The Relationship Between Jaw Injury, Third Molar Removal, and Orthodontic Treatment and TMD Symptoms in University Students in Japan

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Aims: *To determine the association between temporomandibular disorders (TMD) and experiences of jaw injury, third molar removal, and orthodontic treatment, controlling for confounding factors such as age, sex, emotional stress, and oral parafunction.* ***Methods:*** *First-year university students (n = 2,374) were instructed to answer a questionnaire regarding symptoms of TMD, jaw injury, third molar removal, orthodontic treatment, stress, and parafunctional habits. All subjects were classified according to the level of TMD symptoms. Logistic regression was applied to assess the associations of experiences of jaw injury, third molar removal, and orthodontic treatment with presence of TMD symptoms after controlling for age, sex, stress, and parafunctional habits.* ***Results:*** *Of the 2,374 students, 715 students were TMD symptom-positive. They were classified into 7 groups consisting of those with only clicking (group 1), only pain in the temporomandibular joint (group 2), only difficulty in mouth opening (group 3), clicking and pain (group 4), clicking and difficulty in mouth opening (group 5), difficulty in mouth opening and pain (group 6), and all 3 symptoms (group 7). TMD symptoms were significantly associated with jaw injury. Odds ratios were 2.25, 2.47, 3.38, and 2.01 for groups 2, 3, 6, and 7, respectively. Experience of third molar removal was significantly associated with TMD (odds ratio = 1.81 for group 1). No association was found between orthodontic experience and TMD.* ***Conclusion:*** *Experiences of jaw injury and third molar removal might be cumulative and precipitating events in TMD.* J OROFAC PAIN 2008;22:50–56

Key words: jaw injury, orthodontic treatment, third molar removal, university students

The etiology of temporomandibular disorders (TMD) is thought to be multifactorial. Oral parafunction, emotional status, and trauma have been shown to be etiologic factors.[1–3] It has also been shown that trauma to the jaw plays an important role in the initiation or precipitation of TMD[4,5] and that patients suffering from TMD have a positive history of head/cervical trauma related to the onset of TMD symptoms.[2,6] However, these studies were conducted in patient groups, not in the general population, and focused on head or cervical injury rather than jaw injury. Another epidemiologic study carried out in a general population showed no association between history of trauma to the jaw and symptoms of TMD.[7] Hence, there is a need for more information about the prevalence of TMD with respect to trauma to the jaw.

Third molar removal has been suggested as a predisposing factor for the development of TMD symptoms.[8–10] The temporomandibular joint (TMJ) may be affected in most cases after extraction of the maxillary and mandibular third molars, since a published case study demonstrated that posterior maxillary abscess can easily occur in conjunction with a pterygomasseteric abscess.[9] Third molar removal may involve prolonged wide opening of the jaw and the application of considerable forces to the mandible that eventually may result in trauma to the TMJ and associated structures.[10]

It has been suggested that orthodontic therapy is the main cause of TMJ pain.[11] However, Hirata and colleagues[12] support the contention that orthodontic treatment neither increases nor decreases incidence of signs and symptoms of TMD. Thus, it remains uncertain as to what extent, if any, orthodontic treatment influences the TMJ.

The aim of this study was to determine the association between TMD and experiences of jaw injury, third molar removal, and orthodontic treatment, controlling for confounding factors, such as age, sex, emotional stress, and oral parafunction.

Materials and Methods

Subjects

A total of 2,374 first-year students of Hokkaido University participated in this study during general health examinations in April 1994. Since a dental checkup is mandatory for first-year students, no sampling method was used. Before the dental examination, each subject completed a self-administered questionnaire regarding experiences of jaw injury, third molar removal, orthodontic treatment, stress, oral parafunctional habits, and symptoms of TMD. Two experienced dentists obtained verbal consent and supervised the students during completion of the questionnaire to ensure that all questions were correctly understood and fully answered.

