determined using a Kratos™ digital dynamometer. The patients were finally prescribed a non-invasive and reversible treatment such as the use of bite plates, cognitive and behavioral training, and mechanical and thermal physiotherapy. A follow-up for pain remission was carried out during the patients' treatment and a new gnatograph and bite force determination were performed (from one to 11 months) when painful symptoms disappeared, thus obtaining the gnatograph recordings and bite forces in both the symptomatic and asymptomatic phases for each patient. Statistical analysis of the data included the Wilcoxon test, with a level of significance of less than 0.05.

RESULTS

The maximal non-painful mouth opening in patients before and after treatment and the corresponding time interval between the results of the recordings are shown in Table 1. Maximal non-painful mouth opening was significantly greater in patients after the treatment.

The bite force magnitude in patients with myofascial pain on the right and left sides during the symptomatic and asymptomatic phases is presented in Table 2. Bite force magnitude on both sides was significantly greater in patients after the treatment.

Mandibular deviation during maximal mouth opening was absent in 70% of patients after treatment (Table 3). The restriction to lateral mandible excursion disappeared in 50% of patients on the right and left sides (Table 4).

The figures show examples of the recordings obtained. Figure 1 show the magnitude of the patients bite force in Kgf (9.8 $N/m/s^2$) on the right and left sides, in the symptomatic and asymptomatic phases, respectively.

Figures 2 and 3 show the functional analysis of mandibular dynamics in patient (number 1) as recorded using the gnatograph.

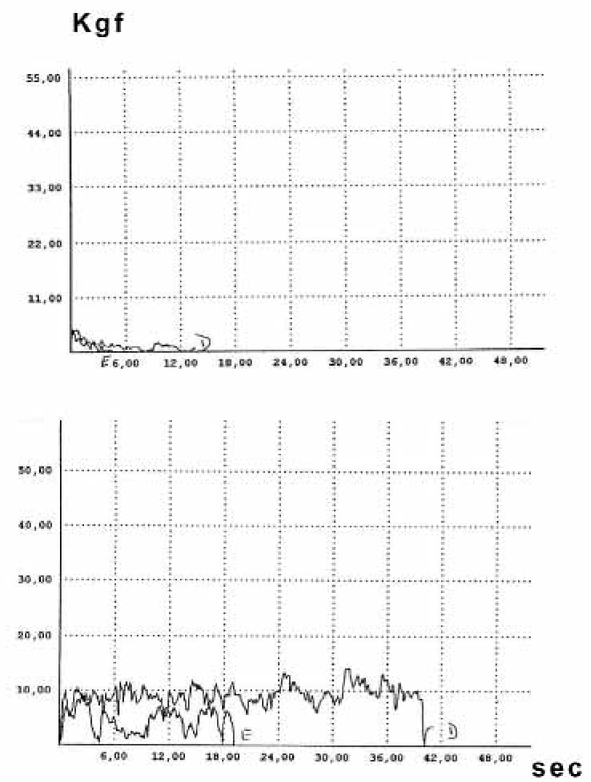

Figure 1. Plot of bite force intensity obtained in patient 1 before (upper) and after (lower) treatment on both sides.

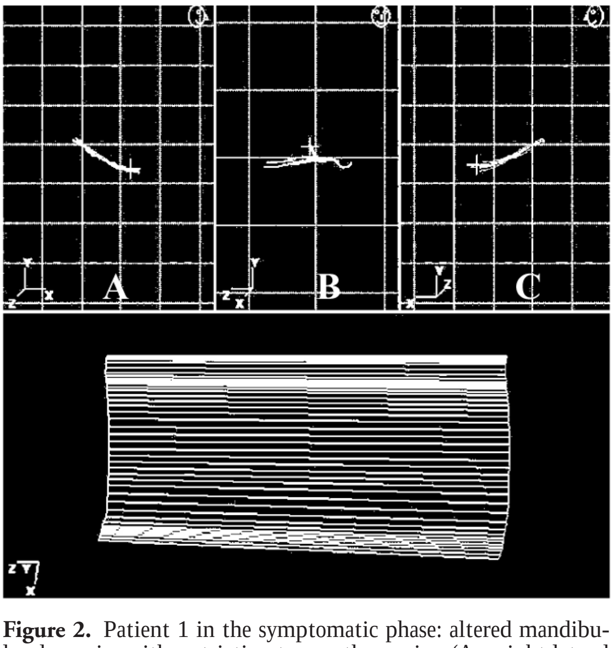

Figure 2. Patient 1 in the symptomatic phase: altered mandibular dynamics with restriction to mouth opening (A – right lateral view and C – left lateral view) and lateral deviation (B – frontal view).

