

# Temporomandibular Disorders Among Smokers and Nonsmokers: A Longitudinal Cohort Study

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***Aims:** To evaluate whether smoking influences the presence and/or development of signs and symptoms of temporomandibular disorders (TMD) among adults. **Methods:** A random sample of subjects 35, 50, and 65 years of age was drawn from the general population and examined with the aid of a questionnaire and a clinical examination. Within the sample, smokers were identified based on reported current smoking and nonsmokers were matched to the smokers based on age, gender, educational level, area of residence, and number of teeth. In total, 268 subjects were matched (134 pairs). Six years after the baseline examination, 122 matched pairs were re-examined. **Results:** Mild symptoms of TMD were reported by approximately 30% of the sample both at baseline and at the follow-up examination 6 years later. Pain in the jaws and/or more severe symptoms of TMD were reported by approximately 15% on both occasions. No significant differences between smokers and nonsmokers were found regarding symptoms of TMD. In both examinations, mild signs (dysfunction index I) were found in approximately 40% of the sample and moderate to severe signs (dysfunction index II to III) in approximately 20%; no statistically significant differences were found between smokers and nonsmokers. No significant differences were found between smokers and nonsmokers regarding the course of symptoms or signs of TMD during the study period. **Conclusion:** Smoking is not a factor related to the presence or development of signs and symptoms of TMD. J OROFAC PAIN 2005;19:209–217*

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A search on PubMed for the period from 1966 to June 2004 using “smoking” and “risk” as key words resulted in identification of 39,731 published articles. When the terms “mandibular dysfunction,” “craniomandibular,” or “temporomandibular” were added, only 2 items were found. One was an article about cancer in the differential diagnosis of orofacial pain,<sup>1</sup> and the other was a letter by Jay proposing smoking as a possible cause of chronic fatigue, fibromyalgia, and temporomandibular disorders (TMD).<sup>2</sup> The letter was written in response to an article by Aaron et al in which they concluded that patients with chronic fatigue syndrome, fibromyalgia, and TMD share key symptoms.<sup>3</sup> Jay argued that smoking, smokeless tobacco, and exposure to environmental tobacco smoke may be the common denominator among the aforementioned patients. A further search on PubMed using the medical subject headings (MeSH) “smoking” or “tobacco” identified 79,000 articles, and when these were combined with “temporomandibular joint disorders,” “temporomandibular joint dysfunction syndrome,” “craniomandibular disorders,” “myofascial pain syndromes,” or “facial pain,” another 2

relevant articles were identified. One of these reported a relationship between smoking and severity of bruxism,<sup>4</sup> and the other was a letter that noted, based on the letter writer's own experience, the lack of studies of possible associations between smoking and temporomandibular joint disorders.<sup>5</sup>

Smoking is quite common in the population. In a European survey from 1987,<sup>6</sup> the prevalence of current smokers was calculated as being between 33% and 46%. In the United Kingdom, the prevalence of current smokers in 1998 among 35- to 59-year-olds was 36% among men and 28% among women.<sup>7</sup> Similar percentages of current cigarette smokers were reported for Italy (35% of men and 24% of women) in 2001.<sup>8</sup> The prevalence of current smokers in the United States was close to 25% (95% CI, 23.7% to 24.7%) in 1990.<sup>9</sup>

According to published statistics, 26% of the Swedish population (16- to 84-year-olds) were current smokers by the end of the 1980s. During the following decade, there was a gradual annual reduction in the number of smokers; 20% of the population were current smokers by the end of the 1990s.<sup>10</sup> A large number of epidemiological, clinical, and experimental studies have demonstrated that smoking is 1 of the most significant risk factors for disease and illness among men and women. Smoking has been related to cancer,<sup>11-13</sup> cardiovascular disorders,<sup>14</sup> gastrointestinal disorders,<sup>15</sup> pain in the lower back,<sup>16-19</sup> intervertebral disc degeneration,<sup>20-22</sup> periodontal disease,<sup>23-25</sup> changes of the connective tissue,<sup>26,27</sup> diabetes mellitus,<sup>28</sup> bruxism,<sup>4,29</sup> and increased risk for tooth pain, painful gums, and temperature sensitivity.<sup>30</sup>

