

**HAND ARM
VIBRATION**



International conference

6-9 JUNE 2023

Espace Prouvé,
Nancy, France

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

Dr Alice Turcot, MD, MSc, FRCPC, Denis Hamel, Mélanie Tessier

une 2023



Presentation Plan

- Background
- Methods
- Results
- Discussion
- Conclusion

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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

Review Paper

S. C. Trenter and A. D. Walmsley
The School of Dentistry, The University of
Birmingham, St Chad's Queensway,
Birmingham B4 6NN, UK

Trenter SC, Walmsley AD: Ultrasonic dental scaler: associated hazards. J Clin Periodontol 2003; 30: 95–101. © Blackwell Munksgaard, 2003.

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



Little, D. ,2011

Figure 2. Air-driven handpiece turbines



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



Burs

Figure 16. MultiPrep burs

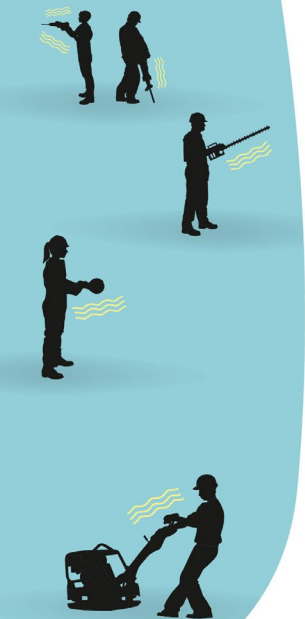


Little, D. 2011

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



Air-turbine



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Dental Hygiene Instruments

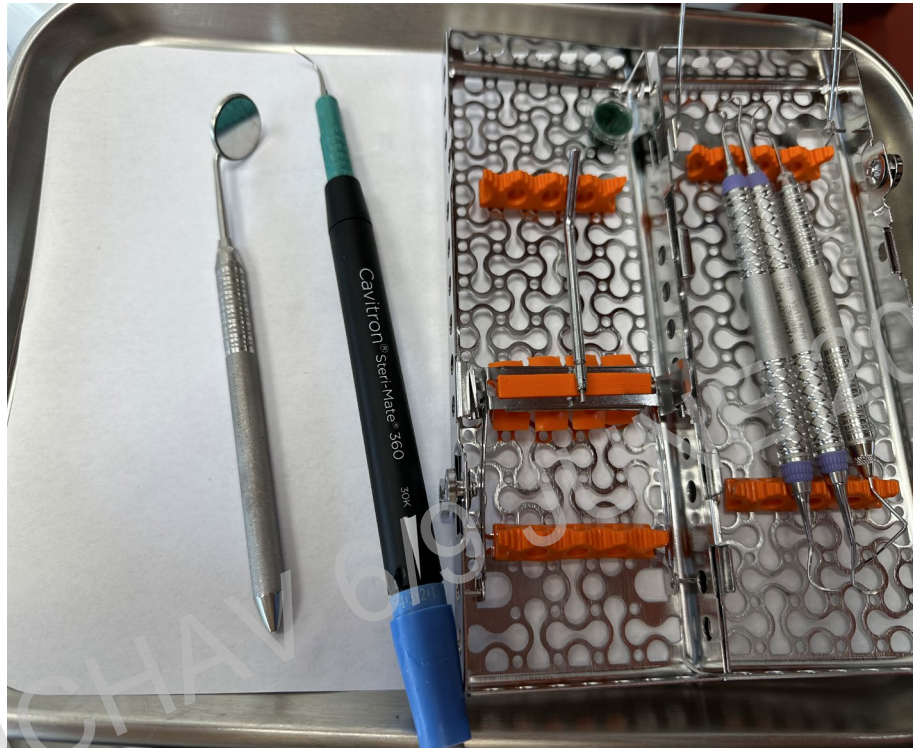
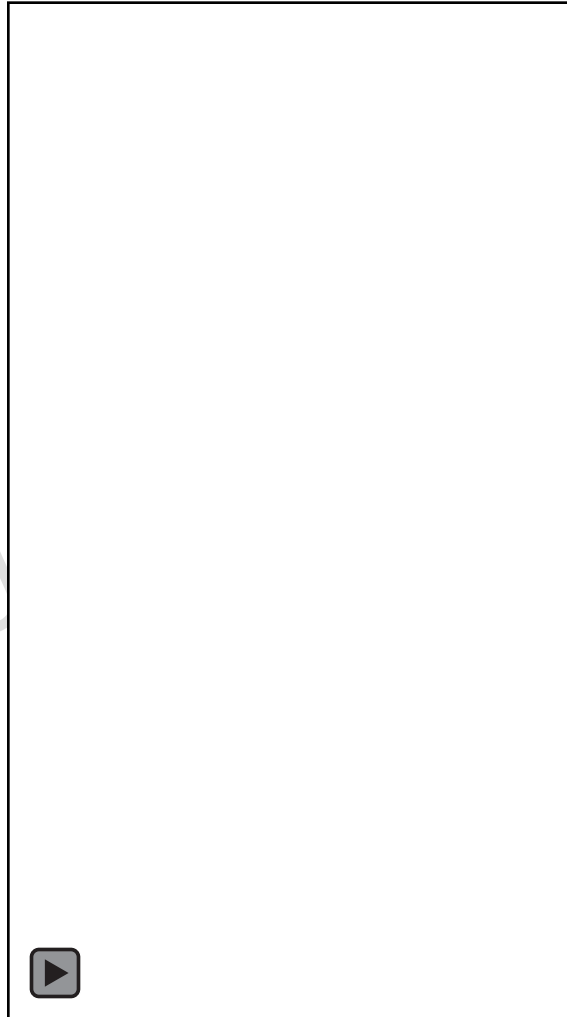
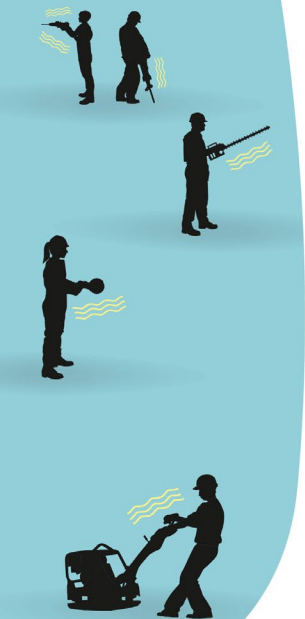