Questionnaire

Questions to distinguish TMD-positive cases from TMD-negative cases were "During the past 6 months, *(i)* Have you ever noticed any sounds around your ears? (clicking), *(ii)* Have you ever felt pain around your ears while opening your mouth or chewing food? (pain in TMJ), and *(iii)* Have you ever felt difficulty in opening your mouth? (difficulty in mouth opening)." Each question was answered by selecting a description of awareness (frequently, sometimes, rarely, or never), in accordance with previous studies.[13,14]

Information regarding self-report of facial trauma or jaw injury ("Have you been hit, had a car accident, a sports injury or other accident where you received a hard blow or bang to your jaw during the past 6 months?") was obtained from the questionnaire.[10] Other questions included in the questionnaire were whether the subjects had had third molar teeth extracted or whether they had undergone orthodontic treatment in the past 6 months.

An adapted form of the Life Events Checklist (LEC) for adolescents that included 23 of the 46 original items was used to obtain information on stress. The prevalence of these life events in the past 12 months was assessed. For ease of comparison, the subjects were divided according to the criteria of Sieber and colleagues[15] into 3 groups: *(a)* subjects with a low stress level (< 5 positive stress items), *(b)* subjects with a moderate stress level (5 to 8 items), and *(c)* subjects with a high stress level (9 to 19 items).

Information on oral parafunctions was obtained by asking questions that required dichotomous answers (yes/no) as follows: *(1)* habit of chewing gum, *(2)* habit of biting hard objects (eg, pencils), *(3)* habit of continuously leaning on the palm (leaning the head or chin on the palm of the hand), *(4)* awareness of night-time bruxing, *(5)* habit of cheek biting, *(6)* tendency to chew food on 1 side, *(7)* tendency to sleep on 1 side, and *(8)* awareness of daytime teeth clenching or grinding,[14] where yes means frequently/sometimes and no means rarely/never.

Statistical Analysis

The SPSS statistical package for Windows, version 11.5, was used for analysis of the data. The students were separated into a TMD-positive group (frequently or sometimes aware of TMD symptoms) and TMD-negative group (rarely/never aware of TMD symptoms). The χ^2 test was used for comparison of 2 non-numerical variables, such as the percentage of "yes" answers by respondents with and without jaw injury, third molar removal, stress (high, moderate, and low levels), orthodontic treatment, and parafunctional habits. An α level of 5% was the threshold for a statistically significant difference. Multiple comparisons involving the same subjects increase the probability that 1 comparison will become statistically significant. Therefore, yes (%) answers by respondents having a parafunction were compared between the groups,

Table 1 Frequencies of Symptoms of TMD

TMD symptoms	Frequency	Percent (%)
TMD-negative	1,659	69.9
Clicking (group 1)	408	17.2
Pain in TMJ (group 2)	60	2.5
Difficulty in mouth opening (group 3)	30	1.3
Clicking and pain in TMJ (group 4)	71	3.0
Clicking and difficulty in mouth opening (group 5)	38	1.6
Pain and difficulty in mouth opening (group 6)	17	0.7
Clicking, pain in TMJ, and difficulty in mouth opening (group 7)	91	3.8
Total	2,374	100.0

Table 2 Percent Distribution of Age and Gender According to TMD-positive and TMD-negative Groups

Variable	TMD-negative group	TMD-positive groups						
		1	2	3	4	5	6	7
Age								
18 to 19 y	88.3	90.0	90.0	93.3	86.8	90.1	88.2	91.2
> 19 y	11.7	10.0	10.0	6.7	13.2	9.9	11.8	8.8
Gender								
Male	73.7	69.4	73.3	66.7	57.9	66.2	70.6	58.2
Female	26.3	30.6	27.7	33.3	42.1	33.8*	29.4	41.8***

*$P < .05$, ***$P < .001$ (significantly higher percentage than the TMD-negative group; χ^2 test).

and Bonferroni correction was used to adjust probability.[10,14] Based on the results of bivariate analysis, variables associated with TMD symptoms were selected as possible factors related to TMD. Furthermore, the strength of association between TMD symptoms and these factors was expressed using logistic regression models as an odds ratio (OR) and a 95% confidence interval (CI).

