Clinical Research Report

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
2018, Vol. 46(12) 4952–4964

DOI: 10.1177/0300060518782346
journals.sagepub.com/home/imr
SAGE

Vertical contact tightness of occlusion comparison between orofacial myalgia patients and asymptomatic controls: a pilot study

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Abstract

Objective: The association between occlusal contact and orofacial pain remains unclear. The aim of this study was to detect occlusal contact tightness by using a new method and to compare differences between patients and asymptomatic controls.

Methods: Fifteen female patients with orofacial myalgia and fifteen age- and sex-matched asymptomatic controls were enrolled. Occlusal contacts were recorded by making bite imprints. The numbers, sizes, and distributions of the contacts were detected by making photos of bite imprints after biting. The Mann-Whitney U test and ANOVA were used for statistical analysis.

Results: In myalgia patients, impact contacts at the molar regions were more frequent, larger in number and area size, and were distributed more on guiding cusps, compared with impact contacts in asymptomatic controls.

Conclusion: Our new method revealed more prevalent and more severe impact contacts in orofacial myalgia patients, compared with asymptomatic controls.

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Keywords
Vertical contact tightness of occlusion, orofacial myalgia, Photoshop, bite imprint, dental occlusion, facial pain

Date received: 12 January 2018; accepted: 21 May 2018

Introduction

Occlusion is defined as the static relationship (contact) between the incising or masticating surfaces of the maxillary or mandibular teeth or tooth analogs.[1] Characteristics of this contact have been evaluated with a variety of approaches.[2–14] Clinical occlusal paper is most often used to detect contact; however, it generally provides information regarding size, location, and site of contact, when used in clinical settings.[2,3] As larger contact size does not indicate stronger contact, detection by other methods is necessary. The T-Scan Occlusion Recording System can determine contact strength, contact time sequence, and spatial distribution.[14] However, this method produces space between opposing teeth, due to penetration by the transducer.[15] Thus, contact tightness is absent from T-Scan recordings.

Occlusal contact is likely related to the function of the masticatory system,[16–18] as well as to dysfunctions, such as temporomandibular disorders (TMDs).[19] Altering occlusal contact elicits biomechanical[20] and biological [21] temporomandibular joint responses. However, until recently, the role of occlusal factors in TMD has remained controversial.[22–24] There has not been wide acceptance of occlusal factors as causative elements in TMD.[25] TMD symptoms have been reported to weakly associate with occlusal contacts, as assessed with wax registrations[26] or occlusal contact patterns during lateral excursions, although the specific laterality of TMD may be associated with particular occlusal contacts.[27]

The contact surface of an occlusion is undulating, which results in complex contact of upper and lower dentition that cannot be easily recorded or described. The concave and convex structures of healthy dentition are generally regarded as well-matched in intercuspal position (ICP). However, contact in eccentric positions or ICP (e.g., by maximal voluntary clenching (MVC)), does not produce an exact fit. The constituents of contacts with different levels of tightness are not well described, and their roles in oral function and dysfunction are unclear.

Orofacial pain is a widespread dysfunction that is typically the chief clinical complaint of TMD patients; myalgia is a common subtype of orofacial pain.[28] In our study, ICP contact was recorded by using a custom-developed method and dental impression materials. Our null hypothesis was that there would be no difference in ICP contact tightness between patients with orofacial myalgia and asymptomatic subjects.

