Absence of association between TMJ disorders and dental fluorosis in Isparta, Turkey

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SUMMARY: The aim of this study was to investigate whether individuals with dental fluorosis (DF) have signs and symptoms of temporomandibular joint (TMJ) disorders (TMD). The study group consisted of 71 dental patients with DF who were born and living in an endemic fluorosis region of Isparta, Turkey. The control group comprised 29 patients not having DF, who applied to our clinics from neighboring communities with low levels of F (<0.3 ppm) in the drinking water. DF in the 71 patients of the study group was classified using a modified version of the Thylstrup-Fejerskov Index: 21 mild, 23 moderate, and 27 severe. All 100 participants were examined clinically, and any signs and symptoms of TMJ disorders (TMD) were recorded using a standard evaluation form. Radiological changes in the TMJ were studied using plain lateral TMJ projection. No statistically significant difference in clinical signs and symptoms of TMJ-TMD was detected between individuals with or without DF. There were also no statistically significant differences in radiological changes in TMJ between the two groups. Thus, this small-scale preliminary survey did not reveal an association between DF and TMJ-TMD. Further investigation is needed, however, to determine dose-related effects of high-F intake on the human stomatognathic system.

Keywords: Dental fluorosis (DF); Isparta, Turkey; Temporomandibular joint (TMJ) disorders; Thylstrup-Fejerskov fluorosis index.

INTRODUCTION

Fluoride (F) is mainly incorporated into calcified tissues (i.e., bones and teeth) because of its high affinity for calcium together with phosphate ion. It replaces the hydroxyl group of hydroxyapatite crystals to form fluoroapatite, which is less soluble and more compact. F also increases metabolic turnover of bone and stimulates proliferation of lower-quality bone cells. 1-4 Excessive intake of F during childhood causes dental fluorosis (DF), and prolonged high F intake can also cause skeletal fluorosis, 5,6 which is characterized by pain, deformities, and limited movement of the joints, the spinal skeleton, and major joints of extremities. Alarcón-Herrera et al. 7 found a linear correlation between the Dean index of DF and the frequency of bone fractures among both children and adults. Articular calcification and necrosis of articular chondrocytes in skeletal fluorosis have been reported. 4 Savas et al. 8 observed that a high number of female patients residing in Isparta, Turkey, who have DF also complained of knee pain. They found that radiological severity of knee osteoarthritis was greater and atypically

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located osteophytes were more frequent in patients with DF. They concluded that residing an area of endemic fluorosis was associated with increased severity of degenerative changes in the bone and joints.

Animal studies also indicate fluorosis may exert adverse effects in the temporomandibular joint (TMJ) structures.9,10 Due to such effects of F on TMJ structures, fluorosis may cause or at least predispose TMJ disorders (TMD). In a histological and histomorphometric study, Kameyama9 demonstrated that mandibular condyles of the rats that received 100 ppm F in the drinking water exhibited a significant increase in both the thickness of the cartilage layer and the density of cancellous bone compared to the controls. In his report, Kameyama proposed that the thickening of the cartilage layer was due to an increase in the number of hypertrophied chondrocytes. In addition, he found that the trabeculae of cancellous bone were thicker with extreme reduction in bone marrow spaces in the mandibular condyles of the rats that received 100 ppm F in their drinking water.9 Harbrow et al.10 also reported that chronic exposure of rats to 100 ppm NaF increased the thickness of the cartilage layer of the mandibular condyle. Stimulation of chondrocytes by F was thought to have delayed the normal processes of capillary invasion, thereby resulting in thickening of the cartilage layer.

The city of Isparta, located in southwestern Turkey, is one of the country’s severe endemic fluorosis regions. In Isparta, F in the natural water supply is the major source of F. The prevalence and severity of DF among the population in the central part of Isparta are substantially higher than expected for F levels in drinking water in the range of 2.16–4.30 ppm.11 The purpose of this study was to investigate whether individuals with DF living in Isparta City have an increased tendency to exhibit signs and symptoms of TMJ.

**MATERIALS AND METHODS**

Patients who had applied to the Dental Faculty of Süleyman Demirel University for dental care were screened for DF. Based on information on the forms, the study group consisted of 71 patients with DF who were born in Isparta. The control group consisted of patients who applied to our clinics from locations with low levels of F (<0.3 ppm) in the drinking water and who did not have DF. When creating the study and control groups, only subjects who were living in the same residential area since birth were selected. All the subjects had normal overjet-overbite relationship and occlusion. Both the study and control group subjects had no history of orthodontic treatment, occlusal equilibration, crown restoration, or history of cranio-mandibular trauma.

