European Review for Medical and Pharmacological Sciences 2020; 24: 8703-8712

Subjects with temporomandibular joint disc displacement and body posture assessment *via* rasterstereography: a pilot case-control study

C. DI PAOLO[1], P. PAPI[1], G. FALISI[2], G. POMPA[1], V. SANTILLI[3], A. POLIMENI[1], A. FIORINI[1]

[1]Department of Oral and Maxillo-Facial Sciences, "Sapienza" University of Rome, Rome, Italy
[2]Department of Life, Health and Environmental Sciences, University of L'Aquila, L'Aquila, Italy
[3]Department of Anatomical and Histological Sciences, Legal Medicine and Orthopedics, Sapienza University of Rome, Rome, Italy

Abstract. – OBJECTIVE: The possible relationship between temporomandibular disorders (TMDs) and body posture is still controversial. Rasterstereography has been introduced as a radiation-free, reliable and non-invasive method to analyze three-dimensional spinal posture. The aim of this case-control study is to evaluate, through rasterstereography, body posture parameters in a group of patients with reducible unilateral dislocation of the articular disc, compared to healthy volunteers.

PATIENTS AND METHODS: Rasterstereographic recordings obtained were compared between the two groups with a paired t-student test. Furthermore, the relationship between Rasterstereographic recordings and clinical data in the TMD group were analyzed by means of multiple regression analysis.

RESULTS: Only lateral deviation was statistically significant different between the two groups (rms VPDM Control group 40% > TMD group, *p*=0.02; 43% control group VPDM max > TMD group, *p*<0.02). In the TMD group, a significant relationship (*p*<0.05) was found out between lateral and rotational deviations of the column and muscular pain, therefore suggesting a possible overactivity of the masticatory muscles, especially of lateral pterygoids' bilaterally and the left masseter.

CONCLUSIONS: Patients with reducible unilateral disc displacement showed limited postural alterations compared to healthy volunteers, only lateral deviations (VPDM rms and VPDM-max) were statistically significant (Œ <0.05) between the two groups.

Key Words:
Temporomandibular disorders, Body posture, Rasterstereography, Orofacial pain, Temporomandibular joint.

Introduction

Temporomandibular disorders (TMDs) comprise a set of clinical conditions affecting the temporomandibular joint (TMJ), masticatory muscles and the associated structures[1,2], representing the most common oro-facial pain[3-5]. According to a recent epidemiological study[6], 30.7% of an adult Italian population sample experienced TMJ clicking, with TMD pain present in 16.3% of subjects. Depending on their severity, TMDs may cause painful and functional limitations, often determining problems either in practice and in social interaction[7,8].

Body posture is defined as the relationship between muscle chains, fascia, ligaments and bone structures in all segments of the human body in upright position[9]. In ideal conditions, weights are perfectly balanced with the minimum energy demand and the maximum productivity[10].

Over the years, several studies[11-22] have investigated the possible relationship between body posture and TMDs, however the current scientific evidence is still controversial and full of ambiguities.

In a recent critical review, Munhoz and Hsing[11] have discussed the paths followed and the speculations regarding the bidirectional relationship between TMDs and body posture alterations. Based on the interconnectivity between the neuromuscular factors and proprioceptors, mediated by the Central Nervous System (CNS), alterations of the cervical spine or other body segments (shoulders, pelvis, legs) might lead to the adaptation of the temporo-mandibular system, with a reciprocal interaction[12,13]. Therefore, a multidisciplinary approach has been recently

Corresponding Author: Piero Papi, MD; e-mail: piero.papi@uniroma1.it

encouraged[14-17] in the diagnosis and treatment of TMDs to better rehabilitate the patient, taking into account painful postural adaptations. Over the years, a great variety of methods and tools have been used for postural assessment[18-20]: physical examination, photographs of the body, postural balance and more recently rasterstereography.

Rasterstereography has been introduced in orthopedics as a radiation-free, reliable and non-invasive method to analyze posture of the spinal and pelvic regions[23-25]. This technology is based on the projection of white lights on the back of the patient, which allows the three-dimensional (3D) detection of pre-set anatomic landmarks and the reconstruction of the spine and pelvis curvatures. Furthermore, also a time component is taken into account by collecting multiple pictures for each measurement, to render a four-dimensional (4D) effect. Just a few authors[26-29] have used rasterstereography to evaluate the correlation between body posture and dento-skeletal malformations, sagittal jaw position and craniofacial morphology.

The association between body posture alterations and dislocation of the articular disc is controversial: Saito et al[30] described a positive correlation, while Rocha et al[31] rejected this hypothesis.

The aim of this case-control study is to evaluate, through rasterstereography, body posture parameters in a group of patients with reducible unilateral dislocation of the articular disc, compared to a demographically matched group of healthy volunteers.

Patients and Methods

Study Design

To address the research purpose, the authors designed and implemented a case-control study, conducted at the Department of Oral and Maxillofacial Sciences, at "Sapienza" University of Rome.

Study Population

The study sample was derived from a total of 213 consecutive patients presenting at the Service of Clinical Gnathology for TMDs treatment between January and June 2018. Subjects with a diagnosis of reducible unilateral dislocation of the articular disc (ICD-9 524 63) with ipsilateral arthralgia (ICD-9 524 62) were included in this study.