Figure1 Dental instruments with different diameter

Ultrasonic Scalers



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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

www.inspq.qc.ca

Le syndrome vibratoire existe-t-il chez les dentistes?

Sondage auprès des membres de la Société Dentaire de Québec

Alice Turcot, M.D., M.Sc., FRCPC
Denis Hamel, Coordonnateur scientifique, statisticien

Institut national de santé publique Québec

Projet de recherche le syndrome vibratoire

Le comité scientifique, avec l'accord du CA, a décidé de soutenir un projet de recherche local qui touche directement notre profession, soit le syndrome vibratoire. Ainsi, le prochain article vous présentera le but de la recherche et un questionnaire sera disponible sur notre site, à partir du 12 septembre. Il sera aussi distribué en version papier lors de notre première activité scientifique de l'année, en septembre 2016. En tant que membres de la SDQ, nous pouvons jouer un rôle important et très spécifique pour faire avancer le projet en question. Participons tous à ce court questionnaire de 12 questions à réponses rapides sans de surinvestissement! Voici le projet présenté en résumé.

Luc Veilleux

AVEZ-VOUS LES DOIGTS BLANCS ET LES MAINS ENGOURDIES ?

L'utilisation cumulative d'outils vibrants entraîne le syndrome vibratoire main-bras. Ce syndrome est mieux décrit chez les travailleurs qui utilisent des meuleuses, des scies à chaîne, des brise-béton, etc. Pourtant, des études récentes ont montré que les outils de dentisterie : turbine à air, pièce à main électrique ou encore les détarteurs à ultrasons pouvaient générer des vibrations à de hautes fréquences néfastes pour la main et le système main-bras. Des études^{1,2} ont décrit des atteintes caractéristiques du syndrome vibratoire chez les dentistes et le personnel auxiliaire (hygiénistes et techniciens dentaires).

Ce syndrome se caractérise par une atteinte vasculaire, neurologique et musculosquelettique³. Le phénomène de Raynaud (photo), c'est-à-dire la décoloration des doigts décrite par le docteur Maurice Raynaud en 1862, représente la manifestation la plus connue du syndrome vibratoire.

