Ipsilateral Molar Clenching Induces Less Pain and Discomfort than Contralateral Molar Clenching in Patients with Unilateral Anterior Disc Displacement of the Temporomandibular Joint

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Aims: To assess the influence of clenching side and location (ie, tooth) on the bite force necessary to induce pain or discomfort in patients with unilateral anterior disc displacement (ADD) of the temporomandibular joint (TMJ). **Methods:** A total of 17 patients with unilateral ADD diagnosed clinically and with magnetic resonance imaging were included. A bite force meter was positioned at each of four experimental positions: the mandibular first premolars and first molars, bilaterally. Subjects were instructed to clench on the bite force meter until they felt pain or discomfort in the orofacial area and to report the location of the pain. Differences in pain location (ADD side versus contralateral side) and in the bite force thresholds for eliciting pain or discomfort were assessed by means of the paired *t* test and Wilcoxon signed-rank test. **Results:** Only 18% of subjects (3 out of 17) reported pain in the TMJ with ADD during clenching at the ipsilateral molar, whereas 65% (11 out of 17) reported joint pain during clenching on the contralateral molar ($P = .005$). At the molars, the mean ± standard deviation bite force necessary to induce pain was 241.2 ± 135.5 N on the side with ADD and 160.9 ± 78.0 N on the contralateral side. The mean molar bite force necessary to induce pain on the side with ADD was significantly higher than that on the contralateral side ($P = .002$). **Conclusion:** Patients with unilateral ADD had fewer reports of TMJ pain and discomfort when they were molar clenching on the ipsilateral side compared to molar clenching on the contralateral side. *J Oral Facial Pain Headache 2016;30:241–248. doi: 10.11607/ofph.1405*

Keywords: *anterior disc displacement, bite force, preferred chewing side, temporomandibular disorders, temporomandibular joint*

Temporomandibular disorders (TMD) are conditions that are associated with pain and dysfunction resulting from functional and structural abnormalities of the masticatory system, especially of the temporomandibular joint (TMJ) and the masticatory muscles.[1] Anterior disc displacement (ADD) of the TMJ is one of the most common TMD.[2] For acceptable masticatory function, the TMJ structures must bear high mechanical loads[3] and this functional loading is normally supported by the articular disc.[4] Displacement of discs in the TMJ is common; approximately 30% of asymptomatic populations have disc displacement.[5,6] Patients with ADD can feel discomfort or pain in the retrodiscal tissues due to mechanical loading during activities such as mastication.[1]

Stegenga et al[7] reported that patients with ADD could maintain a 50-N bite force for a significantly shorter duration of time than healthy subjects and Kogawa et al[8] reported that the maximum bite force of TMD patients was significantly lower than that of healthy subjects. Although bite force measurement has been widely used for functional evaluation of TMD patients, the reason for the low bite force in these patients has not been fully explained. The existence of a preferred chewing side during mastication has been suggested.[9] Ratnasari et al[10] reported that individuals with asymptomatic unilateral ADD showed a significant preference for the ipsilateral side of their jaw during mastication of hard food, suggesting an avoidance of TMJ overloading. In a simulation study, Rues et al[11] found that during unilateral molar bites, the ipsilateral TMJ and contralateral muscles were about 20% less loaded than the opposing TMJ and muscles. Fushima et al[12] also reported higher loading of the contralateral TMJ during unilateral mastication in their study, which analyzed the effect of mastication on the TMJ space in asymptomatic subjects. Using numeric modeling of human muscle and TMJ forces during unilateral static biting, Iwasaki et al[13] found that vertically and buccally directed occlusal forces were associated with higher mean TMJ forces on the contralateral side. In a later 3D mathematic simulation study, Iwasaki et al[14] reported that subjects with TMJ disc displacement had higher joint loads. In a TMJ energy density study, Gallo et al[15] reported the role of mechanical work in cartilage fatigue in subjects with pain and disc displacement. Understanding the occlusal forces in patients with disc displacement and pain during jaw function is important for future studies in this field.