The diagnosis was performed by an expert clinician (CDP) in accordance with the latest edition of the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD)[32] and was confirmed by magnetic-resonance imaging (MRI) for all patients included.

The following exclusion criteria were adopted:

– TMJ pain < 50 according to the Verbal Numeric Scale (VNS);
– previous TMJ surgery;
– presence of dento-skeletal malformations;
– history of orthopedic, head, and/or facial trauma;
– orthodontic or orthopedic treatment;
– current or previous gnathological treatment;
– primary headaches;
– rheumatic diseases and fibromyalgia;
– absence of one or more teeth excluding the third molars;
– positivity for axis 2 of the DC / TMD: Patient Health Questionnaire (PHQ – 9) >15 and Graded Chronic Pain (GAD-7) >9.

The demographically matched control group was derived among the 187 patients presenting at the Oral surgery unit for third molar removal, asymptomatic for TMDs and clinically healthy, based on the following inclusion criteria:

– no TMJ pain (0) according to the VNS
– no uncontrolled systemic diseases
– no pregnancy/lactation;
– no history of orthodontic or gnathological treatments;
– no history of orthopedic, head, and/or facial trauma;
– absence of one or more teeth excluding the third molars;
– no previous TMJ surgery;
– absence of dento-skeletal malformations;
– no rheumatic diseases and fibromyalgia;
– no primary headaches.

All subjects selected were referred to the Physical Medicine and Rehabilitation Unit at "Sapienza" University of Rome for clinical analysis of the spinal column by rasterstereography.

Each patient received detailed descriptions of the study protocol and all subjects signed the inform consent form and gave written approval to be included in the study population, according to the latest version of the World Medical Declaration of Helsinki (2013). The study was approved by the institution review board of "Sapienza" University of Rome (Ref. 02/2018).

Clinical Data

To evaluate presence of dento-skeletal malformations, all patients were clinically exanimated and a lateral cephalometric x-ray and a panoramic radiograph were taken for each subject. Only patients with skeletal class I were enrolled in this study.

Mandibular Movements

A digital caliper rule was used to record the following clinical measurements of mandibular movements in millimeters (mm): maximum unassisted mouth opening, protrusion, and right and left laterality[32].

The maximum unassisted mouth opening was defined as the gap between the incisal edges with the addition of the incisal overbite, measured with a digital caliper rule.

The right and left lateral excursion movements were obtained by asking the patient to open slightly and to move the jaw as far as possible to the right and left, respectively. For the protrusive excursion, the patient was asked to open slightly and move the jaw as forward as possible.

TMJ and Muscular Pain

TMJ pain was evaluated through the Verbal Numeric Scale (VNS), which uses numeric values (0-100) to decipher the intensity of pain, with the following division: 0 (no pain); 0-20 (slight and episodic pain); 20-50 (moderate pain); 50-80 (severe pain); and 80-100 (very severe pain)[33]. Bilateral palpation of the masseter, medial pterygoid, temporal, sternocleidomastoid and digastric muscles was carried out to evaluate muscular pain using a numeric scale (0 = no pain, 1 = mild pain, 2 = Moderate pain, 3 = Severe Pain)[32]. Furthermore, also the lateral pterygoid area was evaluated following the DC/TMD guidelines[32]. This clinical evaluation was performed on all dysfunctional subjects at baseline prior to treatment (time of diagnosis).

Rasterstereography

Rasterstereographic recordings were performed by Formetric 4D (Diers International GmbH, Schlangenbad, Germany) in a standardized position (barefoot and in relaxed posture), following supplier's instructions. Parallel white light lines were projected on the back surface of patients by a slide projector, with the three-dimensional back shape leading to a deformation of the parallel light lines. The fixed anatomical landmarks were represented on the dorsal surface by vertebra prominens (VP), right lumbar dimple (DR) and left lumbar dimple (DL). From these fixed points, the software automatically measured the midpoint between the two dimples (DM) and the twelfth thoracic vertebra (T12) (Figure 1).

With these pre-set points, the system was able to calculate a three-dimensional model of the human spine. Furthermore, three points of in-