L'atteinte vasculaire se manifeste par des crises paroxystiques de décoloration ou de pâleur franche et bien délimitée des phalanges des doigts, s'accompagnant d'une sensation de doigts morts et d'engourdissements. Cette pâleur est bien distincte de la froideur et de la sensibilité exagérée des doigts en présence de température froide. La crise peut évoluer en trois phases successives : phase blanche, suivie ou non d'une phase cyanique, puis d'une phase d'hyperémie douloureuse. Le réchauffement s'accompagne d'une sensation de picotement. L'exposition des mains au froid ou, plus particulièrement, l'exposition du corps entier au froid environnant et plus spécifiquement au froid humide, déclenche les crises.

L'atteinte neurologique se manifeste par des engourdissements et des picotements. Les symptômes peuvent s'accompagner d'une réduction permanente de la perception sensitive provoquant une maladresse dans l'exécution de gestes fins^{4,5}. Cette neuropathie distale diffuse ne correspond pas à un territoire nerveux distinct. Cependant, si le sujet signale des paresthésies nocturnes et des engourdissements dans le territoire du nerf médian, il peut également souffrir d'un syndrome du canal carpien.

L'atteinte musculosquelettique se manifeste par de la douleur, de la raideur et des limitations articulaires, notamment au niveau de l'articulation interphalangienne distale, de la faiblesse musculaire et une diminution de la force de préhension de la main⁶.

Les différentes atteintes peuvent évoluer séparément et à des rythmes différents. Il semble que les symptômes et les signes neurosensoriels apparaissent en premier, bien que les symptômes vasculaires progressent plus rapidement après leur survenue. La période de latence entre le début de l'exposition aux outils vibrants et l'apparition des doigts blancs varie entre quelques mois et quelques années⁷.

De nombreux travailleurs minimisent les effets de la maladie et considèrent leurs symptômes comme faisant partie de leur travail. Par conséquent, ils songent rarement à consulter un médecin à ce sujet ou tardent à le faire.

Dans le but de mieux mesurer l'ampleur de ce problème parmi les dentistes québécois, nous vous invitons prochainement à compléter un court questionnaire en ligne. Les données recueillies seront confidentielles. Cette étude a été approuvée par le Comité scientifique de la Société Dentaire de Québec.