Data on the location in the dental arch where biting elicits the least pain in patients with unilateral ADD would allow better patient education concerning comfortable chewing. Therefore, the present study aimed to assess the influence of clenching side and location (ie, tooth) on the bite force necessary to induce pain or discomfort in patients with unilateral ADD of the TMJ. The null hypothesis was that the side and location (ie, tooth) of experimental clenching does not influence the bite force necessary to induce pain or discomfort in patients with unilateral ADD.

Materials and Methods

Subjects

Of the 132 patients who sought treatment at the TMD clinic in the Occlusion and Removable Prosthodontic Department of Okayama University Hospital from October 2011 through November 2012, a total of 17 fulfilled all of the inclusion criteria and were therefore included. The inclusion criteria were: *(1)* unilateral ADD diagnosed according to the Research Diagnostic Criteria for TMD (RDC/TMD)[16] and confirmed with magnetic resonance imaging (MRI); *(2)* pain in the area just anterior to the tragus of the ear on the side ipsilateral to the ADD during jaw closing or opening (with or without limited jaw opening resulting from that pain); and *(3)* no missing premolars or molars. To determine the location of pain, patients were instructed to carefully point to the pain location with their forefinger. The examiner confirmed whether the patient's finger pointed to the TMJ region or the muscle. The inclusion criteria did not include items related to muscle pain with palpation, joint pain with palpation, joint sounds, or limitation in jaw opening; ie, subjects did not need to have these signs to be included. The exclusion criteria were: *(1)* bilateral ADD confirmed with MRI; *(2)* spontaneous TMJ pain; *(3)* premolar or molar pain; *(4)* premolar or molar dental implant; *(5)* wearing a removable denture prosthesis; *(6)* having taken nonsteroidal anti-inflammatory drugs on the experimental day; *(7)* a history of mandibular bone fracture; and *(8)* not agreeing to participate in this study.

A total of 17 patients (2 males and 15 females; mean ± standard deviation [SD] age: 37.1 ± 14.6 years) with unilateral ADD who complained chiefly of chewing pain were included. Informed consent was obtained from all subjects before inclusion. A single examiner (S.M.) performed all clinical examinations for the final diagnosis throughout the study. The study followed the Helsinki Declaration and was approved by the ethical committee of Okayama University (no. 475).

Clinical Examination

All patients underwent the routine process for new patients of the TMD clinic. At their first visit, a staff member performed preliminary extraoral and intraoral examinations and patients provided their history concerning TMD. Examination items included mouth-opening pattern, vertical range of motion of the mandible (in mm), TMJ sounds (clicking or crepitus) on palpation, and muscle and TMJ palpation for assessing tenderness: the temporalis (posterior, middle, anterior), masseter (origin, body, insertion), medial pterygoid, and digastric (posterior, anterior) muscles were palpated for 2 seconds each. TMJ pain with palpation was assessed for the lateral pole and posterior attachment. After receiving an explanation of the natural course of TMD from the resident staff, all patients made an appointment for MRI of the TMJ at their next examination. A final diagnosis was made at the third examination when one examiner (S.M.) first examined the MRI images. All images to be examined at the third examination were listed by an assistant; the examiner evaluated the images without knowing the results of the preliminary examination. Next, the examiner performed the above-described extraoral and intraoral examinations. The fingertips of the index and third fingers were used to palpate the muscles and TMJ capsules for tenderness as follows: 2 lb of pressure was applied to the extraoral muscles (1 lb in the posterior mandibular region and 1 lb in the submandibular region) and 1 lb of pressure was applied on the joints, according to the RDC/TMD.[16]