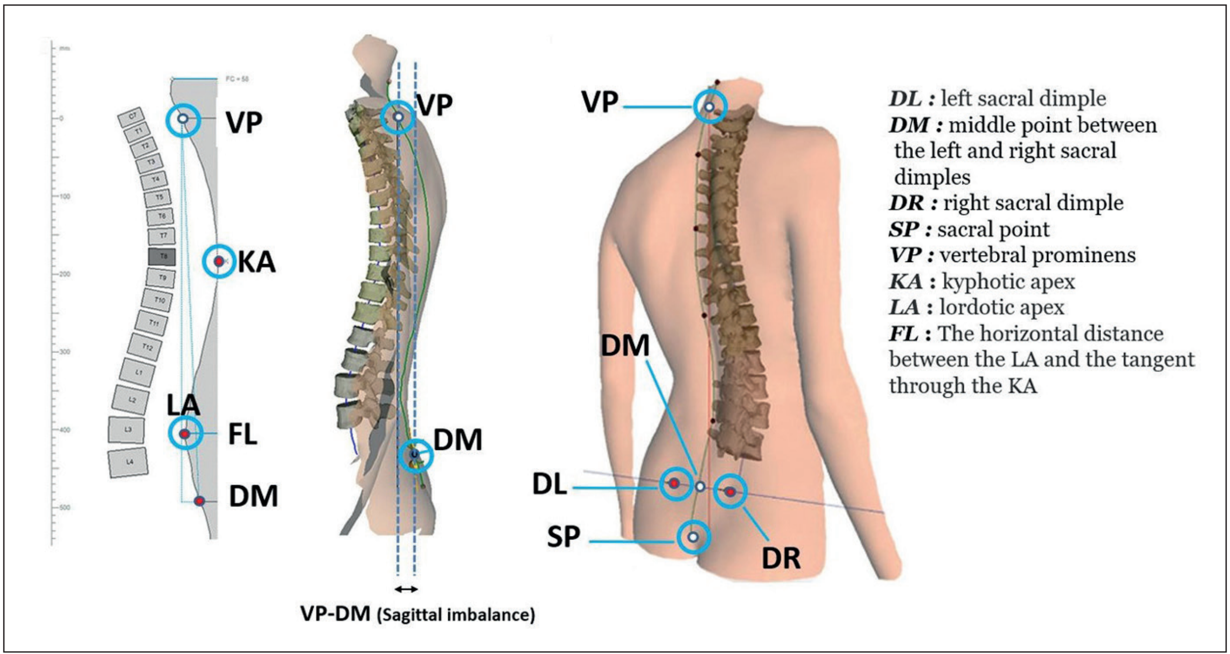

Figure 1. Fixed anatomic landmarks in rasterstereography.

flection along the profile were also indicated: the cervicothoracic (ICT), thoracolumbar (ITL) and lumbosacral (ILS). To compensate the postural variability generated by breathing and/or body oscillation, 6 different scans were taken within 6 minutes for each participant.

The following measurements were recorded on the sagittal, frontal and axial planes:

- Sagittal imbalance VP-DM or Anteroposterior deflexion VP-DM (trunk inclination): the distance in mm between VP and the connecting external plumb line;
- Pelvic obliquity (pelvic tilt): the angle between the line connecting DL and DR and the horizontal;
- Kyphotic Apex KA VPDM: the location of the posterior apex of the sagittal profile, measured in mm;
- Inflection point ITL: the point of maximum negative surface inclination between the KA and the lordotic apex (LA), measured in mm;
- Flèche cervicale: the horizontal distance between the cervical apex and the tangent thorough KA;
- Flèche lombaire: the horizontal distance between LA and the tangent thorough KA;
- Flèche cervicale (VP): the horizontal distance between VP and KA;
- Lordotic Apex LA VPDM: the location of the frontal apex of the sagittal profile in the lower region, measured in mm;
- Kyphotic angle ICT_ITL (max): the angle between the surface tangents from the ICT and ITL;
- Kyphotic angle VP_ITL: the angle between the surface tangents from VP and ITL;
- Kyphotic angle VP_T12: the angle between the surface tangents on VP and the location of the calculated 12th thoracic vertebra (T12);
- Lordotic angle ITL_ILS (max): the angle between the surface tangents from ITL and ILS;
- Lordotic angle ITL_DM: the angle between the surface tangents from ITL and DM (°);
- Lordotic angle T12_DM: the angle between the surface tangents from T12 and DM (°);
- Coronal imbalance VP-DM or Lateral Deflection VP-DM (trunk imbalance) in mm, the lateral distance between VP and DM;
- Pelvic inclination DL_DR: the mean vertical components of the surface normals at DL and DR;
- Pelvic torsion DL_DR: the torsion of the surface normals of DL and DR;
- Pelvis rotation: In the frontal plane, the angle of rotation of DR in relation to DL;
- Rotation surface (rms °): the root mean square (RMS) of the horizontal components of the surface normals on the symmetry line;
- Rotation surface (max): the maximum value of the horizontal components of the surface normals on the symmetry line;
- Rotation surface (+ max): the maximum value of the horizontal components of the surface normals on the symmetry line to the right;
- Rotation surface (- max): the maximum value of the horizontal components of the surface normals on the symmetry line to the left;
- Rotation surface amplitude °: the maximal spinal torsion calculated from the maximal rotation to the right and to the left;
- Lateral deviation VPDM (rms): the RMS deviation of the midline of the spine from the direct connection VP-DM in the frontal plane, measured in mm;
- Lateral deviation VPDM (max): the maximum deviation of the midline of the spine from the direct connection VP-DM in the frontal plane, measured in mm.

Statistical Analysis

Descriptive statistics were computed for each variable included in the study (mean, standard deviation, range). Rasterstereographic recordings obtained were compared with parameters of normality of Hartzmann[34] and between the two groups with a paired *t*-student test.

Furthermore, the relationship between dependent variables (Formetric data) and independent variables (clinical data) in the TMD group was analyzed by means of multiple regression analysis, using a statistical software (MEDCALC® 12.3.0, MedCalc Software bvba, Ostend, Belgium). The level of significance was set at $p < 0.05$.

Results

Tmd Group

Based on the inclusion criteria, 46 subjects were enrolled and included in the TMD group: they were either males (18) and females (28), with a mean age of 35.7 ± 8.7 years (range: 20-65 years). Thirty patients had a diagnosis of unilateral dislocation of the disc on the right side, while sixteen presented unilateral dislocation of the disc on the left side. All patients had right limb dominance and clinical parameters collected are reported in Table I.

Table I. Clinical parameters of the Test group with temporomandibular disorders.

