Odontologic survey of referred patients with symptoms allegedly caused by electricity or visual display units

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Twenty-eight consecutive patients with symptoms allegedly caused by electricity or visual display units were odontologically investigated according to a specially designed registration form including an anamnestic interview and a clinical protocol. The most common oral and general symptoms reported were burning mouth, craniomandibular dysfunction symptoms, skin complaints, and fatigue. Oral symptoms such as craniomandibular dysfunction and general symptoms such as eye complaints and dizziness scored highest on a visual analog scale regarding mean symptom intensity. The patients reported various numbers of medical diagnoses, such as allergic rhinitis or asthma and hypothyroidism. Various dental diseases were found; the most common were temporomandibular joint and masticatory muscle dysfunctions, lesions in the oral mucosa, and periodontal diseases. Urinary-Hg (U-Hg) analysis showed a mean U-Hg concentration of 8.5 nmol Hg/L urine, and none of the patients exceeded the limit of 50 nmol Hg/L urine. The U-Hg concentration was positively correlated with the number of amalgam fillings ($P < 0.01$) and craniomandibular disorders ($P < 0.05$). No or low secretion of the minor mucous glands was found in 43% of the patients. One patient showed hypersensitivity to gold and cobalt. The present study showed that various odontologic factors might be involved in some of these patients' suffering. Thus, it is important that professionals from other disciplines collaborate with dentistry if these patients are to be properly investigated. □ *Oral diagnoses; oral pathology; oral symptoms*

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An increasing number of individuals allege that electromagnetic fields emitted from visual display units (VDUs) or other electrical equipment have adverse health effects. No association has thus far been found between radiation emissions from VDUs and reported spontaneous abortions, birth defects, or other injuries (1), and VDU operators are not exposed to electromagnetic fields at levels where hazards may exist (2). Furthermore, no relation between electromagnetic fields and reported symptoms has been found (3).

Skin and eye complaints, fatigue, and dizziness are examples of common symptoms in this patient group (3–9), and gustatory disturbance, burning mouth, temporomandibular dysfunction, and dry mouth are common oral complaints (7–9). Increased mercury vapor release from dental amalgam specimens in vitro have been reported when exposed to magnetic fields emitted from VDUs, indicating a possible association between such exposure and mercury vapor release from amalgam fillings (10). Thirteen percent of patients with symptoms allegedly related to electricity or VDUs thought that dental amalgam was a causative factor in their hypersensitivity, and therefore they had replaced their amalgam fillings (7). After having these fillings replaced, they reported that the symptoms were reduced. In another study many of the patients thought their symptoms were affected by dental amalgam (56%) or other dental materials (24%), possibly indicating that they were seeking an explanation of their symptoms in an interaction between electromagnetic fields and the material in their dental amalgam fillings (8).

It has been suggested that health complaints and multiple chemical sensitivity syndrome (MCS) in VDU workers have similar etiologic bases when a number of symptoms are in common (11). MCS and environmental illness (EI) are two labels for a condition that includes patients with symptoms allegedly caused by unusual and abnormal sensitivity to food, chemicals, electromagnetic fields, amalgam fillings, and organisms such as *Candida albicans* that are normally well tolerated (12–15). The EI/MCS patients are a heterogeneous group reporting symptoms such as skin complaints, fatigue, malaise, headaches, dizziness, lack of concentration, and memory loss (16). Four views about the etiology of EI/MCS have been proposed: 1) EI/MCS involves physical or psychophysiologic reactions to multiple environmental factors; 2) the symptoms may be precipitated by low-level environmental exposure, but the increased sensitivity is primarily due to psychologic stress; 3) EI/MCS is a misdiagnosis, and low-level environmental exposure is not the cause of the symptoms; and 4) EI/MCS is a belief system manifested by culturally shaped illness behavior (16, 17). Therefore, a multidisciplinary approach has been emphasized when handling EI/MCS patients in clinical practice (17).

The aim of the present study was to odontologically investigate patients with symptoms allegedly caused by

electricity or VDUs and to study odontologic diseases in these patients.

Materials and methods

The subjects were 28 consecutive patients with symptoms allegedly caused by electricity or VDUs referred to the Department of Oral Diagnosis, School of Dentistry, Umeå University, Sweden. Fourteen were women (mean age, 47 years; range, 35–58 years), and 14 were men (mean age, 44 years; range, 32–64 years). All participants gave their informed consent, and the study was approved by the Ethics Committee for Human Experiments at Umeå University.

