Hand-arm vibration syndrome in dentistry: a questionnaire survey among dentists and review of literature

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Presentation Plan

• Background
• Methods
• Results
• Discussion
• Conclusion
Background

• The prevalence of MSK disorders is high among all dental professionals and has been studied worldwide, leading to serious impact on quality of life.
• Females show a higher prevalence than males in some studies.
• Use of dental tools are related to repetitive movements of the hand and fingers, pinch force, static and asymmetrical posture, precise hand movements, awkward postures of the wrist, high-frequency vibration, as well as other factors, such as poor visibility, lack of breaks between patients and high job demand.
Background

- Handpieces and ultrasonic scalers expose dental professionals to high-frequency mechanical vibration, ranging from 0.5 kHz to 50 kHz.
- Air turbines and micromotor handpieces are used for tooth preparation, removal of decays, root canal treatments, restorations, implants surgery, bone cutting procedures and various other procedures.
- Traditional handpieces are either air-driven or electrically driven, running with high or low-speed.
- High-speed electric handpieces operate in the range of 200,000 rpm.
- High speed air-driven handpieces: up to 400,000 rpm.
- Low-speed handpieces used for polishing and removing decays between 20,000 rpm to 40,000 rpm.
- Gear reduction of speed used in low-speed micromotor.
Background

- **Sonic and ultrasonic scalers** are frequently used by dentists, specialists and dental hygienists for periodontal procedures.

- They operate in a wide range of frequencies:
  - Around 3-8 kHz for sonic scalers
  - 18-45 kHz for piezoelectric ultrasonic scalers
  - 25-50 kHz for magnetostrictive scalers

Early studies have shown that dental professionals exposed to high-frequency dental tools have shown neurological and vascular symptoms, especially in the dominant hand, comparable to hand-arm vibration syndrome dating back to 1980.
More Research

Ultrasonic dental scaler: associated hazards


It is unclear from current research as to whether the handpiece vibration causes “white finger” in dental personnel. Research is needed to aid in the development, design and production of an ultrasonic handpiece that will eliminate any vibration hazards to the operator.
High-speed air-driven

Figure 3. Contemporary high-speed air-driven handpieces

Figure 2. Air-driven handpiece turbines

Little, D., 2011
Low-speed air-driven handpieces

Figure 5. Contemporary low-speed air-driven handpiece attachments

Little, D., 2011
Micromotor Electric

Figure 8. Electric motor attachments and speed reducers

Little, D., 2011
Burs

Figure 16. MultiPrep burs

Figure 23. #4 round carbide bur removing decay at slow speed

Little, D. 2011
Air-turbine
Dental Hygiene Instruments

Figure 1 Dental instruments with different diameter
Ultrasonic Scalers
Methods

- Survey among dentists
- Review of literature
  - Vibration assessment of dental vibrating tools
  - HAVS and related disorders in Medline&Embase, inception-2022

Keys words: ultrasonic scalers, dental handpieces, occupational exposure or vibration exposure, dent* or dental personnel or oral health or dental specialists, dental hygienist, and dental laboratory technicians, musculoskeletal pain or disorders, hand-arm vibration syndrome, neuropathy, sensorineural disorder, carpal tunnel syndrome

Inclusion & exclusion criteria
French & English
Survey among dentists- Société Dentaire de Québec

- Short self-administered questionnaire
- Presentation during a annual meeting
- Email to 350 dentists
- Data collection from september 2016- January 2017

Publication in Dental Journal, August 2016
Hand-arm vibration syndrome among dental professionals

Identification
- Records identified from Medline: Embase: Databases (n = 891)
- Records removed before screening: Duplicate records removed (n = 12)
- Records removed for other reasons: plagiarized, retracted, n = 5

Screening
- Records screened and added reference (n = 16)
- Reports sought for retrieval (n = 535)
- Reports excluded (n = 5)
- Reports not retrieved (n = 5)
- Reports assessed for eligibility (n = 350)
- Reports excluded:
  - Other language (n = 2)
  - Different body locations not specified (n = 70)
  - General review on CTS or MSK (n = 19)
  - Review of literature (n = 35)
  - Ergonomic evaluation (n = 10)
  - Letter to editors (n = 2)
  - Retirement (n = 4)

Included
- Studies included in review:
  - n = 161 MSK for hand/ wrist/ finger pain
  - n = 43 for carpal tunnel syndrome
  - n = 23 for HAVS, vascular and neuropathy
  - n = 6 for osteoarthritis