Healthcare costs as a result of smoking are very high. In Denmark, the calculated costs attributable to smoking amounted to 4,100 million DKr in 1995.<sup>31</sup> In the United States, smoking accounts for 6% to 12% of the annual medical costs.<sup>32</sup> In a study from the Netherlands, the healthcare costs for smokers at any given age were as much as 40% higher than those for nonsmokers.<sup>33</sup> In the same study, life expectancy was 7.3 years shorter for men who smoked and 6 years shorter for women who smoked compared to nonsmokers.<sup>33</sup> Even though smoking can be regarded as a general risk factor for many disorders, no previous study seems to have investigated whether smoking is related to pain and functional disturbances in the temporomandibular joints (TMJs) and/or related muscles. TMD may be considered a musculoskeletal disorder, in part a result of loading the tissues beyond their capacity.<sup>34,35</sup> Since previous studies indicate that smoking may influence the function and

capacity of tissues, smokers may have a higher risk of contracting TMD than nonsmokers. In the letter cited earlier the author questioned the general absence of data on smoking in relation to chronic fatigue syndrome, fibromyalgia, and TMD.<sup>2</sup> The author suggested smoking as a possible cause of TMD, since the incidence of musculoskeletal symptoms, sleep disorders, anxiety, depression and mood disorders, perceived stress, chronic pain, gastrointestinal symptoms, and various psychosomatic complaints have been found to be higher in tobacco users than in lifelong nonsmokers. The relationships found between bruxism and smoking<sup>4,29</sup> may also indicate a potentially higher risk for development of signs and symptoms of TMD among smokers than among nonsmokers.

The aim of this study was to evaluate whether smoking influenced the presence and/or development of signs and symptoms of TMD among adults. The null hypothesis tested was that there would be no difference between smokers and nonsmokers in regard to signs and symptoms of TMD.

## Materials and Methods

In 1990 a sample was drawn from all inhabitants aged 35, 50, or 65 years in the county of Västerbotten, Sweden. The total target population was 9,051 individuals. The cohort was stratified into a coastal (mainly urban) area and an inland (mainly rural) area. It was decided that each stratum should constitute 450 individuals, and these were drawn randomly in proportion to the age distribution in each region. Out of the 900 potential subjects, 715 agreed to participate in an epidemiological survey of the oral health status (Table 1). The study included a questionnaire and a clinical examination. A study of the same sample has been presented elsewhere.<sup>36</sup> Subjects were identified on the basis of whether or not they were currently smokers. Smokers and nonsmokers were matched with factors that could be related to both smoking and TMD. These were age, gender, educational level, area of residence, and number of teeth. In total, 268 individuals (134 matched pairs) were examined at baseline. The subjects were invited to a follow-up examination in 1996; 122 matched pairs (91% of those examined at baseline) were re-examined. The study was approved by the Ethical Committee of the Faculty of Medicine and Odontology at Umeå University.

The case histories were collected with the aid of a questionnaire. The questions concerned demography, general health, medication, use of tobacco,

**Table 1** Population and Sample Studied at Baseline (1990) and Follow-up (1996)

|                       | Age       |          |          | Total     |
|-----------------------|-----------|----------|----------|-----------|
|                       | 35        | 50       | 65       |           |
| Base (1990)           |           |          |          |           |
| Population            | 3,588     | 2,746    | 2,717    | 9,051     |
| Sample                | 345       | 271      | 284      | 900       |
| Participants          | 276       | 208      | 231      | 715       |
| Subjects (1990)       |           |          |          |           |
| Nonsmokers            | 79        | 40       | 15       | 134       |
| Current smokers       | 79        | 40       | 15       | 134       |
| Total                 | 158       | 80       | 30       | 268       |
| Re-examination (1996) |           |          |          |           |
| Nonsmokers            | 73        | 35       | 14       | 122       |
| Current smokers       | 73        | 35       | 14       | 122       |
| Total                 | 146 (92%) | 70 (88%) | 28 (93%) | 244 (91%) |

Population: Total number of people born in 1955, 1940, or 1925 who lived in the county of Västerbotten, Sweden, in 1990.

Sample: The number of potential subjects drawn at random from the population.

Participants: The number of people chosen for the sample who agreed to participate.