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Prisma

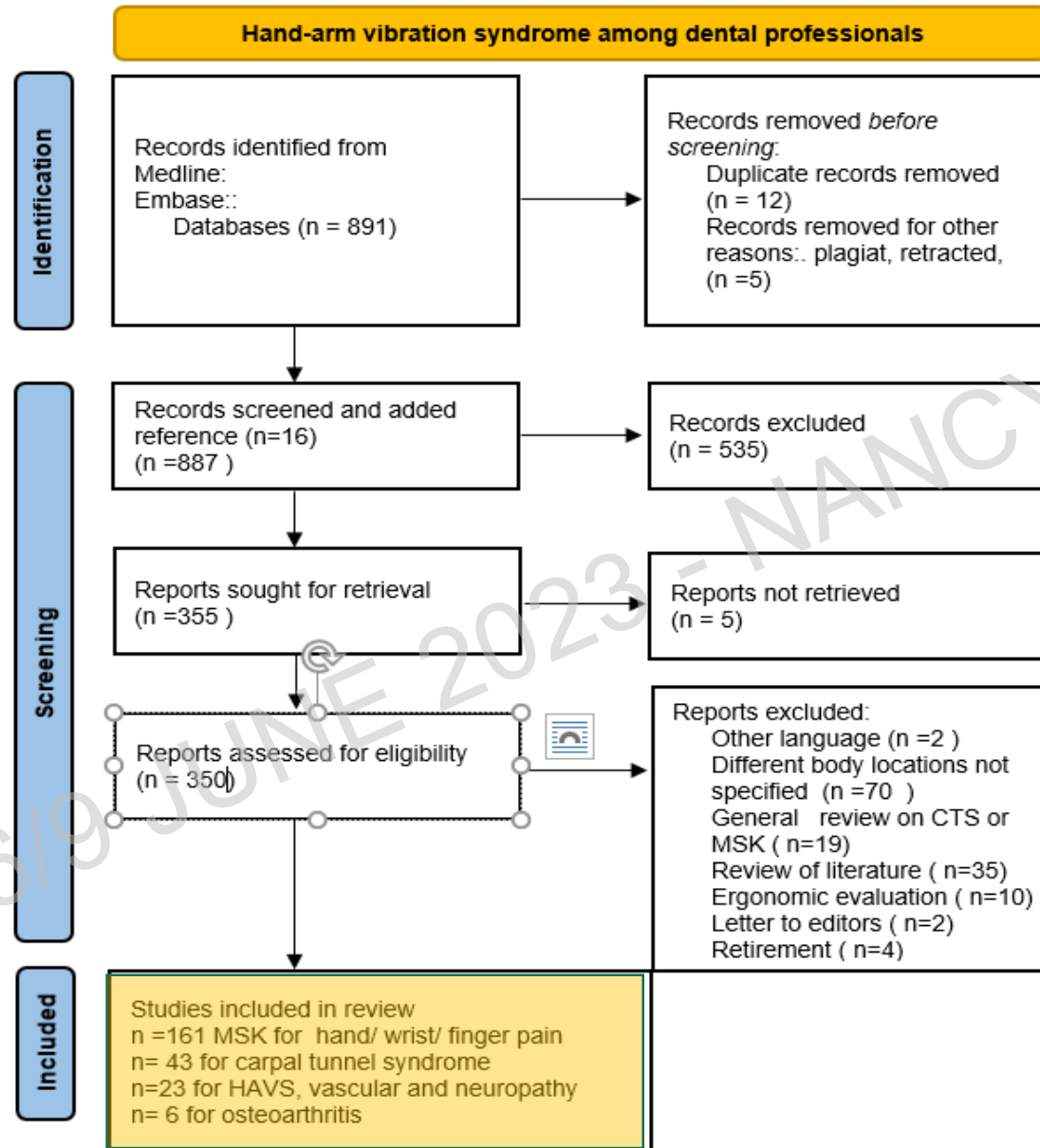


Figure 1. HAVS and dentists

Results of Vibration Assessment

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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

