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Research Article

The mandibular kinematics in relation to structural and functional modification of temporomandibular joint

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Abstract. The aim of this study was to correlate the possible connections between the statical and dynamical occlusion and the pathology of the temporomandibular joint (TMJ), masticatory muscles and parafunctions. Materials and methods: 83 subjects, 38,6% males and 61,4% females were included in the study. Initially we noted the presence of parafunction of stomatognatic system. We correlated the anamnestic data with the clinical results obtained after the examination. The clinical examinations were addressed to the TMJ, the jaw muscles and static and dynamic occlusion. Results: The results showed an increased frequency of malocclusion (71,1%)in women (p=0,004). As well, there is an evidence of an association between active premature contact and temporomandibular dysfunction: joint pain (p = 0.05), unilateral clicking (p = 0.05), and bilateral clicking (p = 0.06). Conclusions: This study showed that dental malocclusion, bruxism and other parafunctions could be considering favoring factors in producing of TMJ dysfunction, along with other associated pathologies.

Key Words: stomatognahtic system, occlusion, temporomandibular disorder, parafunctions

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Introduction

Dental occlusion is one of the major challenges of nowadays dentistry. It is an essential part of all types of dental treatments, regardless of their nature: prosthetic, reconstructive, periodontal, orthodontic and surgical treatments (Buduru&Almasan 2012). It is known that occlusal pathology influences both dental wearing and articular status (temporomandibular joint dysfunction, TMD) (Okeson 1994). Even postural status is influenced by occlusal pathology, according to current ortho posturodontitis studies initiated by Maurice Clauzade (2006).TMD is a more common condition among women aged 45 years (Lung et al 2018). A stable occlusion requires harmony between the biodynamics of temporomandibular joint (TMJ) and the dental guidances (Kim et al 2018). The edentations and their complications such as horizontal and vertical dental malpositions, loss of support of the posterior teeth have serious consequences upon dental occlusion. The mechanism of disorder is due to the appearance of active and passive interferences and premature contacts. Orthodontic syndromes with malocclusion may cause, in time, temporomandibular joint disorders and even structural changes in TMJ. (Koide et al 2017)

However, new published results consider that occlusal changes may play a secondary role than a causative one in producing TMD (Manfrendini et al 2010, Xie et al 2013). Also, unilateral mastication plays an additional role, which was mentioned for the first time by Raymond Gola 30 years ago (Cheynet 2016), along with the habitual sleeping position (Hibi& Ueda 2005), oral respiration or bruxism.

Therefore, dentists should take into consideration the relationship between occlusal changes, masticatory type, parafunctions and postural changes and TMJ status, in order to be able to successfully treat cases in everyday practice such as: tooth loss, dental fractures or a prosthetic treatments, pathological dental wear, pain of the masticatory muscles or other types of pain in the oro-facial area (Dawson 2007, Marini 2013).

The aim of this study was to corelate the connections between the static and dynamic occlusion and the status of the TMJ, masticatory muscles and parafunctions.

Material and method

This study is an analytical, observational, cohort, transversal, and prospective study. The subjects of the study are healthy young people who presented themselves to the Prostodontics Clinic for a routine examination.

The study protocol was approved by the Ethics Committee of the "Iuliu Hatieganu" University of Cluj-Napoca. The subjects included in the study were informed about the study methodology and signed an informed consent prior to being included in the study. The study was conducted between March 2016 and June 2016.

The study included 83 subjects with an M: F ratio of 0.63. Subjects are between 21 and 32 years old with an average of 23.59 ± 2.04 years.

The inclusion criteria in the study were: under 35 years old, undergraduate or completed higher education. The exclusion criteria were: the presence of associated general pathology, anti-inflammatory treatments in progress, the presence of edentation larger than 3 teeth, the presence of orthodontic appliances or retainers, history of trauma, facial bone fractures, TMJ surgery, ongoing dental treatments, or the presence of extensive prosthetic rehabilitation (dental bridge greater than 3 elements), which interfere with the functional movements of the mandible.