Study variable	Test group
Sample size	46
Male	18
Female	28
Age (y) ± SD	35.7 ± 8.72
TMJ pain (VNS)	75.65 ± 12.93
Clinical Data	
Maximum unassisted mouth opening (mm)	44.08 ± 4.64
Protrusion (mm)	4.23 ± 1.49
L Laterality (mm)	8.36 ± 2.09
R Laterality (mm)	9.26 ± 2.24
Muscular Pain on palpation	
Lat. Pterygoid. Area L	1 ± 0.87
Lat. Pterygoid. Area R	2 ± 0.92
Med. Pterygoid. L	1.13 ± 0.94
Med. Pterygoid. R	0.72 ± 0.82
Masseter L	1.22 ± 1.06
Masseter R	2.22 ± 1.02
Temporal L	0.45 ± 0.67
Temporal R	1.86 ± 0.99
Digastric L	0.54 ± 0.73
Digastric R	1.22 ± 1.10
Sternocleidomastoid L	1.86 ± 1.12
Sternocleidomastoid R	0.86 ± 0.94

y= years, SD=standard deviation, VNS= Verbal numeric scale, mm= millimeters L= left, R=right.

Control Group

Forty-six subjects met the inclusion criteria and were enrolled in the control group: 32 females and 14 males, with a mean age of 29.8 ± 6.4 years (range: 19-45 years).

Univariate Analysis

The results of the comparison of rasterstereographic recordings between test and control groups are presented in Figure 2. Only lateral deviation was statistically significant different

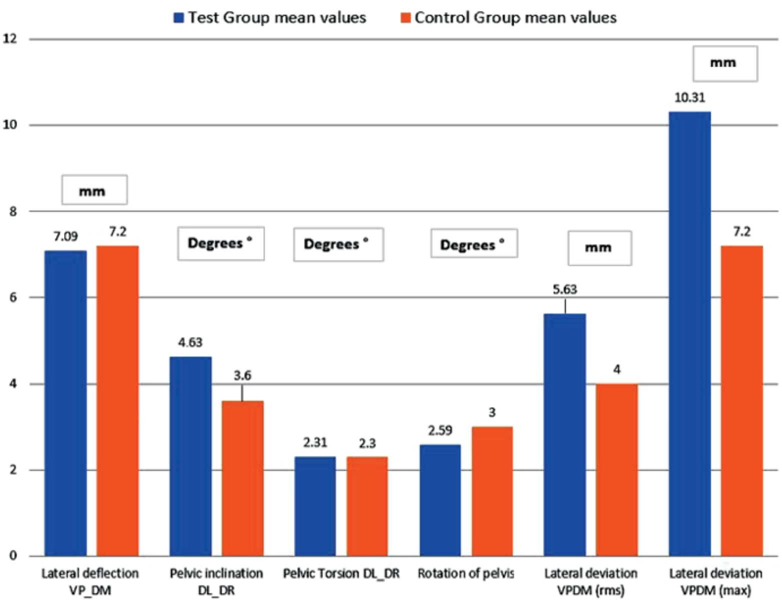

Figure 2. Rasterstereographic recordings results compared between TMD and Control groups.

between the two groups (rms VPDM TMD group 40%> control group, $p = 0.02$; 43% TMD group VPDM max> control group, p=0.02) (Figure 2).

Multivariate Analysis

No statistically significant (p>0.05) associations were found out in the correlation analysis for pain on palpation and rasterstereographic recordings in the TMD group, with the following exceptions.

Pain on palpation Lateral Pterygoid Right Area – Lateral Deviation VPDM (max)

A statistically significant (p=0.0415) relationship between an increase of the lateral deviation (max) and higher VNS values for the right lateral pterygoid area was found, with an r coefficient=0.4380 (Figure 3).

Pain on palpation Lateral Pterygoid Left Area – Rotation surface (max)

A statistically significant (p=0.0305) relationship showed that the rotation of the surface (max) tended to decrease in relation to higher VNS values for the left lateral pterygoid area, with a correlation coefficient r=0.4619 (Figure 4).

Pain on palpation M. Masseter Left – Rot. Surface (+ max)

A statistically significant (p=0.0237) relationship highlighted that the increase in achiness of the left masseter was related to a decrease in the maximum value of vertebral rotation, with a correlation coefficient r=-0.5033 (Figure 5).

Discussion

The aim of this case-control study was to evaluate, through rasterstereography, body posture parameters in a group of patients with reducible unilateral dislocation of the articular disc, compared to a group of healthy volunteers.

Based on the analysis of data obtained with Formetric 4D, some evident alterations of the column alignment were highlighted. The comparison with parameters of normality of Hartzmann showed that, in the TMD group, almost 90.3% of participants presented an alteration of dorsal kyphosis angle, 77.2% of lordotic lumbar angle and 40.9% lateral deviations of the spine. Furthermore, an increase either in vertebral rotations (68.1%) or rotation and inclination of the pelvis (36.3%) was reported in the TMD group. Only lateral deviation was statistically