Materials and methods

Subjects

Subjects were consecutively enrolled from December 2014 to June 2015 at the Department of Orofacial Pain and Temporomandibular Disorders, the Stomatology Hospital, Fourth Military

Medical University. Eligibility criteria included a chief complaint of orofacial pain, which occurred during mouth open or bite in temporalis or masseter muscles, and a diagnosis of myalgia, according to the diagnostic criteria for TMD;[29] no click history; complete natural dentition without any restorations or eruption of the third molar; bilateral angle class I molar and canine relations; no deep overjet (>4 mm) and overbite (>1/3 of buccal surface); good oral hygiene without observable periodontal problems; no dental treatment in the three months prior to the clinical evaluation; and orofacial pain lasting for >3 months in the region of the jaw-closing muscles when performing maximal voluntary mandibular movement(s), clenching, chewing or on palpation, as examined by one of the authors. Mean visual analog scale (VAS) value was recorded by use of a ruler with a pain scale of 0 to 10. Exclusion criteria were a history of orthodontic treatment, orofacial trauma history, known bruxism, neurologic or cervical disturbances, psychological problems, or other disabling complaints. Fifteen age-matched female controls, selected from asymptomatic college students at the Stomatology Hospital of the Fourth Military Medical University, were also enrolled. Each of the 30 subjects provided written informed consent, and the study was approved by the local ethical committee of the Fourth Military Medical University.

Recording procedures

Each subject was seated upright in a dental chair with her feet on the ground. The dental chair was set for patients sitting in a straight position when the operator stood diagonally in front of the patient. The subject was asked to look straight at a white panel that was located 2 m away and mounted on a wall at eye level. This procedure enabled the subject to maintain a natural head position. When seated upright, the subject was required to voluntarily elevate the mandible.[30] Bite imprints (3M ESPE Imprint bite, 3M Deutschil and GmbH, Neuss, Germany) were taken to record occlusal contact. Before recording, the imprint materials were carefully spread on the occlusal surface of the mandibular dentition without a holder. When the imprint material was prepared, the subject was asked to close freely as quickly and forcefully as possible into the material. Before the tests, the subjects were provided instructions regarding appropriate bite imprints. Maximal voluntary clenching was encouraged to ensure the closest possible contact of the teeth in the imprints. Solid bite imprints were carefully taken from the dentition and used for contact analysis after digital photography.

Imaging of contacts

Study casts were taken in Jeltrate Dental Alginate Impression Material (Dentsply, Tianjin, China). Each bite imprint was placed into a maxillary and mandibular study cast (Dental gypsum products, Die stone; Heraeus Kulzer, LLC, South Bend, IN, USA). Digital photos of each cast with and without bite imprints were taken (Canon EOS 60D, Canon macro lens EF 100 mm, f/5.6, 1/250 s, ISO 200, photo size: 3456*2304, resolution: 72 dpi; Canon Inc., Tokyo, Japan). The camera was mounted on a sturdy tripod. Every photo was taken in the same room and the distance between camera lens and study cast was fixed to avoid parallax errors during digital photography of the casts. Care was taken to not change the spatial relation of either the camera or the cast during serial photography.

Contact labeling

Digital pictures of each cast with and without bite imprints were created with

Photoshop software (Adobe Photoshop CS3, Adobe Systems Software Ireland, Ltd., Dublin, Ireland). A blank transient layer was added to the window of the picture with a bite imprint. This layer was used to label areas on the imprint that were penetrated, blurred, or opaque, which represented the impact, medium contact, and loose contact sites, respectively. First, penetrated areas were labeled by using Photoshop software. The blurred areas were then defined as areas where the grey scale value was 20 units greater than the penetrated areas. Accordingly, the opaque areas were 20 grey scale units greater than the blurred areas. In this manner, black, red, and blue were assigned to the corresponding areas at three different contact tightness levels on the added transient layer. This added layer with color labeling was then moved from the picture (with the bite imprint) to the picture of the naked cast (without the bite imprint). With this method, the locations and distributions of occlusal contacts with different contact tightness levels were revealed on the maxillary and mandibular casts (Figure 1). The pictures with the colorful contact labels were used for contact analysis.

Parameters used for contact analysis

The numbers of colored sites representing the contacts at different tightness levels were counted, and the sizes of the colored areas were measured by using Photoshop software. The sum of the numbers and area sizes of each colored site was calculated by one of the authors who was blinded to information regarding subject grouping. The counts of the premolars and molars in each quadrant were used separately for statistical analysis. The counts in the anterior section of the arch were not used because of a lack of occlusal surface for the anterior teeth.

