INTRODUCTION

Osteoarthritis (OA) is the most common joint disorder leading to pain and disability (Dieppe and Lohmander, 2005). In individuals under 45 yrs of age, the prevalence of OA is around 5% and increases rapidly after the age of 55 yrs (Cicuttini and Spector, 1995; Haara et al., 2003). Finger joints are most frequently affected in women (Felson et al., 2000). Genetic susceptibility, obesity, mechanical stress, and traumatic injuries have also been associated with finger OA (Felson et al., 2000; Corti and Rigon, 2003; Haara et al., 2003).

Repetitive work tasks, overuse of the joints, and fatigue of the muscles that protect the joints may increase the risk of OA (Lawrence, 1961; Radin et al., 1971). An increase in hand OA in joints that were used repetitively compared with other joints has been reported (Lawrence, 1961; Hadler et al., 1978; Schmid et al., 1999). It seems plausible that stereotyped repetitive tasks for prolonged periods of time increase the risk of finger OA among dentists. However, no differences were found in the prevalence of radiographic changes between female dentists and controls (Lehto et al., 1990). A recent study by our group showed that female dentists had a lower prevalence of finger OA than did female teachers (Solovieva et al., 2005).

Our aim was to investigate, among female dentists, whether the pattern of work tasks during work history is associated with (1) OA in any finger joint or (2) the localization of OA in the fingers that are used the most.

MATERIALS & METHODS

Study Design and Subjects

The study base consisted of the 45- to 63-year-old female dentists in the public and private sectors registered in the Finnish Dental Association, representing 98% of the active and non-active dentists within Finland in 2002. That year, a questionnaire was sent to 436 dentists randomly selected from the register, with the place of residence (Helsinki or its neighboring cities) as an inclusion criterion. Those who agreed to participate in the study underwent a clinical examination between October, 2002, and March, 2003.

Participation in the study was voluntary and based on the participants' informed consent. The Hospital District of Helsinki and Uusimaa Ethics Committee for Research in Occupational Health and Safety approved the study protocol.
Hand Radiography and Image Analysis

Both hands of the participants were radiographed. Kodak x-ray films were exposed with Siemens x-ray equipment (48 kV, 10 mAs, focus film distance 115 cm). The radiographs were evaluated by an experienced radiologist who was blind to the occupation, age, and the participants' health data.

Each finger joint of both hands was evaluated for OA, and classified into 4 grades compared with reference images (Solovieva et al., 2005): 0 = no OA, 1 = doubtful OA, 2 = mild OA, 3 = moderate OA, and 4 = severe OA. The present scale was modified from the original Kellgren and Lawrence classification criteria (Kellgren and Lawrence, 1957), with less emphasis on the importance of osteophytes, especially in the definition of mild OA. The Kellgren and Lawrence criteria have been criticized for assuming that joint space narrowing occurs after osteophyte formation (Hart and Spector, 2000). The weighted Kappa coefficients of the readings varied from 0.59 to 1.00.

Finger OA was defined to be present if there was a radiograph reading of grade 2 to 4 in any finger. OA in at least one joint of the thumb, index, and middle fingers was compared with OA in at least one joint of the ring and little fingers. OA was defined to be symmetrical if the same joint was affected in both hands.

Questionnaires and Interviews

Self-administered questionnaires included items on anthropometric measures, occupational exposure (number of yrs in dental practice and in clinical practice, main work tasks), daily manual activities (use of computer, leisure time physical activities, other hobbies and household chores), family history of Heberden's nodes (bony excrescences that appear on the distal finger joint), and smoking history.

Body mass index (BMI) [weight (kg) per height squared (m²)] was calculated based on self-reported height and measured (during the clinical examination) weight. BMI was put into tertiles for analyses (low, < 22.5 kg/m²; medium, 22.5-25.5 kg/m²; high, > 25.5 kg/m²).

Work History Assessment

Six main tasks in dental work were identified prior to the study: (1) restorative treatment and endodontics, (2) orthodontics, (3) periodontics, (4) prosthodontics, (5) surgical treatment, and (6) other non-treatment activities (e.g., dental examination, consulting, and administrative tasks). The participants were asked to recall their work history in 10-year periods (at the ages of 25-34, 35-44, and 45-54 yrs) in terms of average number of working hours per week, and the proportion of time (percentage) they performed each task during an average working day.