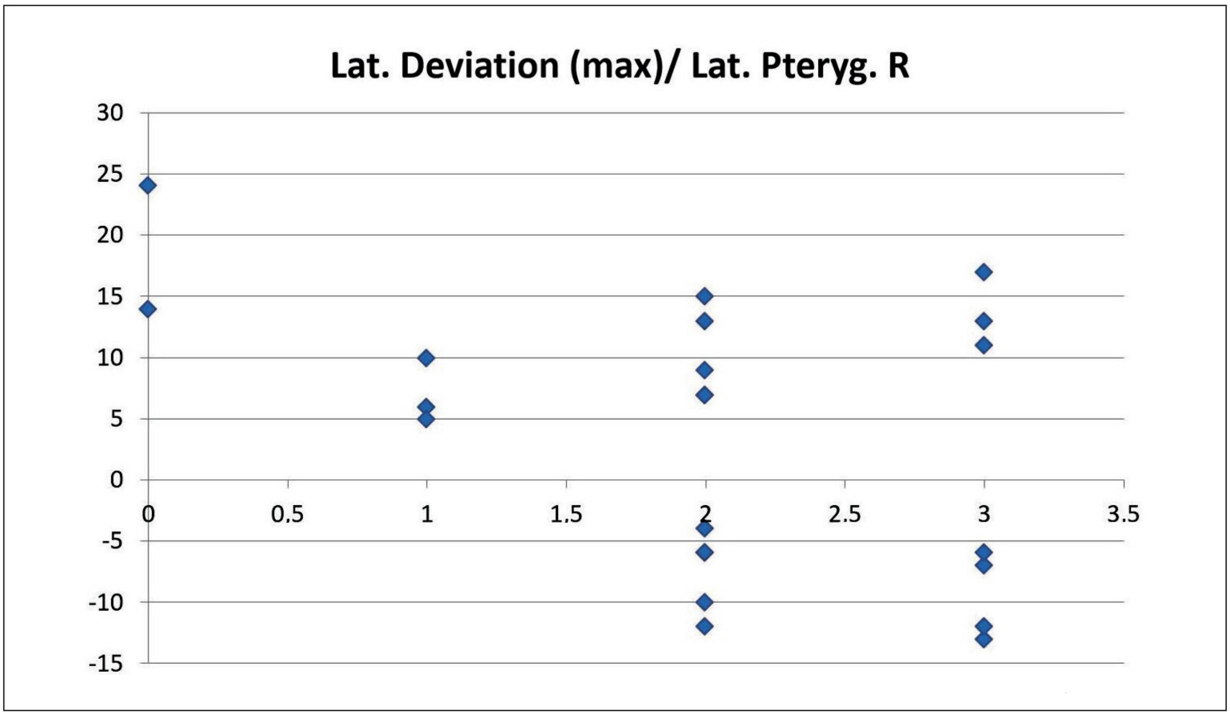

Figure 3. Correlation analysis of Lateral deviation (max) and pain on palpation of Right Lateral Pterygoid Area.

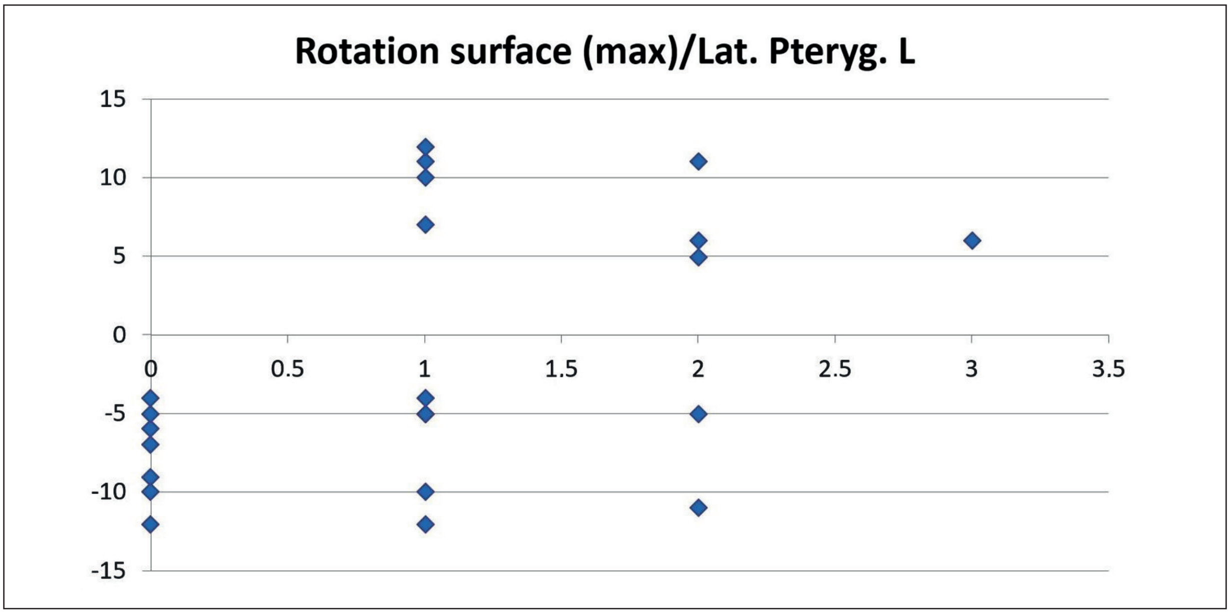

Figure 4. Correlation analysis of Rotation surface (max) and pain on palpation of Left Lateral Pterygoid Area.