Reproducibility of the contact recording and counting

To evaluate the reproducibility of the recording methods for occlusal contact, two bite imprints were taken from each of eight subjects. The contacts of the teeth were labeled and counted by the same author. If the location, number and color of the contacts were consistent, that pair of records was marked as "1"; otherwise, it was marked as "0." The Kappa test results for the black, red, and blue contacts were 0.929, 0.805, and 0.768, respectively.

Statistical analysis

Statistical analyses were performed by using SPSS (Release 13.0*; SPSS Inc., Chicago, IL, USA). Continuous variables were compared by using *t*-tests, while categorical variables were compared by using chi-squared tests. The data for occlusal contact numbers of impacts, medium contacts, and loose contacts did not exhibit normal distributions and were therefore compared by using Mann-Whitney U tests. The occlusal contact areas were compared by using one-way ANOVA. $P < 0.05$ was considered statistically significant.

Results

Fifteen subjects between 18 and 27 years of age (mean age: 22.93 ± 2.57 years) were enrolled in this study; 15 age-matched female controls between 19 and 28 years of age (mean age: 23.33 ± 2.26 years old) were also enrolled. Clinical information for all subjects is shown in Table 1. The mean VAS value in the patient group was 3.47 ± 0.83. Mean values of the maximum unassisted opening length (mm) for patients and controls were 34.73 ± 5.87 mm and 42.20 ± 2.24 mm, respectively. Contact tightness was significantly different between