Statistical Analyses

We applied general linear modeling, with the repeated-measures design as an extension of analysis of variance, to test significant differences among means of the total time, hrs with patients, and hrs of the main work tasks per week, measured several times (at the ages of 25-34, 35-44, and 45-54 yrs, and in the preceding 12 mos). This model uses the multivariate test of significance with the correlated responses on multiple dependent variables. Age was used as a covariate in the analyses. We performed the analysis to evaluate heterogeneity of the dental work tasks during work history, and to justify the need of identification of groups with common work task patterns.

The pattern of work tasks during work history was empirically defined by cluster analysis with the K-means algorithm. A classification procedure was performed based on the weekly duration of five work tasks (1-5, see above). Assignment of a case to a cluster is dependent on the center closest to the case in Euclidean distance (Dillon and Goldstein, 1984). The differences between and among the clusters in age, yrs in practice, and work time were compared by one-way analysis of variance, and in proportion to specialized and private practice by the chi-square test.

The prevalence of OA in the left and right hands was compared by Fisher's exact probability test. The association between the pattern of dental work tasks and OA was investigated by logistic regression analysis. Age, family history of Heberden's nodes, BMI, specialization (general practitioner/specialist), the number of yrs in clinical practice, daily use of computer (hrs), daily manual activities (hrs), and smoking history (never/ever) were used as covariates in the analyses.

Table 1. Distribution of Time Spent on Each Work Task during Different Age Periods in the Work History (mean ± SD): Comparison between General Practitioners and Specialists

<table>
<thead>
<tr>
<th></th>
<th>At the Age of</th>
<th>During the Preceding 12 mos</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25-34 yrs</td>
<td>35-44 yrs</td>
</tr>
<tr>
<td></td>
<td>GP1 Specialists</td>
<td>GP Specialists</td>
</tr>
<tr>
<td>Total working hrs per wk³</td>
<td>33.6 ± 8.5</td>
<td>36.8 ± 8.3</td>
</tr>
<tr>
<td>Total hrs with patients</td>
<td>28.6 ± 8.2</td>
<td>33.4 ± 8.6</td>
</tr>
<tr>
<td>Restorative treatment</td>
<td>19.5 ± 7.5</td>
<td>20.2 ± 11.3</td>
</tr>
<tr>
<td>Periodontics³</td>
<td>0.7 ± 1.9</td>
<td>3.7 ± 8.7</td>
</tr>
<tr>
<td>Dental restorative treatment and endodontics³</td>
<td>3.9 ± 2.8</td>
<td>4.9 ± 5.3</td>
</tr>
<tr>
<td>Prosthodontics³</td>
<td>2.3 ± 2.3</td>
<td>2.6 ± 2.9</td>
</tr>
<tr>
<td>Surgical treatment</td>
<td>2.2 ± 2.3</td>
<td>2.6 ± 5.8</td>
</tr>
<tr>
<td>Hrs of administrative work³</td>
<td>4.9 ± 4.0</td>
<td>3.3 ± 3.8</td>
</tr>
</tbody>
</table>

1 GP, general practitioners.
2 P value for the historical time trend.
3 P value < 0.02 for the comparison of the marginal means between the general practitioners and specialists. General linear model with the repeated-measures design. Mean values are adjusted for age (in yrs).
were controlled for as potential confounders. Adjusted odds ratios (OR) and their 95% confidence intervals (CI) were calculated.

Analyses were performed with the SPSS statistical package (Statistical Package for the Social Sciences, version 12.0.1, SPSS Inc., Chicago, IL, USA).

RESULTS

Of all (N = 1584) female dentists aged 45-63 yrs who were members of the Finnish Dental Association in 2002, 561 were living in Helsinki or its neighboring cities. A questionnaire was sent to 436 of these randomly selected from the register, and of those, 295 (68%) dentists participated in the clinical examination. Four subjects did not answer the questions on work history, and thus 291 dentists were eligible for the analysis.

Dentists' Work History

In total, 262 dentists (90%) were occupationally active during the preceding 12 mos, 13 were retired, and 16 had stopped working due to other reasons. The mean age of the dentists was 54 yrs (median, 54; SD, 6; range, 45-63 yrs), and the mean duration of dental practice was 26 yrs (median, 27; SD, 7; range, 11-40 yrs). The majority (79%) of the dentists were general practitioners, and 60 (21%) were specialists (24 periodontists, 25 orthodontists, six prosthodontists, and five who specialized in surgical treatments). Fifty-five percent of the dentists were private practitioners.

Restorative treatment and endodontics were the most common work tasks (Table 1). The general practitioners spent most of their work time on restorative treatment and endodontics (19.5 hrs at the age of 25-34 yrs, and 17.6 hrs at the age of 45-54 yrs). The specialists' time spent on restorative treatment and endodontics was reduced from 20.2 hrs at the age of 25-34 yrs to 4.5 hrs at the age of 45-54 yrs, while time spent on orthodontics increased from 3.7 hrs to 12.6 hrs, accordingly.