Interview and oral examination

All patients underwent an oral examination to detect whether underlying oral disease could be related to their present symptoms. The examination was performed with semi-structured interviews and clinical protocols according to a registration form specially designed for this purpose. In addition to the odontologic anamnesis, the semi-structured interview covered actual medical diseases and medication. The patients' oral and general symptoms allegedly caused by electricity or VDUs were registered, and symptom intensity was measured with the use of a 10-cm visual analog scale (VAS), graded 0–10 on the back. Caries prevalence and root caries prevalence were registered according to definitions by Koch (18) and Hix & O'Leary (19), respectively. Caries including both the coronal and root parts of the same tooth/surface was registered as root and coronal (primary or recurrent) caries and was counted as one decayed tooth. Periodontal status was registered according to the CPITN index by Ainamo et al. (20). The CPITN index is categorized into five groups: 0 = no periodontal disease; 1 = bleeding only; 2 = calculus; 3 = shallow pockets 4–6 mm; and 4 = deep pockets > 6 mm. Endodontic condition was registered according to routines applied at the Department of Endodontics, Umeå University. Helkimo's anamnestic index and clinical dysfunction index (21) were used to measure of the severity of signs of craniomandibular dysfunction. The anamnestic index is categorized into three groups: A0 = no subjective symptoms; AI = TMJ sounds, tiredness; and AII = TMJ pain, locking, luxation, opening capacity < 40 mm. The clinical dysfunction index has four groups: D0 = no clinical signs of dysfunction; DI = mild dysfunction; DII = moderate dysfunction; and DIII = severe dysfunction. This index is based on the evaluation of five clinical signs: impaired range of movement, impaired functions of the temporomandibular joint (TMJ), muscle pain, TMJ pain, and pain on movement of the mandible. Functional status, according to Eichner (22), was also registered. The Eichner index consists of three main groups: A, B, and C. Occluding teeth in the premolar and molar regions are registered. If there are occluding contacts in the premolar and molar regions bilaterally, a maximum of four supporting zones are obtained and the patient belongs to group A. Group B has one to three supporting zones, and group C has no supporting zones in the premolar and molar regions. Occlusal contacts with fixed crowns and bridges, but not with removable dentures, were included in the index. Edentulous patients with a denture were categorized as Eichner group C.

Examination of the oral mucosa

Oral mucosal lesions were also registered as a part of the clinical examination. When in doubt, second opinions were sought from an experienced specialist in maxillofacial surgery, with special interest in oral medicine, who decided whether an oral mucosal lesion fulfilled the clinical criteria for biopsy.

Candida analysis

Detection of yeast in a clinical specimen was conducted by direct microscopic examination of smears from the oral mucosa and tongue. After fixation the slides were stained by the periodic acid-Schiff (PAS) technique (23).

Saliva analysis

The flow rates of unstimulated and stimulated whole saliva were determined. Unstimulated saliva was collected for 10 min in a graded test tube. Whole saliva stimulated by chewing a standardized piece of paraffin was collected for 5 min. Values below 0.1 mL/min unstimulated saliva and 0.7 mL/min stimulated saliva were defined as hyposalivation (24). The secretion of the minor mucous glands was assessed by inspection of the lower labial mucosa for 5 min. The minor mucous gland secretion was classified from 0 to 3: 0 = no secretion; 1 = low secretion; 2 = average secretion; and 3 = high secretion.

Epicutaneous patch test

To detect any delayed-type hypersensitive reactions, a standard epicutaneous patch test including 43 dental substances according to the Standard European Series (Table 1) was performed on the patients who fulfilled the criterion for such a test. The test substances were applied to normal skin on the patients' backs for 48 h. Twenty-four hours after removal of the patches, the reactions were read by an experienced dermatologist according to hospital routines. A second assessment was made 7 days after removal of the patches in order to cover any late reactions that might have appeared.

Urinary mercury analysis

A urinary mercury analysis (U-Hg) was performed by collecting and pooling urine for 24 h. The U-Hg

concentration was analyzed once by atomic absorption spectrophotometry (25, 26), and concentrations exceeding the limit of 50 nmol Hg/L urine were classified as abnormal (27).

Statistical method

The clinical protocols were registered and analyzed in the data module of the Statistical Package for Social Science (SPSS) for Windows.