This study had two parts: an anamnesis (based on a questionnaire) and a clinical examination. Examinations were performed by a single examiner, following the same examination protocol for each study participant.

Firstly, based on the anamnesis, the following data were recorded: name, age, gender, place of origin (rural or urban), former or current changes of the dento-maxillary apparatus, parafunctions and vicious habits, postural changes like: unilateral mastication, atypical deglutition, oral respiration, bruxism, phonation disorders, ventral sleep, visual disturbances (which may cause posture changes), scoliosis or cervical arthrosis (Buduru 2012)

Secondly, based on clinical examination, we assessed the following: TMJ, mouth opening, masticatory muscles and occlusion.

For TMJ the following parametres were taken into account: the presence of pain (in palpation or during joint movements), asimmetries, joint sounds (clicking/crepitus which may be signs of internal joint derangements or degenerative desease), condyle mobility.

For the mouth opening we assessed the trajectory and the amplitude of the movements. The trajectory was divided in normal (no deviation during movement), sinusoidal or bayonet (when the mandible deviates at the beginning of the movement on the affected part, then returns to the normal trajectory towards the end of the movement) and the deviated (when the movement of the mandible is deviated from the beginning until the end of the mouth opening) (Manfredini et al 2015).

The examination of masticatory muscles assessed the presence of pain in palpation, hypertrophy, hypertonia, muscle contraction and the identification of trigger areas (Duminil&Laplanche 2013).

The occlusal examination was divided in static and dynamic.

The static examination of the occlusion comprised establishing the Angle class (1899) and the evaluation of the Spee and Wilson curves (Hue 2011). A normal Spee curve has a maximum depth of 1-3 mm. Other curve values were included in the group "high curves" (values greater than 3 mm) or "flattened" (straight or even inversed curves). For the Wilson Curve, the normal values were 1-2 mm. Other values were considerated accentuated Wilson curve (> 2 mm) and flattened curves (<1 mm).

The dynamic examination of occlusion included the examination of the centric relation, anterior and lateral guidance.

Centric relation (CR) is the relationship of the mandible to the maxilla when the condyles are in the most superior position in TMJ, against the articular eminentiae (Dawson 2007). CR was determined using bilateral manipulation and the results were considered as follows:

- normal: point centric (maximum intercuspation MI was equal with CR) or long centric (between CR and MI was a sagitally difference of 0.2-1.2 mm);
- abnormal: between MI and CR there is a difference either transversally or sagitally bigger than 2mm.

The anterior guidance was divided in:

- functional: in maximum intercuspation there is contact between the incisal edge of the lower incisors and the oral face of the upper incisors, and the propulsion movement is supported by two pairs of antagonistic incisors, located on both sides of the median line (Massironi et al 2007) with immediate dissoclusion of the posterior teeth;
- nonfunctional: in maximum intercuspation there is a anterior inoclussion, which causes an overload of the temporomandibular joint and the masticatory muscles, with the appearance of the dental wear surfaces.

The lateral guidance was divided in four categories:

- nonfunctional (when there is no occlusal contact between the canines in the position of maximum intercuspation),
- canine guidance (when the movement is supported only by the antagonistic canines located on the same side as the mandible movement direction)
- group function (when the movement is supported by antagonistic canine and all the posterior teeth on the same side)
- antero-lateral function (the movement is supported by canine and one or two incisors consecutive, on the same side).

The last three categories are considered functional and they also imply the disocclusion of all the teeth that do not support the lateral movement, from the beginning until the end. All the nonfunctional situations implied the existence of the occlusal obstacles (interferences and premature contacts), both passive (on opposing side) and active (on the same side).

The occlusal analysis was performed with 40 microns Baush articulating paper of different colours.

The data obtained were analyzed using MedCalc Software version 17.4, with a statistically significant value at $p < 0.05$.

Results

Demographics data are shown in table no. 1.