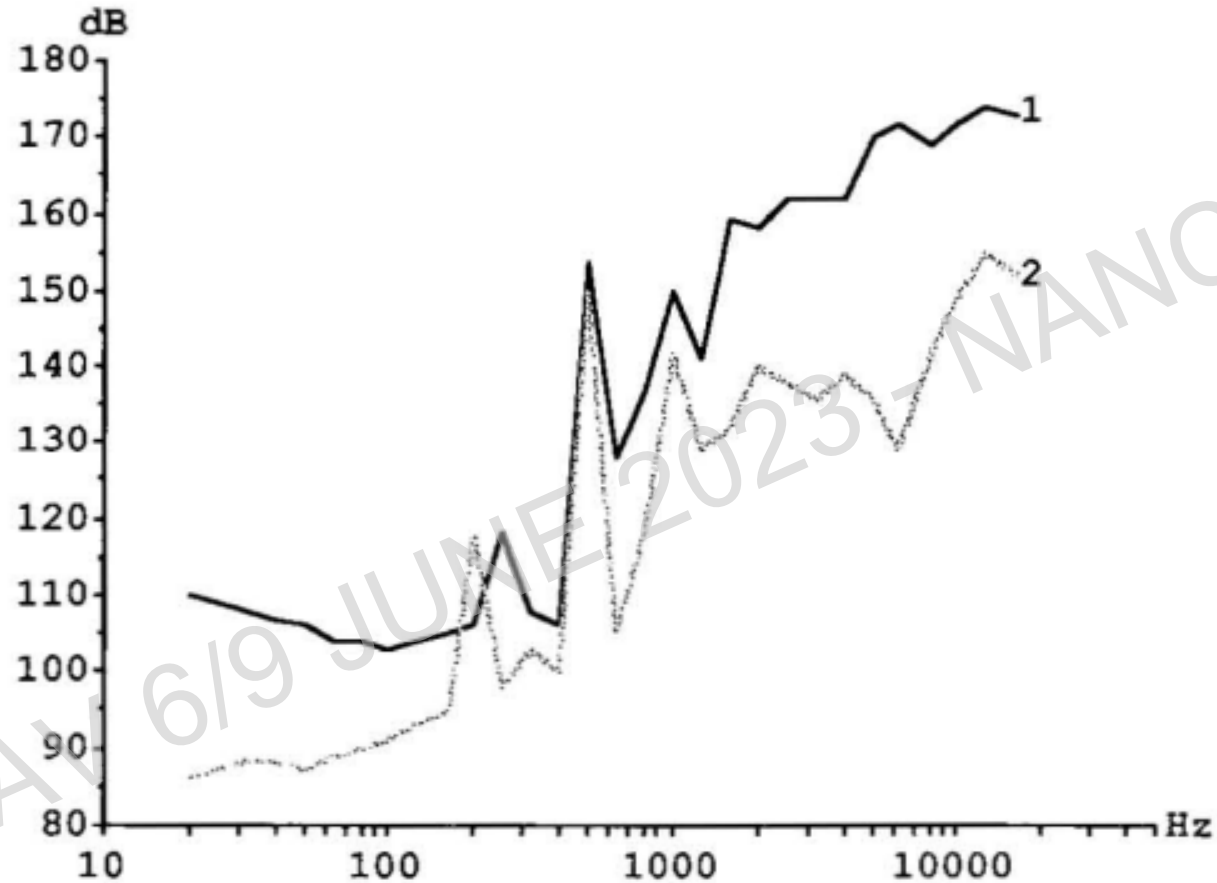


Figure 1. One-third octave spectrum of a workpiece (number 1) and a handheld high-speed grinder at 30 000 revolutions/ min (number 2).

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



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

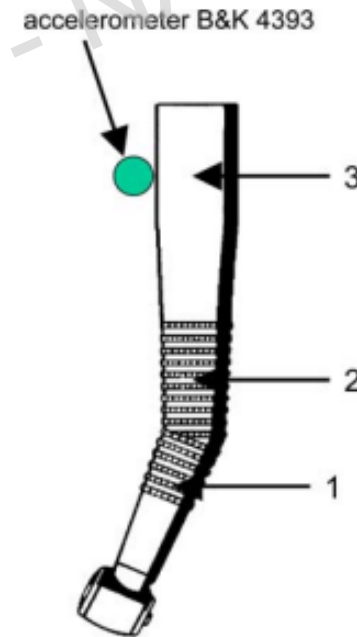


Fig. 2 Vibration measurement positions using laser method

Rytkönen and Sorainen, 2006

Table 1 Handpieces and measuring results

Identification of the handpiece	Measuring time (min)	Weighted vibration (m/s^2)	Ultravibration (m/s^2)
T1	0.4	0.01	100
T2	1.4	0.01	80
T3	0.2	0.01	200
T4	3.7	0.01	100
T5	0.8	0.02	80
T6	0.2	0.04	40
T7	1.1	0.03	80
T8	0.7	0.01	40
T9	0.5	0.01	50
T10	0.8	0.01	100
M1	1.5	0.4	9
M2	1.3	0.3	10
M3	2.5	0.4	6
M4	2.1	0.3	10
M5	1.8	0.3	8
M6	3.4	0.9	10
M7	1.1	0.3	10
M8	0.9	0.3	9
M9	1.7	0.2	20
M10	1.5	0.7	3
M11	2.3	0.3	30
M12	4.5	0.3	30

T air-turbine handpiece, *M* micromotor handpiece

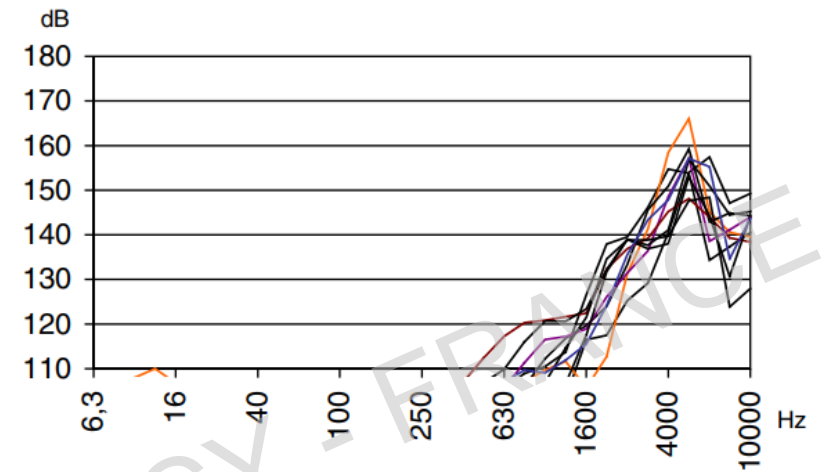


Fig. 3 Vibration 1/3-octave spectra of the air-turbine handpieces ($n=12$)