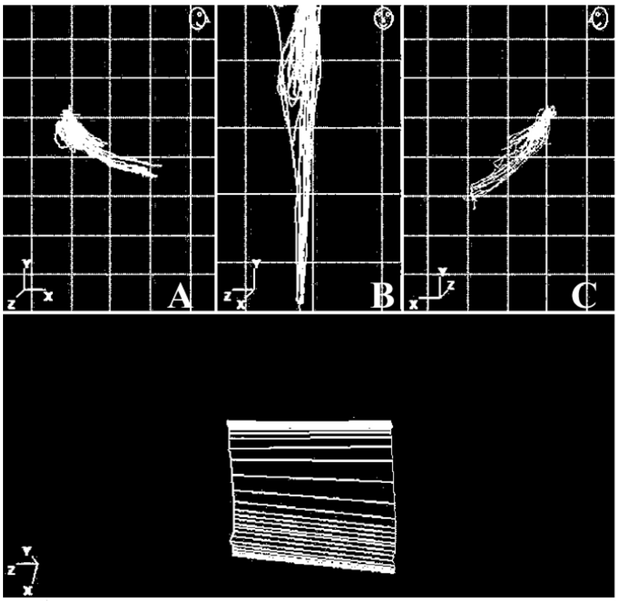

Figure 3. Patient 1 in the asymptomatic phase: greater amplitude of mouth opening (A-B) and absence of lateral deviation (C) after one month of treatment.

Discussion

Both study of mandibular dynamics and the determination of bite force are useful elements for understanding TMD. Obtaining objective information involves the use of calibrated devices that provide data for controlled investigation. Over the years, study of mandibular dynamics has gathered momentum with the development of more precise electronic devices, particularly those using magnetic sensors to capture mandibular movements in a system of three-dimensional coordinates providing data for further computer analysis (Jankelson, 1980; Nielsen et al., 1990; Kuwahara et al., 1992; Lindauer et al., 1995; Matsumoto et al., 1995; Sinn et al., 1996; Peck et al., 1997; Cooper, 1997; Peck et al., 1999a, b; Huang et al., 2002; Castro et al., 2002; Ioi et al., 2003; Celic et al., 2003).

The patients in this study were assessed for signs and symptoms according to the RDC protocol (Dworkin and LeResche, 1992) and the signs were scored according to the Helkimo rating (Helkimo, 1974a; b). The presence of pain characterized the symptomatic phase and the lack of painful feeling represented the asymptomatic phase. The variables studied were: bite force, maximal mouth opening without pain, mandibular deviation during mouth opening, and restriction of lateral movements.

The presence and magnitude of these variables were recorded at the time of the first examination of the patient and when pain was no longer felt, enabling an objective assessment of the treatment prescribed, which varied from one to eleven months. Another study investigating a sample of male subjects compared mandibular movements between patients with TMD and normal individuals (Celic et al., 2003). That study revealed a statistically significant difference in mandibular movements between the study and control groups as well as between individuals in the same group. Such findings are similar to those obtained in the present study, which also reveal differences for the same individual between the symptomatic and asymptomatic phases.

Comparison between the study and control groups might include a certain degree of bias, since each individual has a particular dynamic pattern. However, when an individual follow-up is carried out, this factor does not interfere with the findings. This is especially true when assessing the effectiveness of the treatment.

Regarding maximal mouth opening in TMD patients, authors such as Koop and Lundeberg (1999) and Lewis et al. (2001) confirmed the RDC criteria when they noticed that their patients presenting with pain in the TMJ region had a maximum mouth opening of less than 35 to 40 mm. They also reported a considerable increase in the range of mouth opening after treating their patients for myofascial pain.

The patients in the present study also presented with maximum, non-painful mouth opening limited to less than 40 mm, except for one, who had maximum non-painful mouth opening of 42.5 mm and maximum mouth opening under the painful condition of 47.0 mm, still limited amplitude. After treatment, 100% of our patients showed greater ranges of vertical mandible displacement and reported a more comfortable mastication. These findings are in agreement with those reported by Yatabe et al. (1997), Magnusson et al. (2000), Baba et al. (2001) and Hansdottir and Bakke (2004).