All patients in the study group experienced at least one symptom in the dento-maxillary system. The musculo-articular pathology observed in our group is shown in table no. 2. Most patients exhibited unilateral clicking, less than 10% of them had bilateral clicking or the severe form of alteration, crepitus. Pain was present in muscles and TMJ but it was not present in all patients with clicking and crepitus. The opening of the mouth modifications are present in more than half of the subjects (53 patients), even in the absence of joint symptoms.

The following parafunctions of the dentomaxilar apparatus were found in the study: atypical deglutition in 4 subjects, oral respiration in 10 subjects, 17 subjects had nocturnal bruxism, 1 subject presented disturbance of phonation, 21 had ventral sleep position, 8 subjects had cervical scoliosis, 1 subject had cervicarthrose, and 26 had visual disturbances. When examining the opening of the mouth, we found 4 cases of limited mouth opening, 5 cases of limitation of the maximum right lateral movement and 6 cases of limiting the maximum lateral movement on the left side.

Table 1. Demographics data

Parameter		Study group (n=83)
Age*		23.59±2.04
Sex^	Male	38.6% (32)
	Female	61.4% (51)
Living area^	Urban	96.4% (80)
	Rural	3.6% (3)

Table 2. Joint modifications

Parameter		Presence
Pain	Articular	15.6%(13)
	Mucular	14.4% (12)
Clicking	Unilateral	32.5% (27)
	Bilateral	6.02% (5)
Crepitus		7.22% (6)
Mouth opening changes	Sinusoidal	48.2% (40)
	Deviated	15.5% (13)

Table 3: Angle Classes

Number of subjects	Class I Angle	Class II Angle	Class III Angle
83	62 (74.7%)	12 (14.4%)	9 (10.8%)

Table 4. Occlusion curves

The occlusion curve	Normal	Flattened	Pronounced
Spee	77.1% (64)	10.8% (9)	12% (10)
Wilson	74.7% (62)	16.9% (14)	8.4 % (7)

Table 5. Lateral guidance

Active side	Canine guidance	Group function	Antero-lateral guidance	Nonfunctional guidance
Right	53 (63.9%)	8 (9.6%)	12 (14.5%)	10 (12%)
Left	50 (60.2%)	10 (12%)	13(15.7%)	10 (12%)

The static examination of the occlusion revealed the following Angle classes (see Table no. 3). Only 25% of the subjects presented Angle pathological classes (Class II and III).
The evaluation of occlusion curves revealed that most subjects did not show changes in the occlusion curves: 22.8% had the modified Spee curve, and 25.3% had the pathological Wilson curve (Table no. 4).
The examination of the centric relationship revealed point centric in 24 subjects (28.9%), long centric (50.6%) in 42 subjects, and 17 of premature contacts in R.C. (20.5%).
Examining the propulsion movement revealed a functional propulsion in 80.7% of cases (67 subjects), 19.3% having a vertical open occlusion in the frontal area. Propulsive active interferences were found in 45.8% (38 cases), passive propulsion interferences - 26.5% (22 cases), active premature contacts were found in 34.9% (29 cases), and passive propulsive contacts - in 13.3% 11 cases).
The analysis of lateral movement is presented in table no. 5.
Regarding the mandibular lateral movement, we observed similar situations for active interferences and passive premature contacts on the right and left side (48.2% vs 50.6% and 4.8% respectively on both sides). Passive interference and active premature contacts were more common on the left side (15.7% vs. 9.6% and 25.3% vs 18.1% respectively) without statistically significant differences. In the right lateral movement we noted the presence in 40 cases (48.2%) of the active side interferences, 13 cases (15.7%) had passive side interferences, 21 cases had premature active contacts (25.3%) and 4 cases of passive premature contacts in right side.
Subsequently we compared the association between the pathology of the dynamic occlusion - propulsion and lateral movements with the pathology and parafunctions of the dentomaxilar apparatus (Tables 6 and 7).
Following the examination of the propulsion movements we obtained the following data:
Statistical analysis revealed that propulsive active interference was statistically significantly associated with unilateral and bilateral clicking ($p = 0.05$) and sinusoidal mouth openings ($p = 0.03$) and limiting mouth opening ($p = 0.03$). Passive propulsive interference is statistically significant with ventral sleeping ($p = 0.005$), visual disturbances ($p = 0.05$) and limitation of mouth opening ($p = 0.05$), with maximum lateral limiting in the right ($p = 0.01$) and left ($p = 0.04$). These changes occurred in 88% of subjects with propulsive active interference who had a normal Wilson curve ($p = 0.08$).
Active premature contact in the propulsion movement is more common in women than men ($p = 0.001$), while passive premature contact is more common in males, but statistically significant differences are not noticeable in women. Active premature contact is statistically associated with TMD: joint pain ($p = 0.05$), unilateral clicking ($p = 0.05$), and bilateral clicking ($p = 0.06$). The same dynamic disorder is associated with the modification of the mouth opening trajectory, as the Wilson curve remains unchanged ($p = 0.009$). Passive premature contact only significantly associated with ventral sleep ($p = 0.02$)
After examining right-left side movements, we obtained the following data:.
In terms of right / left lateral movements, active interferences were more commonly observed in women than in men ($p = 0.004$). There were no statistically significant associations between active and passive lateral interferences and pathological changes of the dento-maxilar apparatus. Active premature and passive contacts are not statistically significant associated with pathological changes in the dental system.