significant different between the two groups (rms VPDM control group 40%> TMD group, $p = 0.02$, 95% CI; 43% control group VPDM max> TMD group, $p < 0.02$, 95% CI) and this might be a consequence of the misalignment condition of condyle-disc relationship. A significant relationship was found out between lateral and rotational deviations of the column and muscular pain, therefore suggesting a possible over activity of the masticatory muscles, especially of lateral pterygoids' areas bilaterally and the left masseter. Based on this relationship, patients with more severe and widespread painful conditions at muscular palpation, presented lower lateral deviation of the column, a result in accordance with Ries et al[35]. Conversely, patients presenting a more localized painful manifestation, reported a greater lateral deviation of the spine. It can be hypothesized that these anomalies were related to an impaired mandibular position, which de-

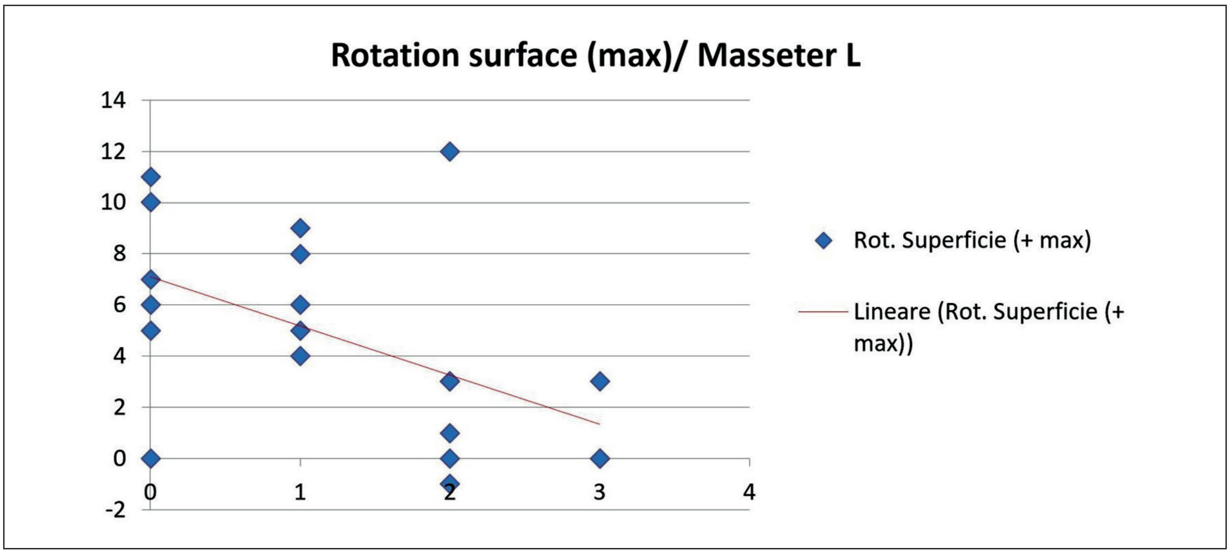

Figure 5. Correlation analysis of Rotation surface (max) and pain on palpation of Left Masseter Muscle.

termined the pathological disc dislocation. Our findings are in accordance with Saito et al[30]: based on their results, subjects with unilateral disc displacement showed postural deviations in the pelvis, lumbar spine, thoracic spine, head and mandible, therefore suggesting a close relationship between body posture and TMDs. On the contrary, Rocha et al[31] reported no statistically significant differences in body posture between subjects with and without unilateral disc displacement. However, in the above-mentioned article, the authors conducted posturographic assessment and postural balance reactions using a balance platform. In our study, rasterstereography was performed to conduct the body posture evaluation, a technique considered reliable and effective in evaluating spinal posture parameters[36]. Therefore, there are no studies to which our findings can be directly compared. In a recent systematic review, Chaves et al[37] found out a strong correlation, in accordance with previous studies[38,39], between myogenous TMDs and alterations of the cranio-cervical segment, but no evidence for global body posture changes in patients with TMD.

Michelotti et al[40] concluded that there was insufficient evidence to support the use of orthodontic therapy to treat spinal alterations. Different articles[31,41] excluded a relationship between TMDs and body posture and individuated the conduction of studies enrolling subjects with TMJ pain as a major limitation to draw clear conclusions. Hence, the presence of pain might induce patients to adapt their posture, with TMD being, therefore, a confounding factor and not the cause of postural alterations[31,41].

Based on our study design, we cannot determine the directionality of the relationship: it is uncertain whether body postural alterations lead to a change of head position and, therefore, as a consequence, to a greater tension of the masticatory muscles, which might be the cause of disc displacement. Otherwise, we can't exclude that the internal derangement of the TMJ was the cause of body posture adaptations.

Limitations

Main limitations of the study are represented by the small sample enrolled and its design: a case-control study does not allow establishing direct cause-effect relationship. Furthermore, the lack of x-ray scans to confirm the rasterstereographic evaluation might lead to a wrong interpretation of our results.

Conclusions

Based on our results and within the limitations of the study, the following conclusions can cautiously be drawn: patients with reducible unilateral disc displacement showed limited postural alterations compared to healthy volunteers, only lateral deviations (VPDM rms and VPDM-max) were statistically significant ($p<0.05$) between the two groups. A significant relationship was found out between lateral and rotational deviations of the column and muscular pain, therefore suggesting a possible over activity of the masticatory muscles, especially of lateral pterygoids' areas bilaterally and the left masseter in the test group. Based on the design of the study, we are not able to define the directionality of the relationship between body posture alterations and reducible disc displacement. To the best of the authors' knowledge, this is the first study to investigate the possible correlation between disc displacement and body postural deviations using a rasterstereographic evaluation. It is extremely important to adopt a multidisciplinary approach while treating TMD patients, in order to select the best rehabilitation techniques, as well as to allow a better understanding of the origin and the onset of TMJ pain. Therefore, highlighting the possible interaction between TMJ and other body segments could be extremely useful for clinicians.