Smokers and nonsmokers were identified based on their smoking status in 1990. Smokers and nonsmokers were matched for age, gender, education, region of residence, and number of teeth. The percentage of subjects re-examined in 1996 is indicated in parentheses.

dental care, oral symptoms, TMJ sounds, fatigue in the jaws, difficulties in opening the jaws wide, pain in the jaws while at rest or during movement, and headaches. The inquiries about smoking covered the subjects' current status regarding smoking, whether they smoked cigarettes or a pipe or both, how many cigarettes they smoked each day, and for how many years they had smoked. The clinical examination of the functions of the jaw included evaluation of the following:

1. TMJ sounds during opening and closing movements. The sounds were registered without the aid of a stethoscope. The sounds were classified as dull clicking, sharp clicking, or crepitations.
2. TMJ locking. This was registered if no sliding movement of 1 or both condyles could be felt and jaw opening was less than 25 mm or if the mandible deviated 5 mm or more when the jaw was opened by the subject.
3. TMJ tenderness. This was registered during lateral and posterior palpation of the TMJ. Only palpation that elicited a palpebral reflex in the eye or a protection reflex was registered.
4. TMJ pain during movement. This was registered

if free movements (opening, closing, or lateral movements) of the jaw elicited TMJ pain.

5. TMJ loading. A wooden spatula was placed between the maxillary and mandibular first molars on the right side. The subject was then asked to clench hard for 30 seconds. If the subject felt any pain in the contralateral TMJ region, "TMJ load pain" was registered. The procedure was repeated on the left side.
6. Maximal mandibular opening capacity. This characteristic was measured to the nearest millimeter with the aid of a ruler, in accordance with the description of Agerberg.<sup>37</sup>
7. Clench symptoms. "Clench symptoms" were defined as symptoms (fatigue or pain) experienced after clenching in the intercuspal position for 30 seconds.
8. Muscle tenderness to palpation. The superficial and deep parts of the masseter muscles, the anterior and posterior regions and tendons of the temporalis muscles, the medial pterygoid muscles, the area of the lateral pterygoid muscles, the sternocleidomastoid muscles, the trapezius muscles, and the muscles of the forearm, thumb, and calf were palpated. Tenderness was registered only if the palpation elicited a palpebral or protective reflex. The subjects were grouped into 5 categories according to the extent of tenderness evoked by palpation of the muscles: (1) no tenderness; (2) jaw muscle tenderness only (local tenderness); (3) neck or shoulder muscle tenderness only; (4) jaw and neck or shoulder muscle tenderness (regional tenderness); or (5) tenderness in all palpated regions of neck, shoulder, arm, hand, and calf muscles (generalized tenderness).<sup>38</sup>
9. Tooth wear was registered on the maxillary and mandibular incisors and canines in accordance with the description of Oilo et al.<sup>39</sup> The wear index comprises 5 grades, but for statistical analysis in this study, those with no or slight tooth wear formed 1 group and those with moderate to severe wear formed the other.

Relevant data were used to classify the subjects according to the anamnestic index (Ai) and the dysfunction index (Di) devised by Helkimo.<sup>40</sup>

### Statistical Analyses

In all stratified analyses, matched pairs with equal levels of the matching variables were merged into common strata in order to increase the statistical power. A stratified Wilcoxon rank sum test was used to test for differences in the distribution of

**Table 2** Distribution of Symptoms of TMD According to the Ai and Signs of TMD According to the Di

|                      | 1990       |      |          |      | <i>P</i> * | 1996       |      |            |      | <i>P</i> * |
|----------------------|------------|------|----------|------|------------|------------|------|------------|------|------------|
|                      | Nonsmokers |      | Smokers  |      |            | Nonsmokers |      | Smokers    |      |            |
|                      | <i>n</i> ‡ | %    | <i>n</i> | %    |            | <i>n</i>   | %    | <i>n</i> ‡ | %    |            |
| <b>Symptoms (Ai)</b> |            |      |          |      |            |            |      |            |      |            |
| None                 | 68         | 56.2 | 67       | 54.9 | .96        | 75         | 61.5 | 70         | 58.3 | .90        |
| Mild                 | 34         | 28.1 | 36       | 29.5 |            | 28         | 23.0 | 37         | 30.8 |            |
| Severe               | 19         | 15.7 | 19       | 15.6 |            | 19         | 15.7 | 13         | 10.9 |            |
| <i>P</i> †           |            |      |          |      |            | .34        |      | .23        |      |            |
| <b>Signs (Di)</b>    |            |      |          |      |            |            |      |            |      |            |
| None                 | 54         | 44.2 | 55       | 45.1 | .91        | 51         | 41.8 | 49         | 40.2 | .58        |
| Mild                 | 49         | 40.2 | 45       | 36.9 |            | 49         | 40.2 | 46         | 37.7 |            |
| Moderate to severe   | 19         | 15.6 | 22       | 18.0 |            | 22         | 18.0 | 27         | 22.1 |            |
| <i>P</i> †           |            |      |          |      |            | .53        |      | .27        |      |            |