The restriction on lateral mandible displacement (horizontal excursion) was another variable explored in our study. Dworkin et al. (1990) and Dworkin and LeResche (1992) classified lateral mandible excursion to the right or to the left as being limited when it was less than 7 mm. Nielsen et al. (1990) reported that patients with craniomandibular disorders associated with muscular pain showed an asymmetric pattern of lateral, protrusion and retrusion movements. In the present study, 30% of the patients did not present with limited lateral excursion and the remaining 70% had limited lateral excursion towards the right before treatment. Among the latter, 80% recovered a satisfactory lateral excursion of the mandible after treatment. Our patients were also assessed for restriction on lateral excursion towards the left, 60% of the individuals having such a limitation. A similar treatment outcome was achieved in this case, with 80% of individuals recovering satisfactory lateral excursion towards the left.

Some authors reported mandibular deviation during the mouth opening movement to be the most important characteristic of TMD. The muscular and articular etiology of such displacement, however, is still a matter of dispute. Some authors report that differential diagnosis can only be carried out with muscle and joint tests, while other sustain that it can be reached through anamnesis. A third group advocates that the painful site determines the muscular or articular etiology of mandibular displacement (Lindauer et al., 1995; Peck et al., 1997; Gsellmann et al., 1998). In our study, the direction —left or right— of lateral mandibular displacement was not taken into account when examining the mouth opening movement. This lateral displacement disappeared in 70% of the patients after treatment, whereas in the remaining 30%, only the painful condition improved. This evidences the importance of lateral mandibular displacement as a characteristic feature of TMD, about which most authors agree.

In the present study, it was observed that the same patient had greater difficulty in chewing a cube of carrot in the symptomatic phase than in the asymptomatic one, owing to the presence of pain. The change in bite force was another significant point observed, as 100% of the patients experienced increased bite force after treatment for their dysfunction. Bite force was assessed on both the right and left sides, consistently observing that the side with the less powerful bite was the side where pain was more intense. This fact has also been reported by most authors. Stohler and Mann (1999), Ioi et al. (2003) and Hansdottir and Bakke (2004) observed that decreased bite force is a major feature in patients with myofascial pain.

Our findings confirm those of the literature pointing to a set of altered conditions that characterizes myofascial pain and contributes to its correct diagnosis and treatment.

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References

Airoldi RL, Gallo LM and Palla S (1994). Precision of the jaw tracking system JAWS-3D. *J Orofac Pain*, 8: 155-163.

Ash MM and Ramfjord S (1995). *Occlusion*. W.B. Saunders, Philadelphia, pp 62-230.

Baba K, Tsukiyama Y, Yamazaki M and Clark GT (2001). A review of temporomandibular disorder diagnostic techniques. *J Prosth Dent*, 86: 184-194.

Castro NB, Varela JMF, Biedma BM, Pousa BR, Quintanilla JS, Bahillo JG and Patino PV (2002). Analysis of the area and lengh of masticatory cycles in male and female subjects. *J Oral Rehabil*, 29: 1160-1164.

Celic R, Jerolimov V, Knezovic Zlataric D and Klaic B (2003). Measurement of mandibular movements in patients with temporomandibular disorders and in asymptomatic subjects. *Coll Antropol*, 27: 43-49.

Cooper BC (1997). The role of bioeletronic instrumentation in the documentation and management of temporomandibular disorders. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 83: 91-100.

Dworkin SF, Huggins KH, Leresche L, Vonkorff M, Howard J, Truelove EL and Sommers EE (1990). Epidemiology of signs and symptoms in temporomandibular disorders: clinical signs in cases and controls. *J Am Dent Assoc*, 120: 273-281.

Dworkin SF and LeResche L (1992). Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. *J Cranio Disord Fac and Oral Pain*, 6: 302-354.

Gsellmann B, Schmid-Schwap M, Piehslinger E and Slavicek R (1998). Lengths of condylar pathways measured with computerized axiography (CADIAX) and occlusal index in patients and volunteers. *J Oral Rehabil*, 25: 146-152.