In Isparta and neighboring communities, local government employee residents have similar, normal family and socio-economic levels. In regard to dental hygiene, patients with periodontitis were not included in the study. From the detailed medical history obtained from each prospective subject, exclusion criteria included taking medications that may influence bone metabolism, any metabolic and inflammatory bone disease, bruxism or parafunctional masticatory habits, acute infection or periodontitis, and a history of psychosomatic disorders.

This study was conducted according to the ethical standards of the Declaration of Helsinki (Current [2008] version) that promote respect for all human beings and protect their health and rights. The local ethics committee approved the study.
A modified version of the Thylstrup-Fejerskov Index (TFI) was used to classify the degree of DF.\textsuperscript{12} Accordingly, TFI scores were evaluated as follows: 0 TFI score = healthy tooth structure; 1–3 TFI scores = mild DF; 4–6 TFI scores = moderate DF; and 7–9 TFI scores = severe DF (see Figure).

Figure. Modified version of the Thylstrup-Fejerskov Index (TFI) used in the study. 1a-1b (16-year-old, female patient): TFI score = 0, Healthy Tooth Structure; 2a-2b (15-year-old, female patients): TFI scores = 1–3, mild fluorosis; 3a-3b (18-year-old, male patients): TFI scores = 4–6, moderate fluorosis; 4a-4b (20-year-old male patient): TFI scores = 7–9, severe fluorosis.
The patients were asked whether they had any of the following symptoms related to TMJ over the past 6 months: TMJ pain during jaw movements; TMJ noise or sounds; impaired mouth opening. Clinical diagnosis for temporomandibular disorders (TMD) was established according to the following criteria.\(^\text{13}\)

1. **Mandibular range of motion:** Mandibular range of motion was evaluated for maximum opening and lateral movements. Maximum opening was measured from central maxillary incisor to the opposing mandibular incisor on a millimeter ruler, taking overbite into consideration. Lateral movements were measured relative to the maxillary midline with the teeth slightly separated. Patients with limited mouth opening ‘soft-end feel’ and ‘hard-end feel’ were noted in order to determine whether the problem takes its origin from muscles or the intracapsular region. Any alterations of the path taken by the midline of the mandible during maximal opening were also recorded.

2. **Pain in the TMJ:** The TMJ pain was identified during palpation, mandibular range of motion, or assisted mandibular opening.

3. **Clicking/Crepitation:** TMJ was auscultated with a stethoscope, while the subject performed three openings, and three lateral and protrusive movements.

4. **Lateral TMJ radiographs:** Radiographic study included examination for the anatomy of the TMJ bony components (any bone resorptions or flattening of the eminence or the condyle); deformities of the joint surfaces; osteophyte formation; osteosclerosis (an overall increase in bone density with thickening of the cortex); subchondral cyst formations; and ossification of the soft tissues such as ligaments, capsule, and disc.

Statistical analyses (Chi-square, Kruskal-Wallis, Mann Whitney U) were performed using SPSS (Ver. 15.0, SPSS Inc., Chicago, IL, USA). The significance level was for p<0.05.

**RESULTS**

Among the 100 patients (28 male and 72 female) who participated in the study, 29 had no DF, 21 had mild, 23 had moderate, and 27 had severe DF. The mean age (between 12–40 years-old) of the patients was 17.37±5.56. The demographic data of the patients who participated in the study are given in the Table, which shows the distribution of the patients according to their TMJ history. As seen in the Table, the most prominent symptom suggesting TMD was the presence of clicking sound. There were no statistically significant differences between pain, limitation of mouth opening, and click history of the patients with and without DF (p>0.05).

When patients were examined for the selected symptoms of TMD, no significant differences were observed between the groups with or without DF (p>0.05).

The mean maximum mouth opening was 39.74±6.36 mm (minimum 14 mm–maximum 54 mm), the mean lateral movements were 5.29±2.36 mm (minimum 0 mm–maximum 13 mm), and the mean protrusive movements were 4.83±2.16 mm (minimum 1 mm–maximum 11 mm). A total of 10 patients had deviation during mouth opening. Of these 3 (10.3%) had no DF, 2 (9.5%) had mild DF, 2 (8.7%) had moderate DF, and 3 (11.1%) had severe DF.