Empirically Defined Pattern of Work Tasks during Work History

Based on the weekly hrs of 5 work tasks, 3 clusters were identified: Cluster 1 (high variation) consisted of 96 (33%) dentists who performed a mixture of different work tasks; cluster 2 (moderate variation) of 64 (22%) dentists who spent half of their work time on restorative treatment and endodontics and another half on prosthodontics, periodontics, and surgical treatment; and cluster 3 (low variation) of 131 (45%) dentists mainly performing restorative treatment and endodontics. The distribution of time spent on each work task during different age periods (in the work history) by work cluster is shown in the Fig. The dentists with high variation in dental work tasks were younger and worked for fewer hours per week than did the dentists with moderate or low variation in work tasks (Table 2).
Table 3. Association of Age, Family History of Heberden’s Nodes, Body Mass Index (BMI)\(^1\), Specialization (General Practitioner/Specialist), and Pattern of Work Tasks with Finger Osteoarthritis (OA) among Dentists

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>OA in Any Finger Joint</th>
<th>OA in Any Joint of the Thumb, Index, and Middle Fingers</th>
<th>OA in Any Joint of the Ring and Little Fingers</th>
<th>Symmetrical OA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR(^2) 95%CI</td>
<td>OR 95%CI</td>
<td>OR 95%CI</td>
<td>OR 95%CI</td>
</tr>
<tr>
<td>Age</td>
<td>1.12 1.07-1.18</td>
<td>1.16 1.10-1.24</td>
<td>1.12 1.07-1.17</td>
<td>1.15 1.09-1.21</td>
</tr>
<tr>
<td>Family history of Heberden’s nodes</td>
<td>No 1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Yes 1.94 1.15-3.28</td>
<td>2.51 1.33-4.73</td>
<td>1.75 1.04-2.93</td>
<td>2.03 1.15-3.59</td>
</tr>
<tr>
<td>BMI(^1)</td>
<td>Low 1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Medium 1.34 0.72-2.49</td>
<td>0.73 0.33-1.62</td>
<td>1.31 0.71-2.44</td>
<td>1.26 0.63-2.53</td>
</tr>
<tr>
<td></td>
<td>High 2.24 1.17-4.31</td>
<td>2.13 1.02-4.48</td>
<td>1.90 1.00-3.62</td>
<td>2.10 1.05-4.20</td>
</tr>
<tr>
<td>Specialization</td>
<td>GP 1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Specialists 1.22 0.63-2.35</td>
<td>0.94 0.42-2.09</td>
<td>1.43 0.75-2.73</td>
<td>1.02 0.50-2.09</td>
</tr>
<tr>
<td>Pattern of work tasks</td>
<td>Cluster 1 1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Cluster 2 1.68 0.81-3.46</td>
<td>2.13 0.85-5.36</td>
<td>1.75 0.86-3.59</td>
<td>1.05 0.46-2.40</td>
</tr>
<tr>
<td></td>
<td>Cluster 3 1.59 0.86-2.93</td>
<td>2.22 1.04-4.91</td>
<td>1.53 0.83-2.82</td>
<td>1.95 0.98-3.86</td>
</tr>
</tbody>
</table>

\(^1\) Logistic regression analysis. BMI (tertiles): low = BMI < 22.5 kg/m\(^2\); medium = BMI 22.5-25.5 kg/m\(^2\); high = BMI > 25.5 kg/m\(^2\). GP, general practitioner. Cluster 1: dentists who have performed variable work tasks. Cluster 2: dentists who have spent half of their work time on restorative treatment and endodontics, and another half on prosthodontics, periodontics, and surgical treatment. Cluster 3: dentists who have spent most of their work time on restorative treatment and endodontics.

\(^2\) Odds ratios (OR) and their 95% confidence intervals (95%CI) were adjusted for yrs in clinical job, daily use of computer (hrs), leisure time physical activity (hrs), daily activities requiring use of hand (hrs), and smoking history (never/ever).

Effect of Pattern of Dental Work Task History on Finger Osteoarthritis

The prevalence of OA in any finger joint was 48%, and that in the thumb, index, and middle fingers 24%, in the ring and little fingers 46%, and of symmetrical OA 32%. The joints of the ring and little fingers were more frequently affected by OA than were the thumb, index, and middle fingers (46% vs. 36%, p < 0.0005, Fisher’s exact probability test), whereas there was no difference between the right and left hands in the prevalence of OA. All types of OA were slightly more prevalent among the specialists than among the general practitioners.