\* Denotes the level of significant difference between nonsmokers and smokers (stratified Wilcoxon rank sum test).

† Denotes the level of significant difference between 1990 and 1996 (Wilcoxon signed rank test).

‡ For 2 subjects the questionnaire was not completely filled out; Ai could not be calculated for those subjects.

signs and symptoms of TMD between smokers and nonsmokers. The relative risks of any TMD sign or symptom for smokers compared to nonsmokers were estimated by odds ratios (ORs) computed via a conditional logistic regression. A Wilcoxon signed rank test was used to compare the distribution of signs and symptoms of TMD between 1990 and 1996 among smokers and nonsmokers. A *P* value less than .05 was considered statistically significant.

## Results

The smokers reported an average daily consumption of 12.4 cigarettes (SD, 6.7; range, 1 to 29), and all had smoked for at least 10 years (mean, 27 years; SD, 10.9; range, 10 to 50 years). Most of the smokers reported that they had smoked since they were teenagers. In a comparison of baseline data between participants and the 12 pairs lost to follow-up, no statistically significant differences were found.

In 1990, mild symptoms of dysfunction, such as TMJ sounds and fatigue or stiffness in the jaws (Ai I), were reported by 29% of the sample and severe

symptoms (Ai II) by 16%. No significant difference between smokers and nonsmokers was found (*P* = .96). The prevalence of symptoms of TMD in 1996 was similar to that found at baseline (Table 2); no significant difference between smokers and nonsmokers was found (*P* = .90). The OR of having 1 or more symptoms of TMD among smokers compared to nonsmokers was 1.03 (95% CI, 0.63 to 1.69) in 1990 and 1.15 (95% CI, 0.69 to 1.91) in 1996. Recurrent headaches (ie, headaches at least once a week) were reported by 14% of the sample in 1990, and in 1996, 13% reported recurrent headaches, with no statistically significant difference between smokers and nonsmokers (*P* = .95 in 1990 and *P* = .94 in 1996).

Mild signs (Di I) were found in 39% of the sample both in 1990 and in 1996. Moderate to severe signs (Di II to Di III) were found among 17% in 1990 and 20% in 1996. No statistically significant differences were found between the smokers and nonsmokers (*P* = .91 in 1990 and *P* = .58 in 1996) regarding the presence of signs of TMD (Table 2). The OR of having 1 or more signs of TMD among smokers compared to nonsmokers was 0.97 (95% CI, 0.58 to 1.61) in 1990 and 1.07 (95% CI, 0.64 to 1.78) in 1996.