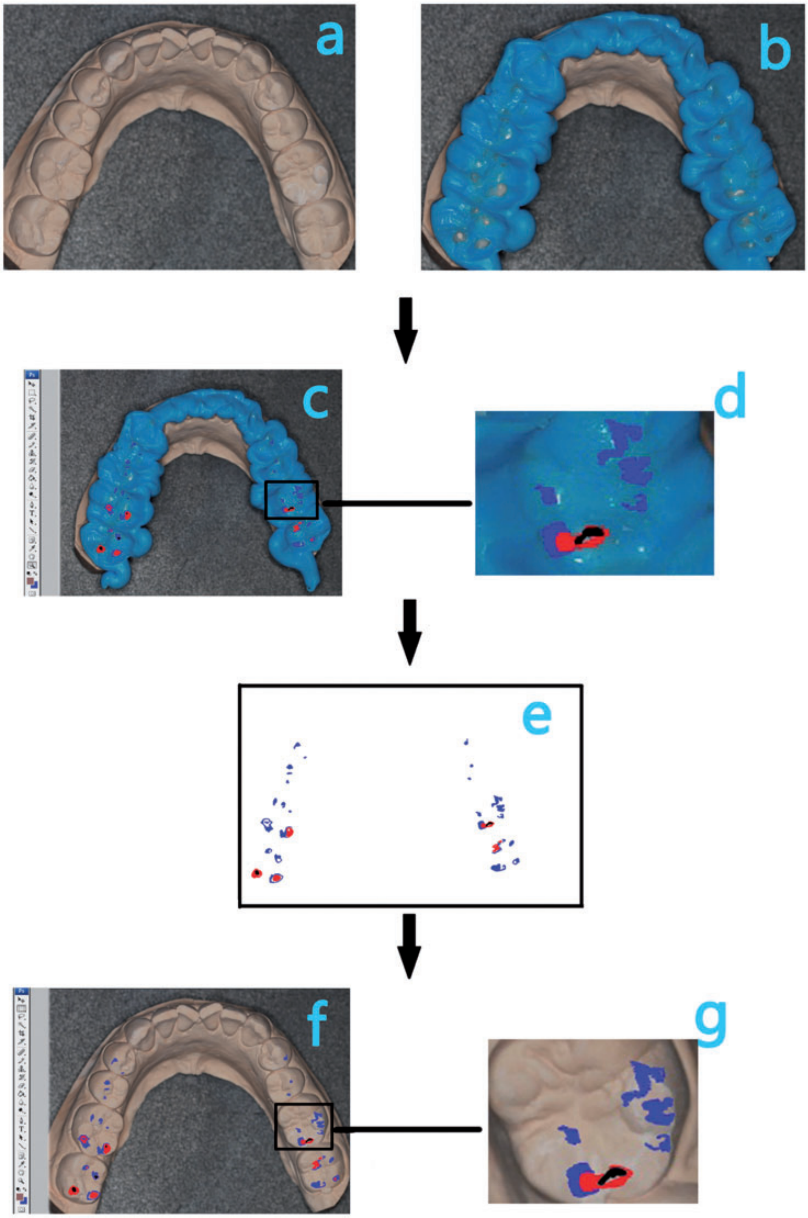

Figure 1. A diagram of contact labeling on the images of the study casts. Pictures of the study casts without (a) and with (b) recorded bite imprints in identical photographic environments. Using Photoshop software (Adobe Photoshop CS3, Adobe Systems Software Ireland Ltd), a blank layer is created over image b (c). On the created blank layer, penetrated points are labeled in black, blurred areas in red, and opaque areas in blue, to represent the impact, medium contacts, and loose contacts, respectively (d). The created layer is transferred from picture c to picture a in Photoshop (e). The contact information recorded by the impression is transferred to the cast (f) and expressed in three colors, representing contact at three tightness levels (g). Note: The areas within the rectangles in images c and f are enlarged in images d and g, respectively

Table 1. Clinical information of the subjects

Group	ID Number	Age (years)	Side with myalgia	Duration of the disease (years)	VAS value of pain	Maximum unassisted opening length (mm)
Patients	1	24	Left	5	4	28
	2	24	Both	1	3	40
	3	18	Left	0.5	5	28
	4	24	Left	3	3	36
	5	23	Both	1	4	35
	6	27	Left	5	4	27
	7	22	Right	1	4	29
	8	24	Left	1	2	43
	9	25	Left	1	4	29
	10	20	Both	1	3	34
	11	25	Both	1	3	42
	12	22	Both	0.5	4	38
	13	25	Both	1	3	37
	14	18	Left	1	2	44
	15	23	Right	2	4	31
	Mean value (1–15)	22.93 ± 2.57	/	1.67 ± 1.48	3.47 ± 0.83	34.73 ± 5.87
Controls	16	23	/	/	/	41
	17	22	/	/	/	44
	18	23	/	/	/	42
	19	24	/	/	/	44
	20	19	/	/	/	43
	21	28	/	/	/	46
	22	22	/	/	/	40
	23	25	/	/	/	38
	24	26	/	/	/	39
	25	26	/	/	/	41
	26	22	/	/	/	44
	27	24	/	/	/	43
	28	22	/	/	/	45
	29	23	/	/	/	41
	30	21	/	/	/	42
	Mean value (16–30)	23.33 ± 2.26	/	/	/	42.20 ± 2.24
P value	/	NS	/	/	/	*

*$P < 0.05$; NS: no significance.

patients and controls, as shown in Figure 2. Detailed comparisons are described below.

Contact frequency

All subjects had medium (red) or loose (blue) contacts. Contact frequencies are shown in Figure 3. Eleven subjects in the control group and 14 in the patient group had impact contacts (black). Two subjects in the control group and 10 in the patient group had >2 impact contacts. The frequency difference between groups for >2 impact contacts was