The dentists in cluster 3 had a two-fold risk of OA in the thumb, index, and middle fingers than those in cluster 1 (Table 3). To explore further the association between the pattern of work task history and the localization of OA, we repeated the analysis for the left and right hands separately. Allowing for other risk factors, the dentists in clusters 2 and 3 had higher odds of OA in the thumb, index, and middle fingers in the right hand (OR 2.84, 95%CI 1.04-7.85; OR 3.05, 95%CI 1.00-9.34, respectively) and in the left hand (OR 2.57, 95%CI 1.09-6.05; OR 2.54, 95%CI 0.96-6.74, respectively) compared with the dentists in cluster 1. There were no statistically significant associations between the pattern of work task history and other types of OA. Age, family history of Heberden’s nodes, and high BMI were associated with all types of OA.

DISCUSSION

The present study showed, for the first time, that the pattern of work tasks during the work history was related to OA in the joints of the thumb, index, and middle fingers among female dentists. The less variation in the work tasks, the higher was the risk of finger OA.

Our study has a few limitations. We studied only women, due to the predominance of hand OA among women (Felson et al., 2000). The possibility of different findings among male dentists cannot be ruled out. Middle-aged subjects were studied because of their sufficiently long work history, and due to the low prevalence of hand OA before the age of 45 yrs. Restriction of the study population to the greater Helsinki area was made for reasons of feasibility related to the arrangement of clinical examinations. The results probably fairly well reflect the occurrence of finger OA in female dentists more generally, since dentistry is an occupation with a relatively consistent work profile. The study design precluded the assessment of an effect of hand workload on the incidence of osteoarthritis. The occupational exposure was retrospectively assessed with a detailed questionnaire. Recall bias may have affected the accuracy of the information gathered about the time spent for each work task by each participant.

As in previous studies, age, obesity, and family history of Heberden’s nodes showed an association with OA in any finger joint and with symmetrical OA. BMI was a determinant for finger OA and for symmetrical OA in a Finnish cohort (Haara et al., 2003). The association between BMI and OA in non-weight-bearing joints suggests a metabolic mechanism (Hart and Spector, 1993). Heberden’s nodes have often been used as a marker of generalized OA (Kellgren and Moore, 1952), and the familial type of Heberden’s nodes is mostly seen in women (Felson et al., 2000). The possibility of different findings among male dentists cannot be ruled out. Middle-aged subjects were studied because of their sufficiently long work history, and due to the low prevalence of hand OA before the age of 45 yrs. Restriction of the study population to the greater Helsinki area was made for reasons of feasibility related to the arrangement of clinical examinations. The results probably fairly well reflect the occurrence of finger OA in female dentists more generally, since dentistry is an occupation with a relatively consistent work profile. The study design precluded the assessment of an effect of hand workload on the incidence of osteoarthritis. The occupational exposure was retrospectively assessed with a detailed questionnaire. Recall bias may have affected the accuracy of the information gathered about the time spent for each work task by each participant.

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injury and hand OA, has not always been supported empirically (Lane et al., 1989; Caspi et al., 2001; Jones et al., 2002; Haara et al., 2004). A beneficial effect of physical activity of moderate intensity on the strength of the muscles and ligaments has been suggested (Rogers et al., 2002). Repetitive movements with relatively low muscle activity may not result in muscle tissue damage, whereas continuous overload of finger joints resulting from highly monotonous usage may lead to joint impairment (Mackinnon and Novak, 1997).

The development of OA depends on a generalized predisposition to the condition (Cooper, 1995), and thus the type of work performed more likely affects the localization of OA within the hand than the development of the disease itself (Hadler et al., 1978). The analysis of the dentists’ work history revealed three patterns that differed by the distribution of performed work tasks. Nearly half of the dentists performed restorative treatment and endodontics more frequently than they performed prosthodontics, periodontics, or surgical treatment.

A high degree of muscular activity has been recorded during work tasks such as amalgam and root filling and tooth extraction (Milerad et al., 1991). In our study, there may have been differences in hand workload between and among the observed work history patterns. The results of this study support the hypothesis that extensive use of particular fingers (thumb, index finger, and middle finger) is associated with OA in the joints of these fingers. Workload history seems to be less important in the etiology of OA in the ring and little fingers, or in symmetrical OA.

In conclusion, among middle-aged female dentists, the pattern of dental work task history is associated with the localization of osteoarthritis in the fingers. Such individuals might achieve a decrease in the prevalence of work-related osteoarthritis by avoiding monotonous work tasks.

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