ISSN: 2634-9221
European Journal of Applied Sciences; Vol. 14 No. 01 (2026) (244-253)
https://doi.org/10.14738/aivp.1401.19751

Work Related Traumatic Dental Injuries, and Their Detrimental Effects on Dentition and Oral Health

Marija Tomevska BDS, & Nadia Kawar DDS MS.

1. University of Illinois Chicago, College of Dentistry, Department of Periodontics

Abstract: Jobs that require physical labor for extended hours over a long period of time, such as working in the construction industry, put workers at higher risk of experiencing occupational hazards. In addition to the intensity of the physical labor, these jobs may also expose workers to chemicals or harsh work environment such as working outdoors, exposure to weather and dust particles and high altitudes or underground. The effect on physical well-being has been studied and protective safety equipment such as helmets are mandated and enforced to protect against physical injury. However not many studies have investigated the effect on dentition. There is not much attention given to implementing protection against dental and oral trauma. Through clinical observation and review of literature review, construction workers are showing signs of chronic dental trauma resulting in advanced dental treatment needs. Work related traumatic dental injuries have resulted in specific pattern of fractured teeth, loss of tooth structure, dental infections, malocclusion, Temporomandibular joint dysfunction and edentulism. (1) Dental treatment of these conditions requires multiple dental visits, often needing a full mouth rehabilitation to restore lost dental structure and altered facial dimensions. Treatment of these condition is usually costly, requiring multiple specialties. The purpose of this article is reviewing available literature to explore the different work conditions that can result in traumatic dental and oral injuries, to highlight their detrimental effects on dentition and oral health and finally to propose implementing and a mandating protective appliance for workers.

INTRODUCTION

Jobs that require physical labor for long hours per day and extended periods of time will eventually take their toll on the human body. Working in the construction industry presents difficult working conditions, exposing workers to one of the most demanding environments in the workplace, making them at a higher risk of experiencing health issues and, consequently, a lower quality of life. (1) Construction workers are at a heightened risk of occupational hazards due to the nature of their work. Workers may experience dental disorders caused by physical demands of the job or exposure to chemical substances, and even mental distress due to working long hours in such an environment.

The operation of heavy machinery, exposure to high-frequency industrial noise, accumulation of dust, and presence of acid fumes from chemical processes, outdoor or underground work sites, all pose significant health risks to workers. Dust particles of varying sizes at construction sites can be inhaled, leading to respiratory and cardiopulmonary diseases. Inhaling dust and acid fumes through the mouth can result not only in systemic issues but also significantly impact the dental apparatus. (2,3,4) Exposure to those conditions can lead to various orofacial disorders, including traumatic dental injuries. The consequences of these injuries are loss of tooth structure, pain, functional disorders such

as difficulties in chewing, and concerns about aesthetics, all of which may affect workers' mental health.

This article intends to provide a review of the occupational hazards that contribute to chronic tooth trauma and thus jeopardize the oral and dental health of workers.

CHEMICAL EXPOSURE

Dental Erosion and Tooth Discoloration

Similar to many oral diseases, such as dental caries, dental erosion is a disorder with a multifactorial etiology. The primary causal factor is the chemical breakdown of enamel and dentine by acids from external or internal origin. During an erosive attack, protons of the acidic agent attack the components of hydroxyapatite, carbonate, phosphate, and hydroxyl ions. As a result of this attack, hydroxyapatite crystals are breaking down, which in turn causes the release of calcium ions. Key factors for the development of dental erosions are the pH, titratable acidity, phosphate, and calcium concentration, as well as the fluoride content of the acid, all of which determine the extent and intensity of the dissolution. (5). Erosion generally appears as bilateral concave defects without the chalky or rough texture commonly associated with bacterial acid decalcification. In the initial stages, erosion impacts the enamel, resulting in a shallow, smooth, glazed surface that often has no developmental ridges or stain lines and is usually free from plaque build-up unless sensitivity affects oral hygiene. (6)

Numerous studies have demonstrated that occupational exposure to acids can lead to dental erosion. (7-18,) Acidic solutions can exist in the air in a few different forms: mist, vapor, and gas. Some of the industries that are exposed to acidic solutions include manufacturing (like phosphate fertilizers, isopropyl alcohol, ethanol, sulfuric acid, nitric acid, and lead acid batteries), construction, petroleum and coal products, oil, and gas extraction, as well as printing and publishing, paper making and leather manufacturing. On top of that, workers in industrial sectors related to metal materials or metal-related compounds, including those involved in smelting copper, electroplating, and pickling, are at higher risk of being exposed to metal-containing acid mist. (19)

In a 2016 study conducted in Lahore, Pakistan, it was concluded that 79.7% of the 236 mineral, chemical, and metal workers who participated in the study had dental erosion. These workers did not gargle during or after work. (7) A similar study was conducted among workers at a glass manufacturing facility in India, involving an examination of 936 subjects. The findings revealed that 77% of these individuals' exhibited signs of dental erosion. (8)

A clinical examination of workers in the automotive battery and phosphate fertilizer industries has revealed that 79% of production line workers experience tooth erosion, primarily affecting the labial surfaces of the maxillary anterior teeth. Additionally, there is notable occlusal attrition of the posterior teeth. This damage occurs from operating in an environment where sulfuric acid is used to process phosphate rock, to make phosphoric acid, which is the main component in most chemical fertilizers. (11) Furthermore, it is noticed that workers who worked for longer years in the production unit exhibited significant and persistent blue-green staining of their teeth. This staining is caused by acidic sulfur-lead mist that deposits on eroded and decayed tooth surfaces. The discoloration is primarily

found on the labial surfaces of the maxillary anterior teeth, which is often related to mouth breathing due to nasal breathing difficulties. (11)