Bite Force Measurement

A 10-mm-thick cotton roll was positioned at one of four experimental positions (mandibular first premolars and first molars, bilaterally) on the mandibular dental arch. Subjects were instructed to gradually clench the cotton roll until they felt pain or discomfort at any site in the orofacial area and to report the location of the pain. Subjects were instructed to increase the bite force gradually over 3 seconds to reach their presumed maximal bite force. Subjects were also instructed to maximally clench if no pain was evoked with clenching. The four locations on the lower dental arch were consecutively examined in a randomized sequence based on the final digit of the patient's clinic identification number (ie, starting from premolar when the last digit was between 0 and 4 or else starting from the molar, and starting from the right when the digit was odd or else starting from the left). After this preliminary training session, a bite force meter (Occlusal Force-meter GM-10, Nagano Keiki Co, Ltd) was placed on one of the four experimental positions on the mandibular dental arch (Fig 1). The sensor head of the bite force meter was covered with a disposable plastic cover. The cover had a circular biting area 10 mm in diameter with a bumpy surface on the occlusal side to avoid slippage. The thickness of the meter with the cover was 8.5 mm. The subjects were instructed to clench on the bite force meter by gradually increasing the clenching force until they felt pain or discomfort at any location in the orofacial area and to report the location of the pain. The subjects were again instructed to maximally clench if no pain was evoked with clenching. The four locations on the lower dental arch were consecutively examined in a sequence randomized for each subject as described above for the biting on cotton rolls. This bite force measurement procedure was repeated twice for each location in each subject. The interval between all clenches was 1 minute. The results for each location were averaged and this mean bite force was defined as the pain (or discomfort)-eliciting bite force (PEBF). A single examiner (Y.K.) measured the bite force in all subjects. During the bite force measurement, the examiner was unaware of which TMJ had ADD.

Fig 1 Bite force meter with disposable cover.

MRI Examination

A 3-Tesla MRI scanner (Magnetom Vision, Siemens Healthcare) was used at the Okayama University Hospital. The TMJs of each subject were examined with MRI with the mouth in the closed and open positions. Fat-suppressed, oblique sagittal proton density-weighted images and T2-weighted images were taken by using a TMJ surface coil and the double-contrast, turbo-spin echo technique. The plane of imaging was set to be perpendicular to the long axis of the condyle. MRI images were examined by two examiners (S.M. and K.O.) who were blind to the clinical information; one (S.M.) examined the MRI images as described above without knowledge of the preliminary clinical examination results and the second (K.O.) examined the images just before processing the data. The results of the two MRI examinations were compared. The diagnoses made by the two examiners for all patients were consistent.

Articular Disc Position

The disc position was evaluated on the closed-mouth MRI images by using the criteria of Robinson de Senna et al.[17] The disc position was considered normal if the thick portion of the posterior band of the disc was over the topmost portion of the condyle between the 11- and 12-o'clock positions. Discs at the 11 o'clock position were considered displaced.

Data Analysis

Differences in the location of pain during clenching on teeth ipsilateral and contralateral to the ADD joint were evaluated with the chi-square test. The Shapiro-Wilk test was used to assess whether the data were normally distributed. Because the mean PEBF at the first premolars on the contralateral side did not have a normal distribution, the Wilcoxon signed-rank test was used to evaluate the difference in mean PEBF during biting at the first premolar on the ipsilateral side compared with the contralateral side. Differences in the mean PEBF at the first molars between the ipsilateral side and contralateral side were evaluated with a paired *t* test after assessment of the distribution normality. *P* values < .05 were considered significant for all statistical analyses.

Results

Table 1 shows the characteristics and pain area for all subjects.