Figure 1. HAVS and dentists
Results of Vibration Assessment
Vibration Assessment

• Handpieces are mostly studied for their cutting & torque efficiency, noise & pinch force or tool handle shape for non-vibrating curettes.
• Information on vibration characteristics of dental handpieces is sparse.
• Vibration assessment is challenging:
  ✓ high frequency of oscillation & small associated displacement amplitude,
  ✓ technical problems relating to the adding mass of the accelerometer,
  ✓ replication of actual work during restorative procedures & periodontal work.
• Interpretation of results due frequency weighting giving more importance to low-frequency vibration.
Vibration Assessment

• 8 studies: air-turbine, micromotor turbines, dental grinders,
• 2 studies: ultrasonic scalers
• Different methodologies:
  ✓ Accelerometer during normal work or simulated drilling on polyacetal plates
  ✓ Laser scanning vibrometer, portable digital vibrometer

• Measurements during idling or drilling

Dental tools generate high-frequency vibrations >1000 Hz
Hjortsberg 1989: High-Speed Grinders, 30,000 rpm

Figure 1. One-third octave spectrum of a workpiece (number 1) and a handheld high-speed grinder at 30,000 revolutions/ min (number 2).
Rytkönen and Sorainen, 2001

- Neither the water and air injection nor the grip force of fingers had any significant effect on the vibration level.
- During idling, the weighted vibration of used micromotor handpieces was on average twice as high as that of the new ones.
- During drilling, the ultravibration was one to six fold compared with idling.
- Drilling increase the vibration of handpieces and the vibration became more broadband.
Rytkönen, 2006

22 dental handpieces recorded during normal work in one direction
Non-contact vibration during idling with Portable Digital Vibrometer

![Image](image-url)

**Fig. 1** Fixating of the accelerometer. Micromotor handpiece on the left and air-turbine handpiece on the right

**Fig. 2** Vibration measurement positions using laser method
Table 1: Handpieces and measuring results

<table>
<thead>
<tr>
<th>Identification of the handpiece</th>
<th>Measuring time (min)</th>
<th>Weighted vibration (m/s²)</th>
<th>Ultravibration (m/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>0.4</td>
<td>0.01</td>
<td>100</td>
</tr>
<tr>
<td>T2</td>
<td>1.4</td>
<td>0.01</td>
<td>80</td>
</tr>
<tr>
<td>T3</td>
<td>0.2</td>
<td>0.01</td>
<td>200</td>
</tr>
<tr>
<td>T4</td>
<td>3.7</td>
<td>0.01</td>
<td>100</td>
</tr>
<tr>
<td>T5</td>
<td>0.8</td>
<td>0.02</td>
<td>80</td>
</tr>
<tr>
<td>T6</td>
<td>0.2</td>
<td>0.04</td>
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<tr>
<td>T7</td>
<td>1.1</td>
<td>0.03</td>
<td>80</td>
</tr>
<tr>
<td>T8</td>
<td>0.7</td>
<td>0.01</td>
<td>40</td>
</tr>
<tr>
<td>T9</td>
<td>0.5</td>
<td>0.01</td>
<td>50</td>
</tr>
<tr>
<td>T10</td>
<td>0.8</td>
<td>0.01</td>
<td>100</td>
</tr>
<tr>
<td>M1</td>
<td>1.5</td>
<td>0.4</td>
<td>9</td>
</tr>
<tr>
<td>M2</td>
<td>1.3</td>
<td>0.3</td>
<td>10</td>
</tr>
<tr>
<td>M3</td>
<td>2.5</td>
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<td>2.1</td>
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<td>M5</td>
<td>1.8</td>
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<tr>
<td>M6</td>
<td>3.4</td>
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<tr>
<td>M7</td>
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<tr>
<td>M8</td>
<td>0.9</td>
<td>0.3</td>
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<td>0.3</td>
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</tr>
<tr>
<td>M12</td>
<td>4.5</td>
<td>0.3</td>
<td>30</td>
</tr>
</tbody>
</table>

T air-turbine handpiece, M micromotor handpiece

Fig. 3: Vibration 1/3-octave spectra of the air-turbine handpieces (n=12)

Fig. 4: Vibration 1/3-octave spectra of the micromotor handpieces (n=10)
Rytkönen and Sorainen, 2006

During work

- The weighted vibrations of air-turbine handpieces: 0.01–0.04 m/s²
- The weighted vibrations of micromotor handpieces: 0.2–0.9 m/s²
- The drilling time per one patient varied from 0.2 to 4.5 min, which means that the daily vibration exposure time of dentists is below 2.5m/s² (assuming vibration equal in all 3 directions)
Ultrasonic Scalers

Scanning laser vibrometer for assessing dental ultrasonic scalers is still at an early stage of development.

Vibration patterns are difficult to quantify due to their high frequency of oscillation.