Future research should be orientated in conducting further studies, with larger samples and a longitudinal design, to confirm or refute the findings of this preliminary study.

Conflict of Interest

The Authors declare that they have no conflict of interests.

References

1) Lai Y, Yap A, Türp J. Prevalence of temporomandibular disorders in patients seeking orthodontic treatment: a systematic review. J Oral Rehabil 2020; 47: 270-280.
2) Okur A, Ozkiris M, Kapusuz Z, Karaçavus S, Saydam L. Characteristics of articular fossa and condyle in patients with temporomandibular joint complaint. Eur Rev Med Pharmacol Sci 2012; 16: 2131-2135.
3) Delwel S, Scherder EJA, de Baat C, Binnekade T, van der Wouden J, Hertogh CMPM, Maier A, Perez RSGM, Lobbezoo F. Orofacial pain and its potential

oral causes in older people with mild cognitive impairment or dementia. J Oral Rehabil 2019; 46: 23-32.

4) Di Paolo C, D'Urso A, Papi P, Di Sabato F, Rosella D, Pompa G, Polimeni A. Temporomandibular disorders and headache: a retrospective analysis of 1198 patients. Pain Res Manag 2017; 3203027.

5) Di Paolo C, Pompa G, Arangio P, di Nunno A, Di Carlo S, Rosella D, Papi P, Cascone P. Evaluation of temporomandibular disorders before and after orthognathic surgery: therapeutic considerations on a sample of 76 patients. J Int Soc Prev Community Dent 2017; 7: 125-129.

6) Iodice G, Cimino R, Vollaro S, Lobbezoo F, Michelotti A. Prevalence of temporomandibular disorder pain, jaw noises and oral behaviours in an adult Italian population sample. J Oral Rehabil 2019; 46: 691-698.

7) Su N, Lobbezoo F, van Wijk A, van der Heijden G, Visscher C. Associations of pain intensity and pain-related disability with psychological and socio-demographic factors in patients with temporomandibular disorders: a cross-sectional study at a specialised dental clinic. J Oral Rehabil 2017; 44: 187-196.

8) Bayat M, Abbasi A, Noorbala A, Mohebbi S, Moharrami M, Yekaninejad M. Oral health-related quality of life in patients with temporomandibular disorders: a case-control study considering psychological aspects. Int J Dent Hyg 2018; 16: 165-170.

9) Claus A, Hides J, Moseley G, Hodges PW. Different ways to balance the spine: subtle changes in sagittal spinal curves affect regional muscle activity. Spine (Phila Pa 1976) 2009; 34: E208-214.

10) O'Sullivan P, Grahamslaw K, Kendell M, Lapenskie S, Möller N, Richards K. The effect of different standing and sitting postures on trunk muscle activity in a pain-free population. Spine (Phila Pa 1976) 2002; 27: 1238-1244.

11) Munhoz WC, Hsing WT. The inconclusiveness of research on functional pathologies of the temporomandibular system and body posture: Paths followed, paths ahead: a critical review [published online ahead of print, 2019 Apr 29]. Cranio 2019; 1-12.

12) Munhoz WC, Hsing WT. Interrelations between orthostatic postural deviations and subjects' age, sex, malocclusion, and specific signs and symptoms of functional pathologies of the temporomandibular system: a preliminary correlation and regression study. Cranio 2014; 32: 175-186.

13) Sakaguchi K, Mehta N, Abdallah E, Forgione A, Hirayama H, Kawasaki T, Yokoyama A. Examination of the Relationship Between Mandibular Position and Body Posture. Cranio 2007; 25: 237-249.

14) Garrigós-Pedrón M, Elizagaray-García I, Domínguez-Gordillo AA, Del-Castillo-Pardo-de-Vera JL, Gil-Martínez A. Temporomandibular disorders: improving outcomes using a multidisciplinary approach. J Multidiscip Healthc 2019; 12: 733-747.

15) Martins W, Blasczyk J, Aparecida Furlan de Oliveira M, Lagôa Gonçalves K, Bonini-Rocha A, Dugailly PM, de Oliveira RJ. Efficacy of musculoskeletal manual approach in the treatment of temporomandibular joint disorder: A systematic review with meta-analysis. Man Ther 2016; 21: 10-17.

16) Rampello A, Papi P, Pompa G, Rampello A, Polimeni A, Di Paolo C. A novel universal device"-LINGUAL RING Ri.P.A.Ra" for TMDs and cranio-cervico-mandibular pains: preliminary results of a randomized control clinical trial. Eur Rev Med Pharmacol Sci 2018; 22: 1180-1190.

17) Cocuzza S, Marino S, Gulino A, Pustorino E, Murabito A, Maniaci L, Sabino R, Taibi M, Di Luca R, Falsaperla G, Campione G, Vecchio M, Pavone P. ENT involvement and orobuccal movements' disorders in Pandas patients: assessment and rehabilitations tools. Eur Rev Med Pharmacol Sci 2019; 23: 4110-4117.