Results

Symptom profile

As seen in Table 2, skin complaints (68%), fatigue (46%), and various eye symptoms (32%) were the most frequently reported general symptoms, while the most frequent oral symptoms were burning mouth (50%), craniomandibular dysfunction symptoms (43%), and gustatory disturbance (25%). Regarding the mean symptom intensity (Table 2), general symptoms such as eye complaints, dizziness, and pain, along with oral symptoms such as craniomandibular dysfunction symptoms, scored highest on the VAS.

Medical diseases and medication

Three patients reported having allergic rhinitis or asthma. The following were reported by one patient each: mild hypertension, hypothyroidism, diabetes mellitus, Sjögren's syndrome, and gout. All of these patients used drugs for their complaints or diseases.

Cariologic, endodontic, and periodontic examination

Various dental treatment needs were found among these 28 patients. Caries was diagnosed in 3 patients. None were in need of endodontic treatment. Severe periodontal disease (CPITN = 4) was found in 2 patients, who needed specialist treatment. Mild or moderate periodontal conditions (CPITN < 4) were diagnosed in 19 patients (68%).

Craniomandibular function

Nine patients (32%) reported symptoms such as TMJ pain, locking, and luxation, which classified them as AII according to Helkimo's anamnestic dysfunction index (Table 3). Symptoms such as TMJ sound and tiredness (AI) were reported by 11%, while 57% reported no TMJ symptoms (A0). According to Helkimo's clinical dysfunction index, severe dysfunction (DIII) was rare; in only one patient were there clinical findings that could be classified as severe. Mild and moderate clinical dysfunction (DI and DII) were both registered in 25% ($n = 7$). All patients included in this study had four supporting zones in the premolar and molar areas (Eichner index, group A).

Table 1. Standard epicutaneous patch test: 43 test substances used in dental practice

1. Methyl methacrylate
2. Triethyleneglycol dimethacrylate
3. Urethane dimethacrylate
4. Ethyleneglycol dimethacrylate
5. Bis-GMA [2,2-bis(2-hydroxy-3-metacryloxypropoxyphenyl) propan]
6. *N,N*-dimethyl-4-toluidine
7. 2-Hydroxy-4-methoxy-benzophenone
8. 1,4-Butanediol dimethacrylate
9. Bis-MA [2,2-bis(4-(metacryloxy)phenyl)propan]
10. Potassium dichromate
11. Mercury
12. Cobalt chloride
13. 2-Hydroxyethyl methacrylate
14. Gold sodium thiosulfate
15. Nickel sulfate
16. Eugenol
17. Colophony
18. *N*-ethyl-4-toluenesulfonamide
19. Formaldehyde
20. 4-Tolyldiethanolamine
21. Copper sulfate
22. Methylhydroquinone
23. Palladium chloride
24. Aluminum chloride hexahydrate
25. Camphoroquinone
26. *N,N*-dimethylaminoethyl methacrylate
27. 1,6-Hexanediol diacrylate
28. 2(2-Hydroxy-5-methylphenyl) benzotriazol
29. Tetrahydrofurfuryl methacrylate
30. Tin
31. Peppermint oil
32. Menthol
33. Balsam of Peru
34. Titanium
35. Calcium titanate
36. Titanium oxalate
37. Titanium nitride
38. Spearmint oil
39. Silver nitrate
40. Anethole
41. Hydroquinone
42. Benzoyl peroxide
43. Sodium fluoride

Oral mucosal lesions

The most common oral mucosal lesion was morsicatio buccarum, which was found in 10 patients, followed by leukoplakia caused by snuff in 4 patients. Hyperkeratosis in the marginal gingiva was found in 3 patients, and Fordyce's spots, amalgam tattoo, and red spots in the soft palate were each found in 1 patient. Some patients had more than one lesion, and no patient fulfilled the criteria for biopsy. Severe lesions were not found among the patients, and 11 patients had an intact oral mucosal surface.

Candida analysis

All 28 patients underwent the test for oral candidiasis. In 7 of them (25%) oral candidiasis was confirmed by the analysis.