Results

The mean age of the subjects was 18.7 ± 1.1 years. Table 1 shows the frequencies of the TMD symptoms. The following TMD symptom-positive groups were identified: subjects with clicking (group 1, n = 408), subjects with TMJ pain (group 2, n = 60), subjects with difficulty in mouth opening (group 3, n = 30), subjects with clicking and TMJ pain (group 4, n = 71), subjects with clicking and difficulty in mouth opening (group 5, n = 38), subjects with TMJ pain and difficulty in mouth opening (group 6, n = 17), and subjects with clicking, TMJ pain, and difficulty in mouth opening (group 7, n = 91).

The prevalences of TMD symptoms according to age and gender are shown in Table 2. The percentages of female subjects were significantly higher in groups 5 and 7 ($P < .05$ and $P < .001$, respectively) than in the TMD-negative group. No significant difference in age distribution was found between any of the TMD-positive groups and the TMD-negative group. Most of the oral parafunctions, except gum chewing, were significantly associated with a TMD symptom (Table 3).

Table 4 shows the relationships of TMD symptoms to jaw injury, third molar removal, stress, and orthodontic treatment. Univariate analysis showed significant associations of the experience of jaw injury with some TMD symptoms (groups 2, 3, 4, 6, and 7). The percentage of subjects with clicking who had undergone third molar extraction was higher than that of TMD-negative subjects. The percentage of subjects with a high level of stress was higher in group 7 than in the TMD-negative group. No significant relation was found between orthodontic treatment and TMD symptoms.

Table 5 summarizes the significant relationships of experience of jaw injury and third molar removal with TMD symptoms revealed by logistic regression analysis after adjustment for age, gender, stress, and oral parafunctions. Subjects with a history of jaw injury had a higher risk of TMJ pain (group 2, OR = 2.25, $P < .05$), difficulty in mouth opening (group

Table 3 Prevalence (%) of Oral Parafunctional Habits in the TMD-negative and TMD-positive Groups

Variable	TMD-negative group	TMD-positive groups 1	2	3	4	5	6	7
Bruxism								
Nonbruxer	90.9	85.0	85.0	76.7	86.8	74.6	82.4	75.8
Bruxer	9.1	15.0**	15.0	23.3	13.1**	25.4	17.6	24.1**
Grinding								
No	92.9	90.0	91.7	86.7	81.6	80.3	100.0	85.7
Yes	7.1	10.0	8.3	13.3	18.4**	19.7	0	14.2
Cheek biting								
No	60.6	50.2	45.0	43.3	47.4	39.4	47.1	50.5
Yes	39.4	49.8**	55.0	56.7	52.6**	60.6	52.9	49.5
Chewing gum								
No	26.2	21.8	26.7	36.7	21.1	25.4	52.9	28.6
Yes	73.8	78.2	73.3	63.3	78.9	74.6	47.1	71.4
Leaning on the palm								
No	35.9	26.2	20.0	23.3	34.2	23.9	41.1	38.5
Yes	64.1	73.8**	80.0	76.7	65.8	76.1	58.8	61.5
Tendency to sleeping on 1 side								
No	18.0	12.3	16.7	10.0	13.1	11.3	5.9	12.1
Yes	82.0	87.7*	83.3	90.0	86.8	88.7	94.1	87.9
Chewing food on 1 side only								
No	58.2	50.2	45.0	46.7	36.8	50.7	64.7	42.9
Yes	41.8	49.8*	55.0	53.3	63.2	49.3	35.3	57.1*
Biting hard objects								
No	38.9	36.0	45.0	20.0	36.8	21.1	47.1	35.2
Yes	61.1	64.0	55.0	80.0	63.2*	78.9	52.9	64.8

No = never/rarely; yes = frequently/sometimes.
*$P < .00625$, **$P < .00125$ (significantly higher percentage than the TMD-negative group; χ^2 test).