**Table 3** Distribution of Signs from the TMJ

| Signs from TMJ          | 1990       |      |         |      | <i>P</i> * | 1996       |      |         |      | <i>P</i> * |  |  |
|-------------------------|------------|------|---------|------|------------|------------|------|---------|------|------------|--|--|
|                         | Nonsmokers |      | Smokers |      |            | Nonsmokers |      | Smokers |      |            |  |  |
|                         | n          | %    | n       | %    |            | n          | %    | n       | %    |            |  |  |
| <b>Sounds</b>           |            |      |         |      |            |            |      |         |      |            |  |  |
| None                    | 84         | 68.9 | 84      | 69.0 | .98        | 80         | 65.6 | 75      | 61.5 | .64        |  |  |
| Dull                    | 15         | 12.3 | 17      | 13.9 |            | 18         | 14.8 | 27      | 22.1 |            |  |  |
| Sharp                   | 21         | 17.2 | 17      | 13.9 |            | 22         | 18.0 | 13      | 10.7 |            |  |  |
| Crepitation             | 2          | 1.6  | 2       | 1.6  |            | 2          | 1.6  | 6       | 4.9  |            |  |  |
| Locking                 | 0          | 0    | 2       | 1.6  |            | 0          | 0    | 1       | 0.8  |            |  |  |
| <b>Tenderness</b>       |            |      |         |      |            |            |      |         |      |            |  |  |
| None                    | 111        | 91.0 | 115     | 94.3 | .35        | 118        | 96.7 | 114     | 93.5 | .21        |  |  |
| Lateral                 | 9          | 7.4  | 5       | 4.1  |            | 3          | 2.5  | 7       | 5.7  |            |  |  |
| Posterior               | 2          | 1.6  | 2       | 1.6  |            | 1          | 0.8  | 1       | 0.8  |            |  |  |
| <b>Pain on movement</b> |            |      |         |      |            |            |      |         |      |            |  |  |
| No                      | 120        | 98.4 | 117     | 95.9 | .26        | 121        | 99.2 | 115     | 94.3 | .03        |  |  |
| <b>Yes</b>              |            |      |         |      |            |            |      |         |      |            |  |  |
| 1 movement              | 2          | 1.6  | 5       | 4.1  |            | 1          | 0.8  | 5       | 4.1  |            |  |  |
| > 1 movement            | 0          | 0    | 0       | 0    |            | 0          | 0    | 2       | 1.6  |            |  |  |
| <b>Load pain</b>        |            |      |         |      |            |            |      |         |      |            |  |  |
| No                      | 96         | 93.2 | 81      | 81.0 | .03        | 87         | 92.6 | 89      | 96.7 | .87        |  |  |
| Yes                     | 7          | 6.8  | 19      | 19.0 |            | 7          | 7.4  | 3       | 3.3  |            |  |  |
| No test <sup>‡</sup>    | 19         |      | 22      |      |            | 28         |      | 30      |      |            |  |  |

\* Denotes the level of significant difference between the distribution of signs from the TMJ between smokers and nonsmokers (stratified Wilcoxon rank sum test).

<sup>‡</sup> Because of missing molars, it was not possible to conduct this test with all subjects.

In order to determine whether there was any dose-response relationship within the smoking sample, the smokers were stratified into 3 groups: “low-frequency smokers” (< 8 cigarettes per day), “moderate-frequency smokers” (8 to 19 cigarettes per day), and “high-frequency smokers” (≥ 20 cigarettes per day). No statistically significant differences between smokers and nonsmokers were found for presence of signs and symptoms of TMD within any category of smoking frequency.

No statistically significant difference was found between smokers and nonsmokers in the course of symptoms of TMD during the study period (Table 2). Approximately 20% of subjects who had no symptoms in 1990 reported symptoms in 1996. Of those who reported symptoms in 1990 (Ai I or Ai II), approximately half reported the same level of symptoms in 1996. This pattern was similar for smokers and nonsmokers.

Of the subjects who had no signs (Di 0) in 1990, 39% had developed signs by 1996. Of those who had signs in 1990 (Di I or Di III), 24% had no such signs in 1996, while approximately half had the same level on the Di in 1996 as in 1990. This pattern was similar for smokers and nonsmokers (Table 2).

The most frequently found sign from the TMJs was clicking sounds (Table 3). The prevalence of both sharp and dull sounds taken together was 29% in 1990 and 33% in 1996. No statistically significant differences between the smokers and nonsmokers were found for TMJ sounds. The OR of clinically registered TMJ sounds for smokers compared to nonsmokers was 1.0 (95% CI, 0.58 to 1.74) in 1990 and 1.2 (95% CI, 0.71 to 2.03) in 1996. Locking of the TMJs was rarely registered and did not increase significantly during the study period. Pain elicited from the contralateral TMJ