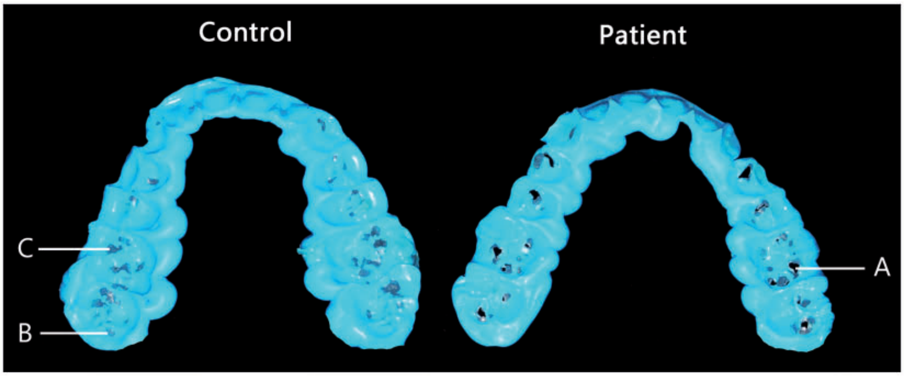

Figure 2. Typical occlusal contact impressions from a patient and a control subject. The patient had more impact contacts, shown as penetration (A), but fewer loose contacts, shown as the opaque (B) contact area. The blurred area (C) is where transparency was between the locations of A and B

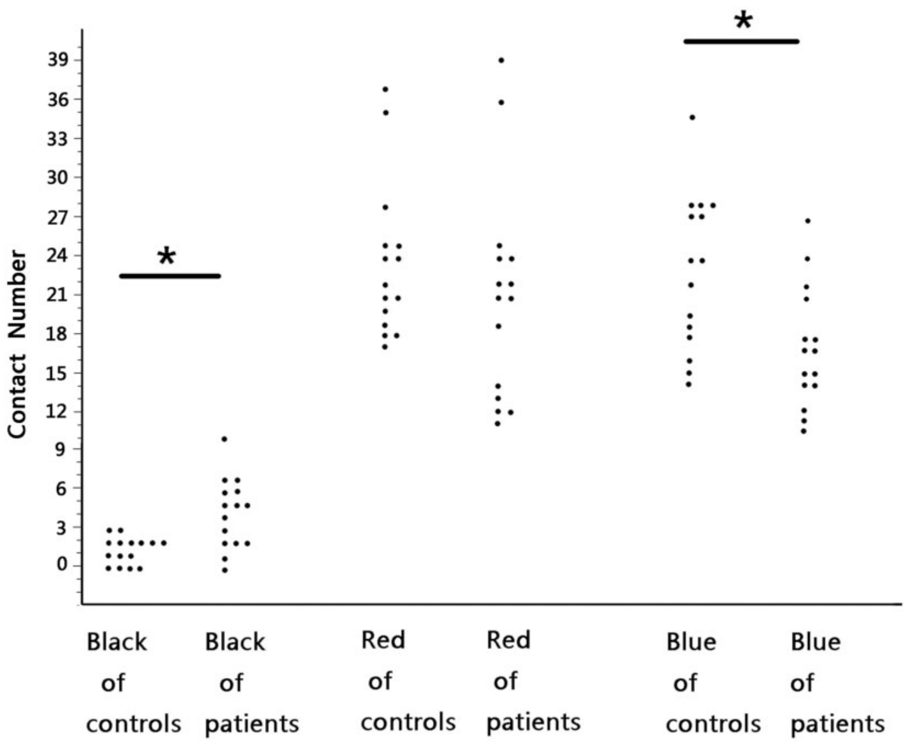

Figure 3. Comparison of the frequency of the impact, medium contacts, and loose contacts between the control group and the myalgia patient group, as indicated by black, red, and blue, respectively, assessed by using our recording methods (see Figure 1)