Pain Location

Table 2 and Fig 2 show the location of pain according to the location of clenching. A significant difference in the location of pain was found between ipsilateral and contralateral molar clenching (P = .02). Only 18% of the subjects (3 out of 17) reported pain in the ADD joint during ipsilateral molar clenching, whereas

Table 1 Characteristics of the TMD Subjects

Subject no.	Age (y)	Sex	ADD side	Disc reduction	Muscle pain with palpation	Joint pain with palpation: Lateral pole	Joint pain with palpation: Posterior attachment	Joint sounds	Vertical range of motion (incisal overlap added) (mm): Maximum unassisted opening w/o pain	Vertical range of motion (incisal overlap added) (mm): Maximum unassisted opening with pain
1	33	F	L	w/o	–	–	–	R1	35	40
2	17	F	L	w/o	L-MM	R1	–	–	38	40
3	72	F	R	w/o	R-SR	–	–	R1	41	48
4	37	F	R	w	R-SR	–	–	R1	36	38
5	26	M	R	w/o	B-MM	R1	–	–	39	51
6	21	M	R	w	–	–	–	L2	27	28
7	37	F	R	w	R-SR	R1	R1	R1	26	28
8	61	F	L	w	–	–	–	L2	34	38
9	47	F	L	w/o	R-SR	–	–	R2	31	41
10	35	F	L	w	–	–	–	–	44	47
11	37	F	R	w	R-SR	R1	L1	–	25	27
12	42	F	L	w/o	–	–	L1	–	19	29
13	27	F	L	w	–	–	L1	L1	35	37
14	38	F	L	w/o	L-Temp	–	L1	L3	32	42
15	35	F	L	w/o	–	–	L1	–	31	36
16	16	F	R	w	L-SR	–	–	R2	23	29
17	49	F	R	w/o	R-MM	R1	–	–	26	28
Mean (SD)	37.1 (14.6)								31.9 (6.8)	36.9 (7.7)

Joint pain with palpation: 1 = mild, 2 = moderate, 3 = severe.
Joint sounds: 0 = none, 1 = coarse click, 2 = fine crepitus, 3 = crepitus.
ADD = anterior disc displacement; SD = standard deviation; F = female; M = male; L = left; R = right; B = bilateral; w = with reduction; w/o = without reduction; MM = masseter muscle; SR = submandibular region; Temp = temporalis muscle.

Table 2 Pain (or Discomfort)-Eliciting Bite Force (PEBF) for Each Subject

Subject no.	Ipsilateral to ADD: Premolar PEBF (N)	Ipsilateral Premolar Pain area	Ipsilateral Molar PEBF (N)	Ipsilateral Molar Pain area	Contralateral to ADD: Premolar PEBF (N)	Contralateral Premolar Pain area	Contralateral Molar PEBF (N)	Contralateral Molar Pain area
1	266	None	643	None	411	L-TMJ	343	L-TMJ
2	110	L-TMJ	425	L-TMJ	47	L-TMJ	142	L-TMJ
3	219	None	340	None	262	None	236	R-TMJ
4	129	R-TMJ	305	R-MM	115	R-TMJ	167	R-TMJ
5	219	None	279	None	194	None	216	None
6	219	None	278	None	221	R-TMJ	295	R-TMJ
7	108	None	244	R-MM	137	None	137	None
8	172	None	219	None	119	L-TMJ	154	L-TMJ
9	180	None	189	None	157	R-MM	119	R-MM
10	146	None	186	None	146	None	196	None
11	68	R-TMJ	180	R-TMJ	108	R-TMJ	131	R-TMJ
12	120	L-TMJ	168	None	130	L-TMJ	114	L-TMJ
13	102	L-MM	159	L-MM	114	L-MM	154	L-MM
14	175	L-MM	156	None	154	L-MM	124	L-TMJ
15	76	None	122	None	47	L-TMJ	67	L-TMJ
16	63	None	117	None	82	None	113	None
17	57	R-TMJ	90	R-TMJ	43	R-TMJ	27	R-TMJ
Mean (SD)	142.9 (63.4)		241.2 (135.5)		146.3 (90.3)		160.9 (78.0)	

ADD = anterior disc displacement; SD = standard deviation; L = left; R = right; TMJ = temporomandibular joint; MM = masseter muscle.