**Table 4** Distribution of Signs from Muscles

| Signs from muscles      | 1990       |      |         |      | <i>P</i> * | 1996       |      |         |      | <i>P</i> * |
|-------------------------|------------|------|---------|------|------------|------------|------|---------|------|------------|
|                         | Nonsmokers |      | Smokers |      |            | Nonsmokers |      | Smokers |      |            |
|                         | n          | %    | n       | %    |            | n          | %    | n       | %    |            |
| Tenderness to palpation |            |      |         |      |            |            |      |         |      |            |
| None                    | 67         | 54.9 | 64      | 52.4 | .83        | 70         | 57.4 | 67      | 54.9 | .48        |
| Jaw muscle              | 26         | 21.3 | 27      | 22.1 |            | 23         | 18.9 | 20      | 16.4 |            |
| Jaw and neck            | 13         | 10.7 | 19      | 15.6 |            | 17         | 13.9 | 18      | 14.8 |            |
| Neck                    | 11         | 9.0  | 9       | 7.4  |            | 9          | 7.4  | 10      | 8.2  |            |
| Generalized             | 5          | 4.1  | 3       | 2.5  |            | 3          | 2.5  | 7       | 5.7  |            |
| Clench symptoms         |            |      |         |      |            |            |      |         |      |            |
| None                    | 100        | 82.6 | 92      | 77.3 | .14        | 99         | 82.5 | 98      | 82.4 | .94        |
| Fatigue                 | 21         | 17.4 | 26      | 21.8 |            | 20         | 16.7 | 19      | 16.0 |            |
| Pain                    | 0          | 0    | 1       | 0.8  |            | 1          | 0.8  | 2       | 1.7  |            |
| No test <sup>‡</sup>    | 1          |      | 3       |      |            | 2          |      | 3       |      |            |

\* Denotes the level of significant difference between the distribution of signs from the TMJ between nonsmokers and smokers (stratified Wilcoxon rank sum test).

<sup>‡</sup> It was not possible to conduct this test with all subjects.

region during clenching on a spatula was found significantly more frequently ( $P = .03$ ) among smokers than among nonsmokers in 1990 (OR, 3.62; 95% CI, 1.39 to 9.40), but in 1996 no significant differences were found (OR, 0.44; 95% CI, 0.11 to 1.74).

Local tenderness to palpation of jaw muscles was found among 22% of the study sample in 1990 and among 18% in 1996 (Table 4). Regional tenderness to palpation was registered among 13% in 1990 and among 14% in 1996, while 3% had generalized tenderness to palpation in 1990 and 4% in 1996. No statistically significant differences were found in the distribution of tenderness to palpation between smokers and nonsmokers ( $P = .83$  in 1990 and  $P = .48$  in 1996). The OR of tenderness to palpation for smokers compared to nonsmokers was 1.11 (95% CI, 0.66 to 1.86) in 1990 and 1.1 (95% CI, 0.67 to 1.81) in 1996. Few subjects reported pain from the jaw muscles during a 30-second clenching task (0.4% in 1990 and 1.2% in 1996). The OR of developing any symptom (fatigue or pain) during the clenching task for smokers compared to nonsmokers was 1.37 (95% CI, 0.72 to 2.62) in 1990 and 1.01 (95% CI, 0.52 to 1.95) in 1996.

The degree of tooth wear did not differ significantly between smokers and nonsmokers. Few subjects had such severe tooth wear that fixed

prosthetic therapy was judged necessary. Severe tooth wear was registered in fewer than 2% of subjects in both 1990 and in 1996.

In 1990, 7.5% of the sample was judged to be in need of treatment because of TMD, and there was no significant difference between the smokers and nonsmokers ( $P = .31$ ). In 1996, 8.1% were judged to need treatments and there was no significant difference between smokers and nonsmokers ( $P = .36$ ). When the treatment need in 1990 was tabulated with the need in 1996, 35% of those judged to be in need of treatment in 1990 were also judged to be in need of treatment in 1996.

## Discussion

The survey was conducted in Västerbotten, a county situated in the north of Sweden. About a third of the population lives in the inland area, and the remaining two thirds live on the coast, mainly in 2 urban regions, Skellefteå (about 70,000 inhabitants) and Umeå (about 100,000 inhabitants). Since the design of the basic study was a stratified sample of 450 subjects from the rural region and 450 subjects from the urban region, the logical decision was to match the current smokers and nonsmokers for region of residence in the follow-up evaluation. The other factors used in the

matching—namely gender, age, educational level, and number of teeth—have all been shown to be related to both smoking and signs and symptoms of TMD<sup>41–43</sup> and were therefore included in the matching process so that smokers and nonsmokers would be as similar as possible in all respects apart from exposure to smoking. The participation rate was good (80% in the first survey and 91% in the 6-year follow-up), allowing inferences from the results to be reliably applied to the population.