Discussion

In the present study we analyzed the associations between occlusal changes and musculo-articular changes in the stomatognatic system. All subjects have experienced one or more occlusion changes that have caused changes in mouth opening, dental, articular, or muscular pain.
In occlusal static examination, most patients had Angle Class 1 (74.69%), a higher percentage than the literature data, which reported 40.4% - 71% depending on the population studied (Gudipaneni et al 2018, Eslamipour et al 2018,Cabrita et al 2017). This results could be explained by the educated subjects included in this study, all being students in dental medicine. Most

Table 6. Propulsion movement

Variable		Active propulsion interference	Passive propulsion interference	Premature active contact in propulsion	Premature passive contact in propulsion
Sex	M	10 (45.5%)	3 (10.3%)	6 (54.6%)	11 (28.9%)
	F	12 (54.5%)	26 (89.7%)	5 (45.5%)	27 (71.1%)
Articular pain		9 (23.7%)	2 (9.1%)	8 (27.6%)	1 (9.1%)
Muscle pain		7 (18.4%)	3 (13.6%)	7 (24.1%)	2 (18.2%)
Unilateral clicking		17 (44.7%)	9 (40.9%)	14 (48.4%)	5 (45.5%)
Bilateral clicking		2 (5.3%)	1 (4.5%)	2 (6.9%)	1 (9.1%)
Crepitus		4 (10.5%)	1 (4.5%)	3 (10.3%)	0 (0%)
Unilateral mastication		3 (7.9%)	4 (18.2%)	4 (13.8%)	3 (27.3%)
Atypical deglutition		1 (2.6%)	1 (4.5%)	0 (0%)	0 (0%)
Oral breathing		2 (5.3%)	3 (13.6%)	1 (3.4%)	1 (9.1%)
Bruxism		7 (18.4%)	5 (22.7%)	4 (13.8%)	2 (18.2%)
Phonation disorders		1 (2.6%)	1 (4.5%)	1 (3.4%)	1 (9.1%)
Ventral sleeping		7 (18.4%)	11 (50%)	8 (27.6%)	6 (54.5%)
Scoliosis		3 (7.9%)	0 (0%)	2 (6.9%)	0 (0%)
Cervicarthrosis		1 (2.6%)	1 (4.5%)	1 (3.4%)	1 (9.1%)
Visual disorders		11 (28.9%)	11 (50%)	9 (31%)	6 (54.5%)
Limitation of mouth opening		2 (5.3%)	3 (13.6%)	0 (0%)	0 (0%)
Limitation of the right side movement		4 (10.5%)	4 (18.2%)	2 (6.9%)	1 (9.1%)
Limitation of the left side movement		4 (10.5%)	4 (18.2%)	1 (3.4%)	0 (0%)
Sinusoidal opening of the mouth		24 (63.2%)	12 (54.5%)	18 (62.1%)	7 (63.6%)
Limited opening of the mouth		5 (13.2%)	3 (13.6%)	6 (20.7%)	0 (0%)
Angle Class I		27 (71.1%)	17 (77.3%)	21 (72.4%)	7 (63.6%)
Angle Class II		6 (15.8%)	3 (13.6%)	4 (13.8%)	2 (18.2%)
Angle Class III		5 (13.2%)	2 (9.1%)	4 (13.8%)	2 (18.2%)
Normal Spee curve		28 (73.7%)	18 (81.3%)	22 (75.9%)	8 (72.7%)
Flattened Spee curve		3 (7.9%)	3 (13.6%)	1 (3.4%)	2 (18.2%)
Accentuated Spee curve		7 (18.4%)	1 (4.5%)	6 (20.7%)	1 (9.1%)
Normal Wilson curve		26 (68.4%)	19 (86.4%)	16 (55.2%)	17 (63.6%)
Flattened Wilson curve		8 (21.1%)	3 (13.6%)	8 (27.6%)	4 (36.4%)
Accentuated Wilson curve		4 (10.5%)	0 (0%)	5 (17.2%)	0 (0%)