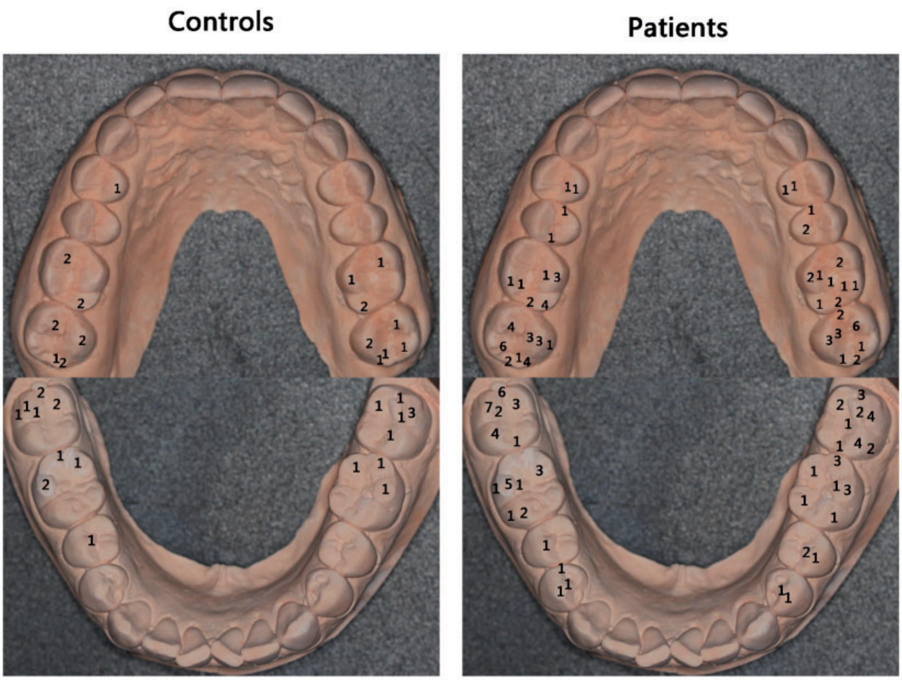

Figure 4. Comparison of the frequency distribution of the impact contacts (black contacts in Figure 1) between controls (left panel) and myalgia patients (right panel). The numbers represent the frequency of the impact contacts at that site. A contact covering two neighboring sites was repeatedly counted when obtaining the numbers of contacts at different sites

significant ($x^2 = 8.889$, $P < 0.05$) (Figure 3, Table 4).

Contact number

The number of impact contacts (black) in the molar region in the patient group was significantly greater than in the control group, while the numbers of loose contacts (blue) in the molar and premolar regions were smaller (Table 2, $P < 0.05$). No differences were observed between groups in the numbers of medium contacts (red) (Table 2).

Contact size

The impact, medium, loose and total contact areas are summarized in Table 3. The area size of the impact contact of molars in the patient group was larger than in the control group ($P < 0.05$).

Impact contact distribution

Impact contacts were more frequently located in the molar region than in the premolar region in both patient and control groups. In the control group, there was one impact contact in the premolar region, while in the molar region there were 21 impact contacts. In contrast, in the patient group, there were nine and 65 contacts in the premolar and molar regions, respectively. In the control group, contacts on the maxillary dentition were most frequent around the tip of the distal-lingual cusp of the first maxillary molar, as well as the tips of the mesial- and distal-lingual cusps and the lingual inclined plane of the

Table 2. Comparison of occlusal contact numbers between patients (n = 15) and controls (n = 15)

	Contact Number						
	Controls			Patients			
#	25%	50%	75%	25%	50%	75%	P value
Black							
Premolars	0	0	0	0	0	1	NS
Molars	0	2	2	2	4	7	**
Red							
Premolars	3	5	6	3	6	7	NS
Molars	16	17	19	11	16	17	NS
Blue							
Premolars	4	6	8	3	5	6	*
Molars	12	16	20	10	11	15	*

#: the representatives of the colors are presented in Figure 1.
*P<0.05 **P<0.01 NS: no significance. Analyzed by Mann-Whitney U test.
All values of P<0.05 were considered to indicate statistical significance.