The specific objective of this study was to evaluate whether smoking can be a cause or a factor in the perpetuation of TMD. The null hypothesis was not rejected, so there was no evidence of smoking being a significant risk factor for TMD. The similarities in prevalence and development of signs and symptoms of TMD during the 6-year period among smokers and nonsmokers were somewhat surprising. The overall prevalence of signs and symptoms of TMD was also well in line with previous epidemiological studies.<sup>44</sup>

It was thought possible that changes in the subjects' smoking status during the observation period could have had some influence on the results. To examine this possibility, a subset of the same sample using smokers who were current smokers in both 1990 and in 1996 was constituted and tested against matched nonsmokers in both 1990 and 1996 (86 matched pairs). This analysis showed comparable results, with no significant differences between smokers and nonsmokers in regard to signs and symptoms of TMD. A further subset of lifetime nonsmokers was then constituted and tested against consistent smokers during the period 1990 to 1996 (58 matched pairs). The results were consistent with the previous analysis.

The course of signs and symptoms during the 6-year period showed that the fluctuating pattern of signs and symptoms of TMD previously found among adolescents and young adults<sup>45–47</sup> was also a reality among adults. The study indicates that approximately half of an adult population with TMD will have their signs and symptoms at a fairly steady level for quite a long period of time. This agrees with a recent study covering subjects of approximately the same ages.<sup>48</sup> This pattern was found for single signs from the TMJs such as clicking, crepitation and locking, and regional tenderness to palpation (jaw and neck muscles). Half of those who reported recurrent headaches (once a week or more often) in 1990 also reported recurrent headaches in 1996. The results indicate that the incidence of both TMD and headaches is fairly high among adults.

There appeared to be a balance within age groups between the number of subjects who fell ill and the number who recovered, since prevalence was quite stationary during the follow-up period. The perpetuation of symptoms of TMD has previously been related to gender.<sup>49,50</sup>

The lack of association between smoking and TMD is interesting. TMD may include dysfunction within the TMJ region, as a result of disc-interference disorders, inflammation, or degeneration.<sup>51</sup> It has been found from other parts of the body that smoking significantly affects circulation outside the intervertebral disc and reduces cellular uptake rate and metabolite production within the disc.<sup>20</sup> In a study based on smoking and nonsmoking twins, those who smoked had 18% greater mean disc degeneration scores in the lumbar region of the spine than did nonsmokers.<sup>21</sup> In another study, smokers had a higher relative risk of lumbar disc disease (risk ratio 2.2) and cervical disc disease (risk ratio 2.9) than nonsmokers.<sup>22</sup> These results indicate that smoking can have a generalized effect on the nutrition of the discs due to impaired microcirculation, and so can make them more vulnerable to mechanical stress.<sup>18</sup> The TMJs however seem to be spared this effect from smoking, at least from a symptomatic point of view.

Another common factor in TMD is muscle fatigue and pain, which are assumed to be due to hyperactivity (clenching and/or grinding).<sup>51</sup> The vasoconstrictive properties of nicotine and the increased level of CO in the bloodstream caused by smoking, which may impair the nutrition of the muscles,<sup>52</sup> may be viewed in relation to this aspect. Again, no indication of a higher prevalence of tenderness to palpation among smokers was found. In an epidemiological study,<sup>41</sup> current smokers were found to have an increased risk of low back pain and widespread pain compared with those who had never smoked. No significant associations between smoking and reported chronic pain in the head or face were found, as in the present study. The results of an Icelandic study based on 862 participants<sup>19</sup> were also in agreement with the current findings. In a recent study of Finnish adolescents, smoking was related to both neck/shoulder pain and low back pain.<sup>53</sup>

Smoking was found not to be significantly related to the presence or development of TMD. The result was interesting from an etiological point of view, since smoking has been related to disc degeneration,<sup>20–22</sup> back and neck pain,<sup>16–19</sup> and bruxism.<sup>4,29</sup> Reaction patterns due to stress or depression have commonly been advocated as factors contributing to TMD.<sup>50,54,55</sup> Even though

stress and depression are also frequently found among smokers,<sup>56–60</sup> it was not such a strong confounder as to create a significant relationship between smoking and TMD. The study shows that signs and symptoms of TMD fluctuate with time among adults and indicate no significant relationship between TMD and smoking.

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