of the subjects had already completed orthodontic treatments before this study, which could correct occlusal class.

Nearly two-thirds of subjects (63.7%) experienced changes in mouth opening (sinusoidal or limited opening). These changes were mainly present in women. Changes in opening the mouth may be due to occlusal changes. Similar changes have been reported in other studies. Nguyen et al (2018) reported limited mouth opening in 10.3% of patients and crepitus in 49.6% of those, different results data from those obtained in this study. However, Nguyen's study was conducted in the elderly, while young people were included in our study. However, in the study of Gesch et al (2005) performed in young and teenagers, the crepitus and clickings were present in 8.8% of the subjects. The percentage reported by Gecsh et al is lower than our study where unilateral clickings predominate. However, the authors have quantified the presence of bilateral clickings and crepitus in the study, the results reported being close to those in the present study (bilateral clicking 6.02% and crepitus 7.22%). Changes in the dento-maxilar apparatus may increase with age, which explains the reported incidence differences in the

Table 7. Lateral movement

Variable		Side active interference	Side passive interference	Side premature active contact	Side premature passive contact
Sex	**M**	4 (30.8%)	8 (30.8%)	2 (33.3%)	14 (26.4%)
	F	9 (69.2%)	18 (69.2%)	4 (66.7%)	27 (71.1%)
Articular pain		9 (17.0%)	2 (15.4%)	4 (15.4%)	1 (16.7%)
Muscular pain		8 (15.1%)	2 (15.4%)	3 (11.5%)	2 (33.3%)
Unilateral clicking		20 (37.7%)	4 (30.8%)	9 (34.6%)	3 (50.0%)
Bilateral clicking		2 (3.8%)	0 (0%)	2 (7.7%)	1 (16.7%)
Crepitus		4 (7.5%)	1 (7.7%)	1 (3.8%)	0 (0%)
Unilateral mastication		11 (20.8%)	2 (15.4%)	5 (19.2%)	1 (16.7%)
Atypic deglutition		2 (3.8%)	0 (0%)	0 (0%)	1 (16.7%)
Oral breathing		6 (11.3%)	1 (7.7%)	4 (15.4%)	0 (0%)
Bruxism		13 (24.5%)	2 (15.4%)	4 (15.4%)	1 (16.7%)
Phonation disorders		1 (1.9%)	1 (7.7%)	0 (0%)	1 (16.7%)
Ventral sleeping		15 (28.3%)	3 (23.1%)	8 (30.8%)	3 (50%)
Scoliosis		4 (7.5%)	1 (7.7%)	4 (15.4%)	1 (16.7%)
Cervicarthrosis		1 (1.9%)	1 (1.9%)	0 (0%)	1 (16.7%)
Visual disorders		18 (34.0%)	4 (30.8%)	6 (23.1%)	1 (16.7%)
Normal Spee curve		39 (73.6%)	10 (76.9%)	18 (69.2%)	4 (66.7%)
Flattened Spee curve		5 (9.4%)	0 (0%)	3 (11.5%)	0 (0%)
Pronounced Spee curve		9 (17.0%)	3 (23.1%)	5 (19.2%)	2 (33.3%)
Normal Wilson curve		39 (73.6%)	11 (84.6%)	18 (69.2%)	4 (66.7%)
Flattened Wilson curve		9 (17.0%)	1 (7.7%)	5 (19.2%)	1 (16.7%)
Accentuated Wilson curve		5 (9.4%)	1 (7.7%)	3 (11.5%)	1 (16.7%)