Patients’ awareness of limited mouth opening did not correlate with measured mouth opening. However, pain history was correlated with maximum mouth
opening (p=0.001), lateral range of motion (p=0.003), and protrusive motion (p=0.01).

Click complaint and sound from the joint showed correlation (p=0.002). Of all patients, 23 had a clicking sound on mouth opening and/or closing. There were no statistically significant differences between erosion or irregularities on joint surfaces between those with and without DF. In addition, no correlation was found between radiographic changes, jaw deviation, and joint sounds (Table).

**Table.** Demographics, history, pain, noise (sound), radiographic changes of TMJ, and mandibular range of motion in the non-DF and DF patients

<table>
<thead>
<tr>
<th>Age ranges (years)</th>
<th>No DF (n=29)</th>
<th>Mild DF (n=21)</th>
<th>Moderate DF (n=23)</th>
<th>Severe DF (n=27)</th>
<th>Total (n=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>15.5 (±2.9)</td>
<td>16.2 (±5.5)</td>
<td>15.7 (±5.1)</td>
<td>21.7 (±6.0)</td>
<td>17.37 (±5.5)</td>
</tr>
<tr>
<td>Female (79.3%)</td>
<td>14 (66.7%)</td>
<td>17 (73.9%)</td>
<td>18 (86.7%)</td>
<td>18 (72%)</td>
<td></td>
</tr>
<tr>
<td>Male (20.7%)</td>
<td>7 (33.3%)</td>
<td>6 (26.1%)</td>
<td>9 (33.3%)</td>
<td>9 (28%)</td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>3 (10.3%)</td>
<td>3 (14.3%)</td>
<td>2 (8.7%)</td>
<td>3 (11.1%)</td>
<td>11 (11%)</td>
</tr>
<tr>
<td>Clicking</td>
<td>5 (17.2%)</td>
<td>3 (14.3%)</td>
<td>2 (8.7%)</td>
<td>6 (22.2%)</td>
<td>16 (16%)</td>
</tr>
<tr>
<td>Limitation on mouth opening</td>
<td>2 (6.9%)</td>
<td>1 (4.8%)</td>
<td>-</td>
<td>3 (11.1%)</td>
<td>6 (6%)</td>
</tr>
<tr>
<td>Palpation</td>
<td>2 (6.9%)</td>
<td>1 (4.8%)</td>
<td>1 (4.3%)</td>
<td>-</td>
<td>4 (4%)</td>
</tr>
<tr>
<td>Mouth opening (1.3%)</td>
<td>-</td>
<td>-</td>
<td>2 (7.4%)</td>
<td>3 (3%)</td>
<td></td>
</tr>
<tr>
<td>Lateral motions (2.6%)</td>
<td>-</td>
<td>-</td>
<td>4 (14.8%)</td>
<td>6 (6%)</td>
<td></td>
</tr>
<tr>
<td>Protrusive motions</td>
<td>1 (3.4%)</td>
<td>1 (4.8%)</td>
<td>2 (8.7%)</td>
<td>2 (7.4%)</td>
<td>6 (6%)</td>
</tr>
<tr>
<td>Maximum mouth opening</td>
<td>39.3 (±7.1)</td>
<td>40.6 (±6.7)</td>
<td>38.3 (±5.2)</td>
<td>40.8 (±6.2)</td>
<td></td>
</tr>
<tr>
<td>Lateral movement</td>
<td>4.2 (±2.1)</td>
<td>5.9 (±2.1)</td>
<td>5.4 (±2.1)</td>
<td>5.9 (±2.6)</td>
<td></td>
</tr>
<tr>
<td>Protrusive movement</td>
<td>4.2 (±2.1)</td>
<td>5.2 (±2.1)</td>
<td>4.4 (±1.8)</td>
<td>5.4 (±2.5)</td>
<td></td>
</tr>
<tr>
<td>Deviation</td>
<td>7 (±24.1)</td>
<td>5.2 (±2.1)</td>
<td>8 (±34.8)</td>
<td>5 (±18.5)</td>
<td></td>
</tr>
<tr>
<td>Clicking</td>
<td>6 (20.7%)</td>
<td>7 (33.3%)</td>
<td>3 (13%)</td>
<td>7 (25.9%)</td>
<td>23 (23%)</td>
</tr>
<tr>
<td>Crepitation</td>
<td>3 (10.3%)</td>
<td>1 (4.8%)</td>
<td>6 (26.1%)</td>
<td>4 (14.8%)</td>
<td>14 (14%)</td>
</tr>
<tr>
<td>Erosion</td>
<td>1 (3.4%)</td>
<td>1 (4.8%)</td>
<td>1 (4.3%)</td>
<td>4 (14.8%)</td>
<td>7 (7%)</td>
</tr>
<tr>
<td>Irregularities</td>
<td>4 (13.8%)</td>
<td>2 (9.5%)</td>
<td>-</td>
<td>11 (11%)</td>
<td></td>
</tr>
</tbody>
</table>