Table 3. Comparison of the occlusal contact area between patients (n = 15) and controls (n = 15)

	Area (Pixels)				
	Controls		Patients		
#	Mean ± SD	95%CI	Mean ± SD	95%CI	P value
Black					
Premolars	42 ± 17.3	(1.3, 82.7)	81.6 ± 26.2	(25.1, 138.1)	NS
Molars	844.67 ± 152.7	(459.9, 1229.5)	1697.9 ± 209.4	(1415.3, 1980.4)	**
Red					
Premolars	3264.1 ± 442.8	(2560.4, 3967.8)	2564.1 ± 306.3	(2006.2, 3122)	NS
Molars	234976.4 ± 1592.6	(19318.4, 26472)	17928.4 ± 2004.7	(13221.8, 22493.5)	NS
Blue					
Premolars	1986.4 ± 289.3	(1537.2, 2338)	1701.2 ± 166.2	(1352.5, 2046.7)	NS
Molars	16163.8 ± 873.8	(13352.8, 19267)	14164.4 ± 1175.4	(11134.3, 17169.4)	NS

**P < 0.01 NS: no significance. Analyzed by one-way ANOVA test.
All values of P < 0.05 were considered to indicate statistical significance.

Table 4. Frequency difference for >2 impact contacts between groups

	Number of subjects			
	Controls	Patients	x^2	P value
Impact number ≤2	10	2	8.889	0.003
Impact number >2	5	13		

mesial-buccal cusp of the second molar. In the patient group, contacts on the maxillary dentition were in the lingual inclined plane of the mesial- and distal-buccal cusp of the second molars. Contacts on the mandibular dentition in the control group were primarily located around the tip of the distal part of the first and second mandibular molars. In the patient group, however, contacts on the mandibular dentition were scattered among the distal-buccal cusps of the first molars, the mesial- and distal-buccal cusps and distal margins of the second molars, and the buccal inclined plane of the distal-lingual cusp (Figure 4). No correlation was found in the occlusion contact pattern of subjects with the presence of unilateral or bilateral orofacial myalgia.

Discussion

Here, a new method was developed to evaluate the tightness of occlusal contact and its difference in patients with orofacial myalgia, compared with age-matched, asymptomatic controls. The data showed that occlusal contacts at three levels of tightness can be repeatedly detected. Although MVC is not generally performed during natural mandibular function, it is suggested, and widely accepted, as a standard approach for functional evaluation of the masticatory system.[31] A similar standard is forced vital capacity, which is the maximum expiratory volume of the lung and can be used to measure lung capacity. Notably, we found that, compared with healthy controls, impact contacts in patients with orofacial myalgia occurred at a higher frequency, were larger in number and area size, and were distributed more on guiding cusps than on supporting cusps. In contrast, loose contacts were lower in frequency and number in patients, compared with healthy controls.

The present method provides an approach to record and analyze contact tightness as impact contact, medium contact, or loose contact. The frequency, location, size and distribution of the contact can then be analyzed in terms of these three levels of tightness. The current data indicated that multiple impact contacts are unhealthy because patients with myalgia, a disorder described as pain of muscle origin, which is often considered a subset of TMD,[29] had 2-fold greater median impact contacts than asymptomatic controls. This is consistent with the observation that a single occlusal factor is not of great importance for the development of TMD,[22,23] and concurs with the finding that individuals with dental problems (e.g., tooth loss) in fewer quadrants have a lower prevalence of TMD.[24] It also supports the assertion that artificial interference is more likely to induce TMD symptoms in those with a history of TMD than in those without such a history.[32] Humans may avoid the influence of a small number of impact contacts by, for example, moving the mandible slightly aside; a periodontal-muscular feedback mechanism is likely involved. However, when the number of impact contacts increases, this potential preventive mechanism may fail because the multiple impact contacts are less able to be completely eluded. The mandible can alternatively be elevated with enhanced muscular activity to elevate the mandibular dentition closer to the maxillary dentition, enabling effective chewing of foods. However, this effort is ineffective because the multi-impact contacts prevent other sites of occlusal surfaces from becoming closer, shown as a smaller number of loose contacts. In this theoretical framework, the lower number of loose contacts in our patient group may not be due to a low level of clenching caused by pain. Instead, it may be attributed to a larger number of impact contacts.