mentioned studies. They could be improved by properly managed orthodontic treatment, so that Nguyen's severe changes in the geriatric population are not reached.

The literature in the field has highlighted the presence of increased malocclusion in female patients in different populations, correlated with disk displacements, evidenced by the presence of clickings. These observations can be justified by increased ligament laxity following the presence of estrogen hormones and the psychological profile of females. (Chisnoiu et al 2014, Eberhard et al 2014) This study highlighted the increased presence of premature interferences and premature contacts in female subjects in both propulsive and the lateral movement.

The association between propulsive premature active contacts and unilateral clickings accompanied in some cases by pain in TMJ, is demonstrated in this study, being consistent with the literature. Leonor Sanchez Perez (2013), in his study on Mexican students, found significant association between malocclusion with anterior crowding and maxilary overjet and TMD.

The parafunctions associated with occlusal changes most commonly observed in this study were night bruxism and sleeping in ventral position. Similar data is presented in other studies. Thus, Panek et al (2012), in a study conducted on students observed the presence of bruxism in most of them. But this study does not analyze the occlusion changes only parafunctions, different from our study. In fact, nocturnal bruxism was similarly reported by Henrikson et al (1997) in patients with temporomandibular dysfunction. Involvement of dental malocclusion and bruxism in the occurrence of articular dysfunction remains an intensely discussed subject. Studies conducted so far can not attribute a determinant factor, at most, a favoring factor along with other associated pathologies, also underlined by the results of this study. (Manfredini et al 2010, Xie et al 2013)

The sinusoidal trajectory of the mouth opening, which most often suggests a disorder such as the disk displacement with reduction, is associated with propulsive passive interferences and premature contacts and is consistent with the data collected from the literature (Manfredini et al 2015). The hypothesis of the association between malocclusion and visual disturbances (myopia) strongly debated by recent studies (Monaco et al 2012), was not supported by our research.

We did not identify an association between articular pain and interferences, although Kaselo et al (2007) highlights the presence of this association. There was no correlation between passive interferences, considered more harmful than active ones, and fatigue and pain in the masticatory muscle, contrary to previous studies of Belser&Hannam (1985). There is a possibility that the number of patients has been insufficient for the study to have statistically significant relevance for these variables as well. This study analyzes exhaustively the associations between occlusal changes and musculo-articular changes in young patients in Romania, revealing some changes that could be corrected by orthodontic treatment. The study also has some limits. Firstly, the small number of subjects included in the study did not allow the analysis of the data recorded on subgroups of patients.

It would be interesting to analyze these structural and functional modifications after a specific orthodontic treatment or how will evolve without orthodontic treatment.

Conclusions

Articular dysfunction and occlusal pathology are more common in female patients. All subjects analyzed had at least one symptom in dento-maxillary system. Limitation of the mouth opening observed in half of the patients caused joint and muscle pain. Bruxism and ventral sleep are most commonly associated with occlusal pathological changes. Examination of occlusal dynamics revealed that active premature contact is statistically associated with temporomandibular dysfunction: joint pain, unilateral clicking, and bilateral clicking, suggesting a pathological role of these factors comparated with passive premature contacts.

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