65% (11 out of 17) reported joint pain during contralateral molar clenching (P = .005). During contralateral premolar clenching, the most frequent pain location was the joint with ADD, followed by no pain anywhere, pain in the contralateral masseter muscle, and pain in the ipsilateral masseter muscle. During ipsilateral premolar clenching, patients most frequently reported no pain anywhere, followed by pain in the ADD joint and pain in the ipsilateral masseter muscle. No significant differences in pain location were observed between ipsilateral and contralateral premolar clenching (P = .16).

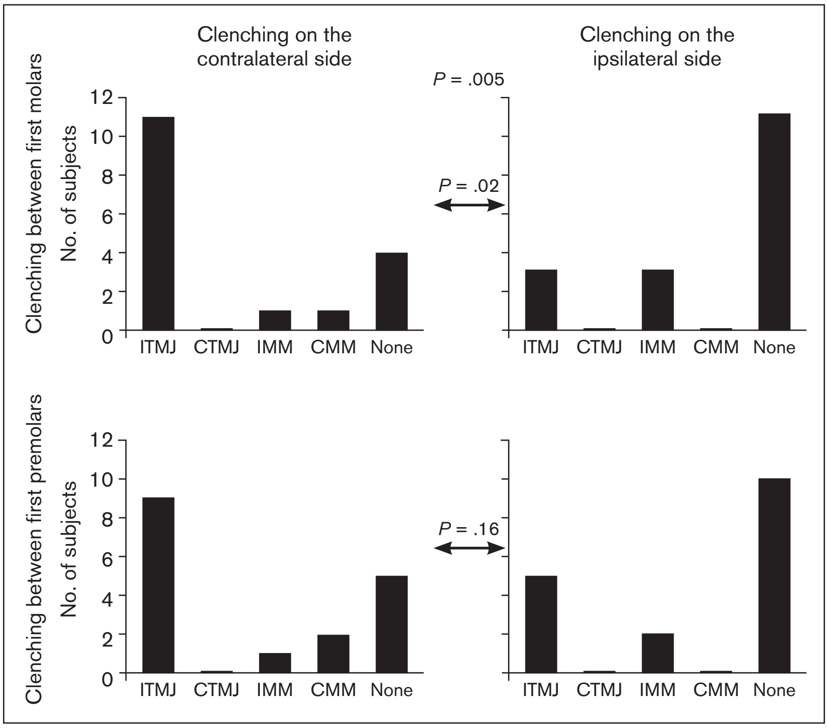

Fig 2 Number of subjects reporting pain elicited by clenching in the molar and premolar areas. Significantly higher occurrence of pain was observed during contralateral clenching than ipsilateral clenching (P = .005). A significant difference in the location of pain was found between ipsilateral and contralateral molar clenching (P = .02). No significant differences in pain location were observed between ipsilateral and contralateral premolar clenching. ITMJ = ipsilateral TMJ; CTMJ = contralateral TMJ; IMM = ipsilateral masticatory muscle; CMM = contralateral masticatory muscle; none = no pain induced.

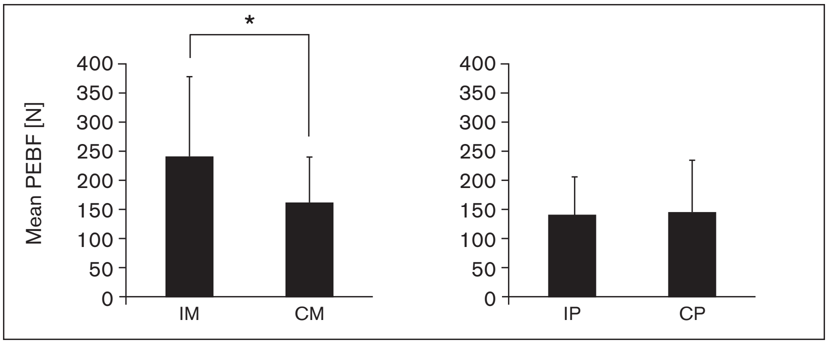

Fig 3 Clenching force (mean and SD) that elicited TMJ pain. Significantly higher mean pain-free bite forces were generated at the ipsilateral molars than at the contralateral molars. PEBF = pain-eliciting bite force; IM = ipsilateral molar; CM = contralateral molar; IP = ipsilateral premolar; CP = contralateral premolar. **P* = .002.