The oscillation patterns along the length of the scaling tip do vary with water flow rate and power setting.

The tip produces a node (point of zero movement) at 4 mm from the free end of the tip.

Poole, 2002, 2004
Results of the survey among dentists
Survey Among Dentists

71 dentists (f: 37, m: 30). Four incomplete questionnaires. Low response rate (71/350)

Years of practice: 0–10 years (n = 19), 11–20 y (n = 11), 21–30 y (n = 26), to more than 30 y (n = 11)

85% declared having exposure to handpieces for more than 11 h/week

- White fingers: 20% (f:13, m:1), 4 dentists consulted a physician
- Numbness & tingling: 22%, 6 medical consultations
- Pain or stiffness: 36%
- Cold intolerance: 64%

14 dentists related their disorders to their work
Results of Literature Review

1. Vascular disorder
2. Neurological disorder
3. Carpal tunnel syndrome
4. Wrist/hand/finger pain
5. Osteoarthritis
6. Diminished grip strength
HAVS Vascular Findings

✓ 13 studies (1 abstract)
  • Year: 1989-2021
  • Dental hygienists & students, dentists, dental technicians
  • Study design: Cross-sectional (n = 7), case-control (n = 3), survey among workers seeking compensation (n = 1), longitudinal (n = 1)
  • Methods: Self-administered questionnaire, SK staging Q, cold provocation test (n = 2)
  • Prevalence of symptoms: 1,9%-80%
HAVS: Vascular Findings

No documentation of A(8) for each subject, 1 study with mean cumulative exposure mh/s²

- Higher frequency in dentists/pharmacists ($p < 0.05$) (Milerad, 1990)
- No increase of vascular symptoms in the groups exposed to vibration vs non-exposed (Akesson, 1995)
- Significant positive correlation: prevalence and frequency of cold sensation and daily usage time (h) (Yoshida, 1991)
- 1st and 2nd fingers in hand holding handpiece (Jaques & Burke, 1994)
Neurological Disorder

- 23 studies (1982-2016)
  - Prevalence: 0-94% numbness, clumsiness, loss of dexterity, reduced sensibility, tingling
  - Difficult to distinguish neurological disorder from CTS

- Dentists with long term experience had neurological symptoms in the D hand more often than short term (Ekenvall, 1990)
- Dentists vs pharmacists: RR: 4.2 (CI 95%: 2.3–7.7) (Milerad, 1990)
- Women reported more sensorineural disorders OR: 2.6 (CI 95%: 1.06–6.7) (Zoidaki, 2013)
- Numbness & tingling increase with each hr per week vibrating tools (Morse, 2003)
- Increase risk of high vs low total time dental filling & root canal OR: 1.9 (CI 95%: 1.03–3.6) (Rytkönen, 2006)
- Sensorineural symptoms in dentists: root canal (manual vs. rotor) OR: 3.4 (CI 95%: 1.08–10.9) (Zoidaki, 2013)
- Significant positive correlation: prevalence and frequency of numbness and the daily usage time (h) of high-speed type machines (Yoshida, 1991)
Neurological Disorder Raised VPT and abnormal tests

- **Dental technicians** *(Hjortsberg, 1989)*

- Significant difference between left hands of the dentists and both hands of controls *(Lundström, 1982)*
- Some association between the years of work and vibration thresholds *(Hjorstberg, 1989)*
- Fundamental difference between vibration exposure and other biomechanical risk factors and elevated threshold at 125 Hz *(Warren, 2010)*
- Subset of hygienist: higher prevalence of paresthesias, low grip strength, elevated VPT greater cumulative vibration exposure OR =1.2 (CI 1.01–1.45) *(Cherniak, 2006)*
- Exposed and unexposed fingers were similarly affected: other etiology *(Ekenvall, 1990)*

Decreasing two point discrimination with yrs of practice *(Gibjels 2006, Shabazian 2009)* *(Akesson 1995: no significant difference)*

Carpal Tunnel Syndrome

- 43 studies in dentists, dental hygienists, dental students, dental specialists
- Year: 1985-2021
  - Various diagnostic methods: Questionnaire, Boston CTS questionnaire, Katz diagram, Tinel & Phalen test, nerve conduction tests, vibrometry
  - Symptoms: Numbness, hand weakness, night pain, hand clumsiness, loss of normal sensation, problem with coordination, weakness and fatigue, morning swelling, frequent dropping of objects
  - Female dentists had a significantly greater risk of having CTS symptoms (Alhusain, 2019, Aljunaid, 2012, Alkodier, 2022, Madhsoudipour, 2021, Ohlendorf, 2000, Mubashra, 2022)
  - Increasing with age (Haghighat 2012)
  - Dominant and non-dominant hands (Maghsoudipour 2021)
Carpal Tunnel Syndrome and Dental Work