18) Hanke BA, Motschall E, Türp JC. Association between orthopedic and dental findings: what level of evidence is available? J Orofac Orthop 2007; 68: 91-107.

19) Perinetti G, Contardo L. Posturography as a diagnostic aid in dentistry: a systematic review. J Oral Rehabil 2009; 36: 922-936.

20) Rocha CP, Croci CS, Caria PHF. Is there a relationship between temporomandibular disorders and head and cervical posture? A systematic review. J Oral Rehabil 2013; 40: 875-881.

21) Joy TE, Tanuja S, Pillai RR, Dhas Manchil PR, Raveendranathan R. Assessment of craniocervical posture in TMJ disorders using lateral radiographic view: a cross-sectional study. Cranio 2019; 13: 1-7.

22) Fiorillo L, Musumeci G. TMJ dysfunction and systemic correlation. J Funct Morphol Kinesiol 2020; 5: 20.

23) Mohokum M, Mendoza S, Udo W, Sitter H, Paletta JR, Skwara A. Reproducibility of rasterstereography for kyphotic and lordotic angles, trunk length and trunk inclination. Spine (Phila Pa 1976) 2010; 35: 1353-1358.

24) Guidetti L, Bonavolontà V, Tito A, Reis VM, Gallotta MC, Baldari C. Intra- and interday reliability of spine rasterstereography. Biomed Res Int 2013; 2013: 745480.

25) Girdler S, Cho B, Mikhail CM, Cheung ZB, Maza N, Kang-Wook Cho S. Emerging techniques in diagnostic imaging for idiopathic scoliosis in children and adolescents: a review of the literature. World Neurosurg 2020; 136: 128-135.

26) De Giorgi I, Castroflorio T, Cugliari G, Deregibus A. Does occlusal splint affect posture? A randomized controlled trial. Cranio 2018; 14: 1-9.

27) Sinko K, Grohs JG, Millesi-Schobel G, Watzinger F, Turhani D, Undt G, Baumann A. Dysgnathia, orthognathic surgery and spinal posture. Int J Oral Maxillofac Surg 2006; 35: 312-317.

28) Lippold C, Moiseenko T, Drerup B, Schilgen M, Vegh A, Danesh G. Spine deviations and orthodontic

treatment of asymmetric malocclusions in children. BMC Musculoskelet Disord 2012; 13: 151.

29) März K, Adler W, Matta RE, Wolf L, Wichmann M, Bergauer B. Can different occlusal positions instantaneously impact spine and body posture?: a pilot study using rasterstereography for a three-dimensional evaluation. J Orofac Orthop 2017; 78: 221-232.

30) Saito ET, Akashi PM, Sacco Ide C. Global body posture evaluation in patients with temporomandibular joint disorder. Clinics (Sao Paulo) 2009; 64: 35-39.

31) Rocha T, Castro MA, Guarda-Nardini L, Manfredini D. Subjects with temporomandibular joint disc displacement do not feature any peculiar changes in body posture. J Oral Rehabil 2017; 44: 81-88.

32) Schiffman E, Ohrbach R. Executive summary of the diagnostic criteria for temporomandibular disorders for clinical and research applications. J Am Dent Assoc 2016; 147: 438-445.

33) Conti PC, de Azevedo LR, de Souza NV, Ferreira FV. Pain measurement in TMD patients: evaluation of precision and sensitivity of different scales. J Oral Rehabil 2001; 28: 534-539.

34) Harzmann H. Methode und Klinische Einsatzmöglichkeiten der dreidimensionalen Rückenoberflächenvermessung mit der Videorasterstereographie (VRS). Individuelle Gesundheitsleistungen (IGEL). [Method and Clinical Applications of Three-dimensional back surface measurement with the Videorasterstereography. Individual health services]. Orthopädie 2001; 81-104.

35) Ries LG, Bérzin F. Analysis of the postural stability in individuals with or without signs and symptoms of temporomandibular disorder. Braz Oral Res 2008; 22: 378-383.

36) Krott NL, Wild M, Betsch M. Meta-analysis of the validity and reliability of rasterstereographic measurements of spinal posture. Eur Spine J 2020 Apr 10. doi: 10.1007/s00586-020-06402-x. [Epub ahead of print].

37) Chaves TC, Turci AM, Pinheiro CF, Sousa LM, Grossi DB. Static body postural misalignment in individuals with temporomandibular disorders: a systematic review. Braz J Phys Ther 2014; 18: 481-501.

38) Grondin F, Hall T. Changes in cervical movement impairment and pain following orofacial treatment in patients with chronic arthralgic temporomandibular disorder with pain: a prospective case series. Physiother. Theory Pract 2017; 33: 52-61.

39) Walczyńska-Dragon K, Baron S, Nitecka-Buchta A, Tkacz E. Correlation between TMD and cervical spine pain and mobility: is the whole body balance TMJ elated? Biomed Res Int 2014; 2014: 582414.

40) Michelotti A, Buonocore G, Manzo P, Pellegrino G, Farella M. Dental occlusion and posture: an overview. Prog Orthodont 2011; 12: 53-58.

41) Manfredini D, Castroflorio T, Perinetti G, Guarda-Nardini L. Dental occlusion, body posture and temporomandibular disorders: where we are now and where we are heading for. J Oral Rehabil 2012; 39: 463-471.