Indeed, maxillary and mandibular teeth typically do not contact in a precisely fitted pattern as a mortar and pestle might. This feature facilitates dynamic changing of locations and sizes of contacts and spaces during chewing; it is beneficial to repeatedly fill the occlusal concave with food, and then to crush and grind it through direct contact between convex and concave structures during dynamic chewing movements. By using the method in this study, we were unable to determine how loose the occlusal spaces should be in healthy individuals, although they should be consistent with the compensation range of the periodontal socket. However, the present reduction of loose contacts implied increasing space between maxillary and mandibular teeth and an increasing requirement of muscular contraction levels when foods are prepared for chewing. Hyperactivity of the jaw muscles is then induced through periodontal-elevators biofeedback via connections between trigeminal mesencephalic nucleus neurons and trigeminal motor nucleus.[33] This may explain the myalgia of muscular failure.[34]

Dynamic occlusal interferences, such as those produced during retrusive, protrusive or lateral excursive movements, have been extensively reported in the literature; however, agreement regarding their dysfunctional roles has not been achieved.[27,35,36] Regarding disagreements in the data, recordings of occlusal interferences are affected by the distance and direction of the movement from the centric position and, more importantly, by the patient's understanding of the moving tasks, as well as by the trauma avoidance reflex elicited from periodontal mechanoreceptors. Because of this, eccentric contacts were not taken into consideration in the current work. However, the present data indicating that patients had more impact contacts than asymptomatic controls support that fluent occlusal guidance should be maintained for health,[31] because multi-impact contacts are less likely to provide fluent coincident guidance than a single contact. Based on these relationships, to achieve healthy function, teeth that are not engaged in fluent eccentric guidance should disocclude.[37,38] In addition to the increased impact contact number, the locations of the impact contacts were impressive, because the patients had more impact contacts on the guiding cusps than on the supporting cusps. Normally, centric occlusion contacts are distributed around supporting cusps.[11] In molars, the supporting cusp is larger in area and more obtuse in shape, compared with the guiding cusp. Therefore, it is beneficial to transfer occlusal loading along the long axis of the tooth to the root region. Heavy contacts on guiding cusps, which are typically smaller in area but more precipitous in shape, could change this loading pattern and are thus likely to affect jaw-muscle function via periodontal feedback mechanisms.

When evaluating the current results, it should be noted that anterior contacts were not included in this study. Further, patients with TMD are heterogeneous and the etiology of TMD is considered multifactorial. The cause-effect relationship between occlusal contact and orofacial myalgia remains an open question. The limited number of cases, recruitment of females only, and lack of therapeutic trial, must be improved in further observations. Comparisons of contacts before and after occlusal modification or similar approaches could provide further conclusions. Given that the impact contacts that need to be eliminated are from more than one site, the original medium contacts, shown in red in these findings, could become impacts when the original impact contacts are ground off. This possibility makes occlusal adjustment therapy even more challenging. The tooth wear in this young adult group was not assessed, as we focused on the contact pattern, regardless of factors that caused the contact in that pattern. Study cast could reflect the stable occlusion of dentition. However, the occlusion is flexible, changing and adjusting constantly according to forces such as biting pattern, flexible bone of the jaws and joints, muscles with different forces and activities on the two sides, and the cartilage of the temporomandibular joints; these all contribute to great variation in the dentition that cannot be expressed by casts of the dentition. The occlusal contact pattern of eccentric movement also must be further studied.

Conclusion

By using a newly developed method, we revealed that the impact contacts in some myalgia patients (female subjects with class I occlusion) were more frequent, larger in number and area size, and distributed more on the guiding cusps, compared with impact contacts in asymptomatic controls.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

The study was supported by the Nature Science Foundation of China [No.81530033] and the Fundamental Research Funds for the Central Universities [No. xjj2018286].

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