• The number of heavy calculus patients per day, “clock” position around the dental chair & years in practice (Liss, 1995, MacDonald, 1988, Lalumandier, 2001, Haghighi, 2013)

• Increased number of working hrs/wk OR: 12.667, (95% CI: 1.17- 221.8) (Khan, 2013)

• Number of patients/day: Dental workers who treat between 7-9 patients per day reported 5 or more symptoms more often than workers who treated either fewer patients (p < .05) (Rice, 1996)

• Root canal and operative treatment at higher risk than other practices (Haghighat, 2012)

• Dental students: the use of finger pinch grip showed an inverse association with CTS (P=0.04) (Aljunaid, 2021)
Carpal Tunnel and Vibration Exposure

HAV exposure time > 2hr/day: OR 2.25 (CI 95% 1.23- 4.1) p < 0.001 (Maghsoudipour, 2021)

Mean time of exposure to vibration (hr/day) was significantly higher in the dentists with CTS (3.53 ± 1.26) compared to dentists without CTS (2.83 ± 1.30) (Maghsoudipour, 2021)

14 experienced hygienists with diagnosed CTS/no CTS: twice the average weekly use of vibratory instruments (Cherniak, 2006)

- In dental students: Number of hours using vibrating instruments not associated with the hand and finger discomfort (OR: 0.724, 95% CI: 0.301-1.506) (Khan, 2013)

- In dental students: No significant differences in nerve conduction study between dental students exposed to hand-held vibrating tools for 2 to 6.5 years and medical residents not exposed to vibration (Limbu, 2020)
Musculoskeletal Wrist/Hand/Fingers Pain

✓ 161 studies
• Prevalence of pain: range: 17%-75%
• All dental personnel

No association: (Dantas, 2015- but elbow pain), Garpin, 2017, Khan, 2013)
Positive association with dental work:
✓ Number of hours/day, hrs/week (Decharat, 2016, Kahn, 2013)
✓ Standing (Barghout, 2011)
✓ Inability to select the size of dental tools (Feng, 2014)
✓ Time spend forcefully gripping the tool (Kumar, 2013)
✓ High job demand and stress (Feng, 2015)
Osteoarthritis

- 6 studies: dentists (n=3) female dentists (n=3)
- Study design: case-control (n=1), cross-sectional (n=5)

Arthritic (DIP) joints greater than that in controls < 50 yrs

More severe OA (grade 3 +) in the R-hand thumb-index-middle fingers significantly elevated among the dentists/teachers

  OR: 2.61, (95% CI 1.03–6.59)

Low task variation vs high variation osteoarthritis in the 1rst, 2nd, 3rd

  OR: 2.22, (95% CI 1.04–4.91)

1srt CMC OA Thumb disability female dentist/males:

  adj OR 2.21, (95% CI 1.31-3.56)

Dentists aged >50 years: 9 times higher odds of thumb disability

  adj OR 9.63, (95% CI 1.05-88.47)
Decreased Grip Strength

✓ 6 studies
• Cross-sectional, observational intervention study, case-control, 1995-2016
• Dentists, dental hygienists, dental technicians

Hand weakness (37.5%-85%), lower grip strength vs control group

✓ Significant associations between the full hand grip and the Sensibility Index (SI) of the little finger of the dominant hand within the dentist group
✓ The pinch grip was significantly associated with the SI for the index finger of the dominant hand
✓ Finger pinch force inversely associated with the finger symptoms
✓ Dental hygienist subgroup with a combination of subjective hand weakness, low calibrated pinch force in task simulations, paresthesias, and raised VPTs
Discussion

• Dental handpieces expose dental professionals to high vibration frequency
• Challenging vibration assessment
• Exposure to vibration poorly described in epidemiological studies
• Contributory factors: Hand intensive work, local stress, and high pinch force, confounding factors (age, BMI, medical problems, etc)
• Quality of studies to be reviewed
• High-frequency vibration is absorbed by superficial tissues and tissue structures affecting mechanoreceptors

Salimi-Nezrad, 2018)
Conclusion

• Dental handpieces contain powerful vibration at high-frequency.
• HAVS and related disorders is a concern for dental workers.
• Vibration assessment and frequency weighting.
• Studies on HAVS with adequate protocol among dental professionals.
• Workplace to be designed and fitted in accordance with the principles of ergonomics.
• Maintenance of dental tools, lighter tools.
• More researches

https://www.youtube.com/watch?v=4-SV8On6yHg
Thank You For Your Attention