Table 4 Prevalence (%) of the Experience of Jaw Injury, Third Molar Removal, Stress, and Orthodontic Treatment in the TMD-negative and TMD-positive Groups

Variable	TMD-negative group	TMD-positive groups 1	2	3	4	5	6	7
Jaw injury								
No	89.0	85.8	78.3	76.7	84.2	76.1	70.6	79.1
Yes	11.0	14.2	21.7**	23.3*	15.8***	23.9	29.4*	20.9**
Third molar removal								
No	92.5	87.5	96.7	93.3	94.7	93.0	94.1	89.0
Yes	7.5	12.5***	3.3	6.7	5.3	7.0	5.9	11.0
Stress								
Low	59.1	57.8	55.0	46.7	60.5	46.5	76.5	47.3
Moderate	26.0	25.7	25.0	30.0	23.7	33.8	11.8	26.4
High	14.9	16.5	20.0	23.3	15.8	19.7	11.7	26.3**
Orthodontic treatment								
Yes	82.8	78.7	85.0	80.0	81.6	83.1	94.1	84.6
No	17.2	21.3	15.0	20.0	18.4	16.9	5.9	15.4

*$P < .05$, $P < .0$ ***$P < .001$ (significantly higher percentage than the TMD-negative group; χ^2 test).

3, OR = 2.47, $P < .05$), TMJ pain and difficulty in mouth opening combined (group 6, OR = 3.38, $P < .05$), and all TMD symptoms (group 7, OR = 2.01, $P < .05$). Subjects who had undergone extraction of third molars also had a higher risk of clicking (group 1, OR = 1.81, $P < .001$). No significant relation was found between stress or orthodontic treatment and TMD symptoms.

Discussion

To the authors' knowledge, this is the first study in Japan to investigate possible associations between third molar removal, jaw injury, and orthodontic treatment and increased risk of TMD after adjustment for potentially confounding variables. This study showed that external trauma to the jaw

Table 5 Results of Multiple Logistic Regression Analysis After Adjustment for Age, Gender, and Oral Parafunction (OR and 95% CI)

TMD symptoms	Significant factors			
	Jaw injury		Third molar removal	
	OR	95% CI	OR	95% CI
Clicking			1.81***	1.27–2.57
Pain in TMJ	2.25*	1.19–4.23		
Difficulty in mouth opening	2.47*	1.05–5.84		
Pain in TMJ and difficulty in mouth opening	3.38*	1.18–9.71		
Clicking, pain in TMJ, and difficulty in mouth opening	2.01*	1.15–3.50		

*$P < .05$; ***$P < .001$.
No significant relation was found between stress or orthodontic treatment and TMD symptoms.

region is an important predisposing factor in the etiology of TMD. An association between extrinsic trauma and TMD symptoms was also shown in a study in which subjects with a history of extrinsic trauma showed an increased risk (2.85:1; $P < .01$) of limited mouth opening.[16] Huang and colleagues[10] identified trauma as a risk factor for diagnostic subgroups of painful TMD.

The results of the present study showed significant correlations of TMD with pain in the TMJ (group 2), difficulty in mouth opening (group 3), pain and difficulty in mouth opening (group 6), a combination of these 3 symptoms (group 7), and experience of jaw injury (groups 2, 3, 4, 6, and 7; Table 5). These findings suggest that pain in the TMJ and difficulty in mouth opening, rather than clicking, are related to jaw injury. This conclusion is in agreement with the results of other studies.[5,10,16] De Boever and Keersmaekers[5] reported that mouth opening was significantly reduced in jaw-trauma patients compared with a nontrauma group. On the other hand, Locker and Slade[7] did not find any association between TMD symptoms and jaw injury. This may be due to their study design, which did not allow estimation of the strength of the risk factor–symptom relationship with measures such as ORs and attributable risk.[7] The conflicting results suggest that the exact role of jaw injury in the etiology of TMD is not yet fully understood.

In the present study, a strong correlation between clicking sounds and jaw trauma was not found. One possible reason for this is that clicking might have been ignored and unreported because of its painless nature, whereas TMJ pain and difficulty in mouth opening can easily be recognized when they occur.[17]