**DISCUSSION**

Dental fluorosis (DF) is a developmental disturbance of dental enamel caused by successive exposures to high concentrations of F during tooth development, leading to enamel with lower mineral content and increased porosity. The severity of the disorder appears to be directly related to the magnitude and duration of high-F exposure.

Czarnowsky et al. have shown that increased F intake adversely affects bone density. In a study of industrial fluorosis, a close relationship was found between the occurrence of skeletal fluorosis and the time and degree of F exposure. Ohmi et al. investigated the effects of fluoridation and its discontinuation on the
middle and apical parts of the alveolar bone and the body of the mandible of rats, finding that the upper parts of the alveolar bone and the alveolar crest presented the highest rates of resorption after discontinuation of F exposure. In animal models with a wide range of F in the drinking water, tooth F content was associated with bone F content. Toth F concentration in mice exposed to a wide range of F in their diet confirmed the possibility of usage of teeth as a biomarker for skeletal exposure. In addition, a strong positive correlation between the degree of DF and mandibular bone F content was found in a sample of red deer exposed to elevated levels of F in the environment, thereby demonstrating the usefulness of DF as a biomarker of increased F exposure for biomonitoring studies in deer.

As noted in the Introduction, Savas et al. suggested that endemic DF in Turkey might be associated with increased severity of degenerative changes in the bone and knee osteoarthritis. In the present study, it has not been determined whether osteoarthritis follows the course of internal dental derangements following disc displacements or vice versa. Dentition and the occlusal status of the patients were also similar. However, there was no significant difference between control and DF subjects in regard to the prevalence of osteoarthritis.

Temporomandibular disorders (TMD) including abnormal, incomplete, or impaired function of the TMJ, along with a collection of symptoms frequently observed in various combinations were first described by Costen in the 1930s, which he claimed to be reflexes due to irritation of the auriculotemporal and/or chorda tympanic nerves as they emerge from the tympanic plate caused by altered anatomic relations and derangements of the TMJ associated with loss of occlusal vertical dimension, loss of posterior tooth support, and/or other malocclusions. The symptoms can also include headache about the vertex and occiput, tinnitus, pain about the ear, impaired hearing, and pain about the tongue. There is thus a myriad of possible variables in TMD and certainly many confounding issues and unknowns. Therefore, to include all such possible or controversial confounding factors for TMD needs a very large population for study because of so many parameters. However, incorporating these additional parameters in the present study of DF and TMD was not feasible because of the small sample of the study groups.

In our study, we found no TMJ bony differences between the control and DF patients. Çağlayan and Tozoğlu showed that TMJs have incidental findings in radiographic evaluations, such as erosion of the condyle, osteophytes, and bifid condyle. Also in the present study, radiographic changes were found to be similar in both the control and DF groups. Still, the effects of F on humans are known to be determined primarily by the nature, dose, and duration of F exposure, age, sex, dietary habits, genetic factors, and combinations of them. Overall, the total quantity and period of F ingestion appear to be the most important factors determining the clinical course of skeletal fluorosis, which is characterized by immobilization of joints of the axial skeleton and of major joints of the extremities.

In conclusion, clinical and radiological examination of TMJ in DF patients in our study showed no significant differences from the control subjects without DF. As noted above, the effects of F are mainly determined by the nature, dose, and
duration of F exposure, together with other factors like age, sex, genetic differences, and dietary habits or their combination. TMDs also have a very complex multi-factored pathology. Thus, the connection between DF and TMD needs to be evaluated on larger study populations in multidisciplinary manner. In the present study, the apparent absence of a relationship between TMD and DF may be due to limitations of the size of sample groups and thus can be seen as preliminary for further studies.

REFERENCES