Pain Threshold Bite Force

The mean (± SD) PEBF at the molars on the ADD side (241.2 ± 135.5 N) was significantly larger than that on the contralateral side (160.9 ± 78.0 N) (*P* = .002, paired *t* test, Fig 3). No significant difference was observed between the mean PEBF at the premolars on the ADD side (142.9 ± 63.4 N) and the contralateral side (146.3 ± 90.3 N) (*P* = .816, Wilcoxon signed-rank test).

Discussion

The PEBF in unilateral ADD patients during clenching on the ipsilateral or contralateral molar and premolar areas was evaluated. When clenching of the molars was performed, a significantly larger bite force was necessary to elicit pain in the joint with ADD clenching on the ipsilateral side rather than on the contralateral side. No significant difference between the sides was observed with premolar clenching. Many studies corroborate the idea that pain is the major limiting factor in the magnitude of bite force.[4,18–20] The prevalence of TMJ pain in the joint with ADD was significantly higher during contralateral molar clenching than during ipsilateral molar clenching. In a static mathematic simulation model of unilateral molar clenching, Korioth and Hannam[21] reported that forces on the joint are greater on the contralateral side. Accordingly, the lower mean PEBF observed during contralateral clenching in the present study might be related to pain or discomfort in the ADD joint, caused by the loading force generated during the contralateral molar clench.

Bite force in TMD patients is reported to be significantly lower than that in healthy subjects,[8] and Kogawa et al[8] and van der Bilt et al[22] reported that there is no difference between left- and right-side bite forces in healthy subjects. The present study revealed a significant difference between PEBF on the ipsilateral side and the contralateral side in patients with unilateral ADD. Therefore, it is reasonable to infer that the joint condition acted as an occlusal force–regulating factor. In their evaluation of premolar- versus molar-supported biting, Wang et al[23] reported that EMG activity in the masseter and anterior temporalis muscles was significantly lower in premolar-supported biting than in molar-supported biting during centric and eccentric maximal voluntary biting. Hattori et al[24] reported that bite force magnitudes at the first premolar, second premolar, and first molar were 11%, 21%, and 81% of the magnitude at the second molar, respectively. Therefore, because bite force during premolar-supported biting and molar-supported biting are inherently different, the present study did not directly compare bite force values between the premolar area and the molar area.

The preferred chewing side is a well-known concept in mastication. Ratnasari et al[10] reported a significant preference in patients with ADD for chewing on the side with ADD during mastication of hard food, and suggested that patients were able to masticate with larger bite forces on the side ipsilateral to their ADD. In the present study, the PEBF in the TMJ with ADD was significantly larger on the ipsilateral side compared with the contralateral side when molar clenching was performed. During biting at the molars, patients reported TMJ pain less often when biting on the ipsilateral side than on the contralateral side. Therefore, in patients with unilateral ADD, mastication on the ipsilateral molar may result in larger bite forces and less pain.

ADD of the TMJ is observed not only in symptomatic TMD patients, but also in asymptomatic individuals. MRI can accurately display joint abnormalities and is regarded as the best method for diagnostic assessment of the TMJ.[25] In the present study, MRI was used to precisely diagnose ADD, and clear relationships were observed between the side of ADD and PEBF. In future studies, enrolling asymptomatic subjects with unilateral ADD diagnosed with MRI might help to clarify the relationship between maximal bite force and ADD.