Table 2. Distribution, mean intensity, and range measured by a visual analog scale (VAS) of the most frequent general and oral symptoms in 28 patients with symptoms allegedly caused by electricity or visual display units

Symptoms	*n*	%	Mean VAS	Range
General				
Skin complaints	19	68	5.5	2.0–8.0
Fatigue	13	46	5.4	1.5–8.0
Various eye symptoms	9	32	6.4	2.0–8.0
Pain	7	25	6.1	3.5–9.0
Headache	7	25	5.2	3.5–7.0
Dizziness	6	21	6.4	2.5–8.5
Palpitations	4	14	6.0	4.5–8.0
Sleep disturbance	2	7	4.3	3.5–5.1
Oral				
Burning mouth	14	50	4.5	3.0–9.5
Craniomandibular dysfunction symptoms	12	43	5.8	3.0–8.0
Gustatory disturbance	7	25	3.9	2.0–9.5
Dry mouth	7	25	4.0	1.0–7.5

Table 3. Distribution of Helkimo's anamnestic and dysfunction indices in 28 patients with symptoms allegedly caused by electricity or visual display units

Index	*n*	%
Anamnestic dysfunction index *		
A0	16	57
AI	3	11
AII	9	32
Clinical dysfunction index†		
D0	13	46
DI	7	25
DII	7	25
DIII	1	4

* A0 = no subjective symptoms; AI = temporomandibular joint (TMJ) sound, tiredness; AII = TMJ pain, locking, luxation, opening capacity < 40 mm.
† D0 = no dysfunction; DI = mild dysfunction; DII = moderate dysfunction; DIII = severe dysfunction.

Saliva analysis

The unstimulated flow rates ranged from 0.00 mL/min to 1.00 mL/min, and the mean flow rate was 0.35 mL/min. Three patients (10.7%) had an unstimulated saliva flow rate below 0.1 mL/min. The stimulated saliva flow rate ranged from 0.29 mL/min to 4.00 mL/min, and the mean flow rate was 1.9 mL/min. One patient had a stimulated saliva flow rate below 0.7 mL/min. One patient had no secretion of the minor mucous glands, 11 (39%) had low secretion, 12 (43%) had average secretion, and 4 (14%) had high secretion.

Urinary-Hg analysis and epicutaneous patch test

The mercury content in urine was measured in 26 of the 28 patients. The mean U-Hg concentration was 8.5 nmol/L (range, 1.0–24.1 nmol/L). The U-Hg concentration was positively correlated with the numbers of amalgam fillings ($P < 0.01$) and craniomandibular disorders ($P < 0.05$). Five of the 28 patients fulfilled the criterion for the epicutaneous patch test, and the results revealed hypersensitive reaction to gold in combination with cobalt in 1 patient. No other positive reactions to the dental test substances were found.

Discussion

The symptom profile reported in the present study, including both general and oral complaints, is very similar to those described in other studies (3–9). The relatively high frequency and intensity of oral complaints among patients with symptoms allegedly caused by electromagnetic fields suggest that these patients often consult their dentists, which is also our clinical experience. Nearly one-third of the patients studied reported that they had various medical diseases that might be related to their symptoms.

Periodontal disease and TMJ dysfunction were rather common in these patients. Neither the frequency nor the severity of these symptoms and diseases differed from that in the normal population reported by Agerberg & Bergenholtz (28).

Even if no severe oral mucosal lesions could be found and no patient fulfilled the criteria for biopsy, the importance of an oral mucosal investigation should not be underestimated.

The fact that 43% of the patients had no or low secretion of the minor mucous glands is an important finding. The causes behind the decreased secretion of these glands are still unknown (29), but side effects of medication and psychologic processes have been suggested as causative factors (30).

Regarding the urinary-Hg analysis, none of the patients showed levels of U-Hg concentration above the limit of 50 nmol/L; in fact, the highest level recorded was 24.1 nmol/L. The belief that exposure of dental amalgam fillings to electromagnetic fields increases the release of mercury vapor has no support in this study, but the number of amalgam fillings and presence of craniomandibular disorders seem to be important for the U-Hg concentration. Only one patient showed a hypersensitivity reaction to gold and cobalt that was considered clinically relevant by the dermatologist. This patient had severe burning mouth syndrome and gustatory disturbance, symptoms that have been reported by Bergdahl (9) to be common among patients who relate their problem to electromagnetic fields.

In summary, the odontologic diagnoses of the patients with symptoms allegedly caused by electromagnetic fields underline the importance of seeking odontologic expertise when investigating such patients. The diagnosis environmental illness or multiple chemical sensitivity syndrome should, at least in some patients, be regarded as a misdiagnosis.

This study indicated that various factors of odontologic nature might be associated with some of these patients' suffering. Therefore, it is important that professionals from other disciplines collaborate with dentistry if these patients are to be properly investigated. The management of these patients, according to the management protocol developed at the Department of Oral Diagnosis, Umeå University, is considered to fulfill the demands for good care and adequate treatment.

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