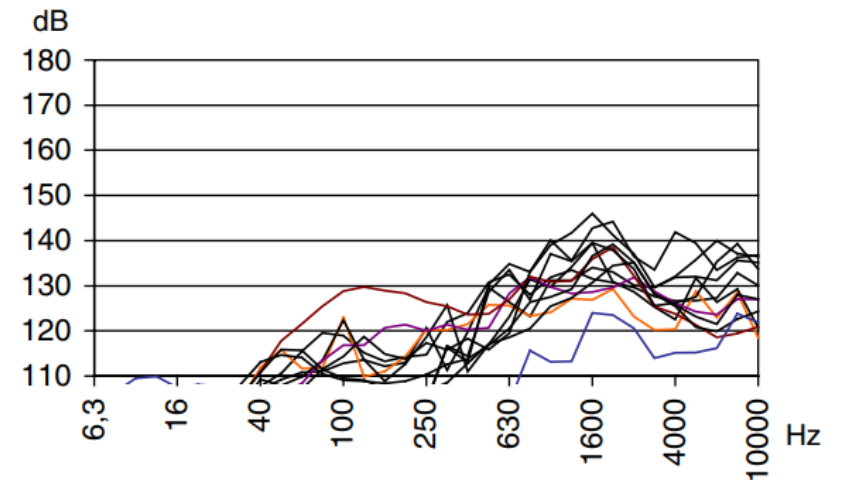


Fig. 4 Vibration 1/3-octave spectra of the micromotor handpieces ($n=10$)

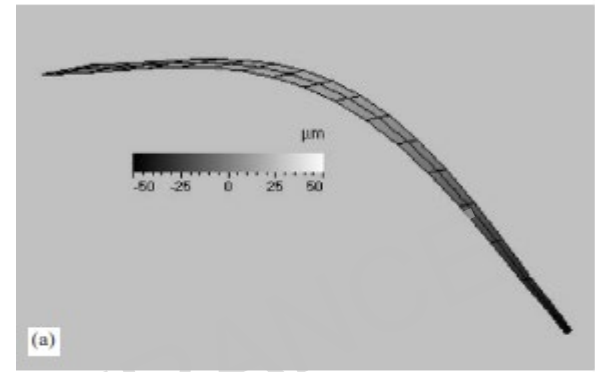
Rytkönen and Sorainen, 2006

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

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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

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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/s^2

- ✓ 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

- ✓ Dentists (*Lundström and Lindmark, 1982, Ekenvall, 1990, Akesson, 1995*)
- ✓ Dental hygienists (*Akesson, 1995, Conrad, 1993, Cherniak, 2006, Warren 2010*)
- ✓ 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)

Increased warming & cooling threshold (*Hjorstberg, 1989, Shabazian, 2009*), **negative** (*Ekenvall, 1990*)

Carpal Tunnel Syndrome

✓43 studies in dentists, dental hygienist, 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

Positive association with vibrating tools (*Alexopoulos, 2004, Alyaha, 2018, Singh, 2022*)

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*)
- ✓ Scaling (*Booyens, 2009, Hayes, 2012, Lalumandier 2001, Liss, 1995*)
- ✓ 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 1st, 2nd, 3rd

OR: 2.22, (95%CI 1.04–4.91)

1st 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

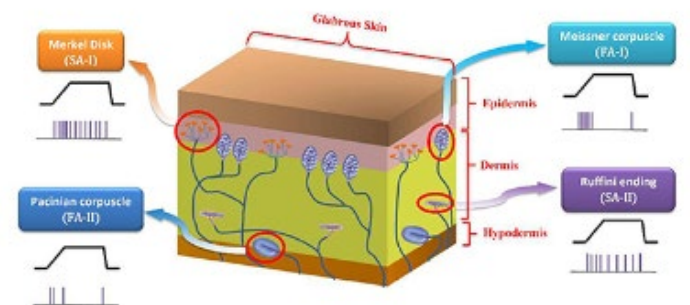


Discussion

- 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)

Figure 1



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