It was reported in a previous study that mechanical loading on the TMJ is greater on the contralateral side than on the working side during unilateral clenching.[26] The results of this study are consistent with a study using static mathematic simulation models that predicted TMJ loading.[21] The simulation model showed that joint forces are greater on the contralateral side during unilateral molar clenching. Ratnasari et al[10] suggested that patients with unilateral painful ADD often report marked alleviation of their TMJ pain after being given behavioral instruction to masticate on the ADD side when they need to chew hard food stuffs. The results of this study support their clinical findings and suggest that sensations in the joint with ADD might affect the maximal bite force in ADD patients. Thus, masticating hard food on the ipsilateral side might help to prevent unnecessary mechanical irritation to the TMJ with ADD.

Study Limitations

The present study has clinical implications, providing scientific data that could help patients with ADD improve physiologic adaptation. However, the study had several limitations. First, the direction of the exerted occlusal force in the present study was too simple to simulate mastication, which inevitably includes various directions of occlusal force.[11] Second, the sample size was small. Future studies are needed with a larger sample size and more precise classification of ADD conditions; eg, the characteristics of the pain and the direction of masticatory muscle structures.

Another limitation of the present study was that ADD subjects both with and without reduction were included. Naeije et al[27] reported in their systematic review on TMJ disc displacement that many of the studied masticatory systems with chronic disc displacement appeared to be clinically normal, with the pain-free range of mandibular motion falling within normal values. Individuals with these chronic and stable TMJs do not seek treatment and hence were not included in the present study. As shown in the inclusion criteria, all subjects in the present study had pain in the area just anterior to the tragus of the ear on the side with ADD. Thus it is reasonable to consider that their TMJ conditions were not chronic and stable. The same argument could be applied to ADD patients with reduction. The patients experienced pain, and it would be reasonable to think that their TMJ conditions were different from chronic and stable ADD with reduction. From this perspective, it is possible that the ADD patients in the present study had the associated conditions of both ADD and joint pain; however, local anesthetic block was not used in this study to definitively diagnose arthrogenous pain. Thus, it was not possible to be assured with absolute certainty that the pain felt and localized by the patient in front of the ear was a joint pain. However, the study by Iwasaki et al,[14] who used 3D numeric models of isometric biting to study TMJ mechanical loads, are consistent with the results of the present study supporting the view that the pain was actually joint pain. That study classified subjects into two groups: the disc displacement and normal disc position groups.

Their disc displacement group included subjects in RDC/TMD categories IIa, IIb, and IIc. They successfully clarified the characteristic significant difference in the mechanical load on the TMJ between the groups. Thus, their classification of subjects and their results are consistent with those of the present study. Future studies are needed to evaluate the PEBF in individuals without ADD joint pain.

In the experimental protocol, subjects were asked to clench until they felt pain or discomfort. Pain is different from discomfort and so these two words imply different conditions, which is a limitation of this study. The term "discomfort" was included for ethical reasons to minimize unnecessary invasion or tissue injury. Additionally, because the preliminary training session using cotton rolls was performed before bite force measurement, subjects could decide to what extent they would bite during the measurement session. It is reasonable to consider that the degree of discomfort or pain necessary to stop experimental clenching would be intra-individually consistent regardless of the biting location. The cotton roll–training had another advantage in that subjects could experience the pain caused by biting without the possible additional fear caused by biting the unfamiliar equipment of the bite force meter for the first time. However, it is possible that biting on the hard surface of the unfamiliar bite meter caused further reduction in bite force.

Patient 16 showed extremely low bite force and reported no pain. Although unusual, the data were included to avoid sampling bias. Her data demonstrated another limitation of this experimental protocol, which is the difficulty of asking a patient with pain to perform painful movements for research purposes.

Identification of the location of pain was another limitation of this study. The duration of palpation was 2 seconds in this study. Because prolonged palpation of 5 seconds, which helps distinguish pain radiation, was not performed in this study, data on referred pain or radiation or referral of pain could not be evaluated. Future studies are needed to evaluate radiation of pain in patients with ADD.

Conclusions

Patients with unilateral ADD had fewer reports of TMJ pain and discomfort when they were molar clenching on the ipsilateral side compared to molar clenching on the contralateral side.

Acknowledgments

The authors declare no conflicts of interest associated with this article.

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