No attempt was made to investigate the link between third molar removal and symptoms of TMD. However, third molar removal seemed to be a predisposing factor in this study population. Logistic-regression analysis showed that subjects who had undergone third molar extraction were more predisposed to feel clicking ($P < .01$) than subjects who had not undergone third molar extraction. This may be because third molar removal involves prolonged wide opening of the mouth, application of considerable forces to the mandible, and, if performed under general anesthesia, a reduction in the patient's protective mechanisms. Any of these could result in trauma to the TMJ or the muscles of mastication, giving rise to symptoms of TMD.[10] Several studies on TMD have shown an association between TMD symptoms and third molar removal.[1,8,10,18] Moses and colleagues[9] reported on a patient who developed TMD symptoms, including TMJ clicking and painful limitation of mandibular mouth opening, 2 weeks after third molar extraction. They reported that the TMD symptoms were caused by deposition of a moderate amount of fluid adjacent to the TMJ. Threlfall and colleagues[19] reported that extraction of a third molar substantially increases the risk of developing TMJ disc displacement with reduction. Since clicking indicating TMJ disc displacement is the most common symptom in TMD patients,[20] their study helps to clarify our understanding of third molar removal as a predisposing factor for clicking. Further studies are needed to clarify the mechanisms accounting for the association between symptoms of TMD and third molar removal. A prospective design would allow for a more definitive assessment of this predisposing factor.

The prevalence of signs and symptoms of TMD in subjects who had received orthodontic treatment has been investigated in several studies, but a relationship between orthodontic treatment and the

presence of signs and symptoms of TMD has not been shown.[12,21–24] Reynders[23] reported that orthodontic treatment performed during adolescence does not influence TMD development. McNamara and colleagues[24] also reported that the risk of developing TMD could not be correlated to any type of orthodontic mechanics performed during adolescence. However, Williamson[25] screened 304 orthodontically treated patients aged 6 to 16 years and found that 107 (35.2%) of the patients had pain, clicking, or both, unilaterally or bilaterally. They also reported that 35% of the orthodontic patients had incipient TMJ dysfunction prior to initiation of treatment.[25]

Psychological factors explain why some patients seem to be more troubled by some symptoms of TMD.[26] Effect of stress on the masticatory system is due to increased parafunctional activity and muscle tension.[27] Stressful life events have also been investigated in previous studies, and it has been shown that subjects with a high level of emotional stress developed TMD symptoms more frequently than did subjects with a low level of stress.[15,28] However, no relationship between stress and TMD symptoms was found in the present study. The reason may be that excessive stress produces masticatory muscle hyperactivity giving rise to muscle pain rather than TMJ symptoms[29]; however, students were not asked about muscle pain in the present study.

Parafunctional habits have also been shown to correlate with TMD. The prevalence of oral parafunctions in this investigation was similar to those previously reported.[14,30,31] Some studies, however, have failed to demonstrate such an association and have shown instead that oral parafunctions such as bruxism, cheek biting, and gum chewing are common and usually do not harm the stomatognathic apparatus.[3,32,33] However, the subjects of those studies were young (< 15 years old), and the results could have been influenced by improper interpretation of the questionnaires given to the parents, which suggests the importance of interviewing the parents in the presence of their child. While the existence of such an association seems to be controversial, oral parafunction is still highlighted as a potential risk factor in TMD etiology.[3] On the other hand, Winocur and colleagues[32] suggested that reported nocturnal bruxism tends to be underscored. If tooth wear had been clinically assessed in the present study, an association between bruxism and TMD might have been found.

The female subjects in this study had a significantly higher risk of developing TMD symptoms than did the male subjects. Results of European and US studies[10,34] and results of Asian studies[35,36] have shown a significant difference between TMD prevalence in male subjects compared with female subjects; thus, the present study is in accordance with previously published results. It is possible that females are more susceptible to deterioration of TMJ structures.[37] Biological, cultural, hormonal, or environmental factors acting alone or in combination may be responsible for the observed association between TMD and female gender.

All data in the present study were collected from written questionnaires; clinical examinations were not conducted. Since clinically determined prevalence (point prevalence) might be less than the prevalence of TMD symptoms reported on the questionnaires (period prevalence), period prevalence was used as the diagnostic criterion for TMD in the present study. The results of several studies support the validity of questionnaires for epidemiologic studies of TMD symptoms.[36,38] One limitation of the present study is that it was not a cohort study. Another limitation is that only questionnaires were used to determine history of jaw injury and third molar removal; medical records were not checked.

In summary, trauma to the jaw and third molar removal were identified as predisposing factors for symptoms of TMD. A more detailed understanding of these factors may be helpful for the development of targeted approaches to TMD therapy and prevention.

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