Hansdottir R and Bakke M (2004). Joint tenderness, jaw opening, chewing velocity, and bite force in patients with temporomandibular joint pain and matched healthy control subjects. *J Orofac Pain*, 18: 108-113.

Helkimo M (1974a). Studies of function and dysfunction of the masticatory system. II – Index for anamnestic and clinical dysfunction and oclusal state. *Swed Dent J*, 67: 101-119.

Helkimo M (1974b). Studies of function and dysfunction of the masticatory system. III – Analyses of anamnestic and clinical recordings of dysfunction with the aid of indices. *Swed Dent J*, 67: 165-182.

Huang BY, Durrant CJ, Johnson CWL and Murray GM (2002). A method of indirect registration of the coordinates of condylar points with a six-degree-of-freedom jaw tracker. *J Neurosc Method*, 117: 183-191.

Ioi H, Counts AL and Nanda RS (2003). Condylar movement analysis in subjects with clinically normal temporomandibular joints, utilizing an amorphous sensor. *J Oral Rehabil*, 30: 379-385.

JANKELSON B (1980). Measurement accuracy of the mandibular kinesiograph: a computerized study. *J Prosthet Dent*, 44: 656-665.

KOOP S and LUNDEBERG T (1999). Pain, allodynia, and serum serotonin level in orofacial pain of muscular origin. *J Orofac Pain,* 13: 56-62.

KUWAHARA T, MIYAUCHI S and MARUYAMA T (1992). Clinical classification of the mandibular movements during mastication in subjects with TMJ disorders. *Int J Prosthodont,* 5: 122-129.

LEWIS RP, BUSCHANG PH and THROCKMORTON GS (2001). Sex differences in mandibular movements during opening and closing. *Am J Orthod Dentofacial Orthop,* 120: 294-303.

LINDAUER SJ, SABOL G, ISAACSON RJ and DAVIDOVITCH M (1995). Condylar movement and mandibular rotation during jaw opening. *Am J Orthod Dentofacial Orthoped,* 107: 573-577.

MAGNUSSON T, EGERMARK I and CARLSSON GE (2000). A longitudinal epidemiologic study of signs and symptoms of temporomandibular disorders from 15 to 35 years of age. *J Orofac Pain,* 14: 310-319.

MATSUMOTO A, CELAR RM, CELAR A, SATO S, SUZUKI Y and SLAVICEK R (1995). An analysis of hinge axis translation and rotation during opening and closing in dentulous and edentulous subjects. *Cranio,* 13: 238-241.

NIELSEN IL, MARCEL T, CHUN D and MILLER AJ (1990). Patterns of mandibular movements in subjects with craniomandibular disorders. *J Prosthet Dent,* 63: 202-217.

OKESON JP (1998). *Dores bucofaciais de Bell*. Quintessence, São Paulo.

PALLA S and SALAORNI C (1994). Condylar rotation and anterior translation in healthy human temporomandibular joints. *Schw Monat Zah,* 104: 415-422.

PECK CC, JOHNSON CWL and KLINEBERG IJ (1997). The variability of condylar point pathways in open-close jaw movements. *J Prosthet Dent,* 77: 394-403.

PECK CC, MURRAY GM, JOHNSON CWL and KLINEBERG IJ (1999a). Trajectories of condylar points during working-side excursive movements of the mandible. *J Prosthet Dent,* 81: 444-451.

PECK CC, MURRAY GM, JOHNSON CWL and KLINEBERG IJ (1999b). Trajectories of condylar points during non-working side and protrusive movements of the mandible. *J Prosthet Dent,* 82: 322-331.

SATO S, NASU F and MOTEGI K (2003). Analysis of kinesiograph recordings and masticatory efficiency after treatment of non-reducing disk displacement of the temporomandibular joint. *J Oral Rehabil,* 30: 708-713.

SINN DP, ASSIS EA and THROCKMORTON GS (1996). Mandibular excursions and maximum bite forces in patients with temporomandibular joint disorders. *J Oral Maxillofac Surg,* 54: 671-679.

STOHLER CS and MANN WR (1999). Muscle-related temporomandibular disorders. *J Orofac Pain,* 13: 273-284.

YATABE M, ZWIJNENBURG A, MEGENS CC and NAEIJE M (1997). Movements of the mandibular condyle kinematic center during jaw opening and closing. *J Dent Res,* 76: 714-719.