In addition to the erosion, occupational and environmental factors significantly impact dental coloration. Extended exposure to metals like iron and manganese can cause black stains on teeth, while mercury and lead dust may result in blue-green tints. In addition to that, exposure to copper and nickel can produce green stains, and inhaling chromic acid fumes can lead to deep orange discoloration. These factors illustrate how the environment can change the appearance of teeth. (20)

Personal protective equipment, like wearing masks, is recommended to reduce dental erosion caused by occupational exposure to acid. A research study conducted among industrial workers in Korea found that workers wearing respiratory masks had 0.63 times lower odds of overall occupational dental erosion compared to those without masks. However, it also noted that masks were not effective in preventing severe dental erosion. (18). Please note that the dietary habits of these workers were not taken into consideration, which could also be an indirect factor in the erosion process.

PHYSICAL EXPOSURE

Mechanical Exposure Causing Dental Abrasion

Abrasion is the physical wear of the tooth surface through an abnormal mechanical process independent of occlusion. It involves a foreign object or substance repeatedly contacting the tooth. (6)

Occupational exposure to abrasive dust can lead to tooth abrasion. A study among workers in the Danish granite industry revealed that exposure to abrasive quartz dust over a period of time can result in dental abrasion. The prevalence of tooth abrasion was 100% and mostly on the front teeth. (21)

Unhealthy working habits have also been associated with tooth abrasion in workers in construction and industrial settings. Holding foreign objects like nails between the teeth can lead to wear on those particular teeth in people working on construction sites.

A study amongst clothing industry workers has shown that incisal tooth abrasion was present in 90% of workers who had a habit of cutting the thread with their teeth instead of using scissors. As a result of that action, the teeth sustained defects in the form of solitary, oval, or multiple cuts on their incisal surface. (22)

Auditory Exposure to Noises Causing Dental Abrasion and Pulpal Changes

There is emerging evidence that industrial noise can also lead to tooth wear. A study conducted on 39 Wistar rats, who were exposed to industrial noise for one, four, and seven months, found that the average area of the molar cusps was significantly different between exposed and non-exposed animals. Furthermore, it states that the most notable differences appeared between the first and fourth months. The overall crown loss from month one to month seven was 17.3% in the control group and 46.5% in the exposed group, and the differences between these variations were significant ($p<0.001$). (23) One more study on Wistar rats revealed that chronic exposure to Industrial Noise (IN), rich in Low Frequency

Noise (LFN), causes systemic fibrotic transformation and sustained stress. The results from the study demonstrated the presence of a band-like structure between the pulp and dentin in the roof chamber of the teeth of Industrial Noise-exposed animals. It is concluded that these changes may be related to either direct impact of sound pressure or to an adaptive response from the pulp-dentin complex linked to teeth grinding. (24)

Another study amongst textile workers in Montenegro also confirmed the statement that exposure to high-level industrial noise might be significantly related to tooth abrasion. They state that there is a difference in the mechanism of noise on tooth abrasion when compared to other occupational factors. They argue that whilst dust, acid, and bad chewing habits act directly on teeth, the effect of noise is indirect; the high-level industrial noise increases higher muscle activity, especially the masseter muscle, and consequently induces tooth clenching and grinding. (25)

Based on the presented research, it can be indicated that construction workers operating heavy machinery in high-noise environments who do not utilize personal protective equipment, such as earplugs, may be at risk of experiencing tooth abrasion due to high noise exposure. However, further studies are needed to investigate this finding.

Mechanical Exposure Causing Dental Attrition

Attrition is the physiologic wearing away of tooth surfaces as a result of tooth-to-tooth contact, such as in mastication, with possible intervention by abrasive substances. It usually occurs on the occlusal and incisal contacting surfaces and, uncommonly, on axial surfaces when an unusual malocclusion exists. Attrition is related to the aging process but may be accelerated by extrinsic factors such as coarse diet, chewing tobacco, abrasive dust, parafunctional habits of clenching and bruxism, traumatic occlusion in the partially edentulous dentition, anterior open bite, and anterior teeth in edge-to-edge relationship or crossbite, as well as due to iatrogenic dentistry and use of ceramic material in dental prosthesis. (6)(26)

In a review on occupational dental hazards from 2015, it is mentioned that attrition is the most common dental problem noticed in miners. It continues by stating that workers with significant exposure to airborne olivine dust might experience considerable tooth wear. The extent of tooth wear, represented by the subsets' rank summaries, was clearly related to increased cumulative exposure to airborne dust. (27)

Severe tooth wear can result in loss of the vertical dimension of occlusion (VDO) and function of the surrounding musculoskeletal structures. It has been shown that patients who experience advanced tooth wear have some changes in their facial morphology due to a reduction in the vertical dimension of the face. These implications are exacerbated by increased mandibular pseudo-prognathism, which can be a compensatory functional mechanism. Progressive tooth wear can lead to significant loss of tooth structure, which often requires an advanced and expensive prosthetic rehabilitation to reconstruct the occlusion. (28) On its effect on soft tissue, narrowed vermillion borders and depressed lip commissures are not only esthetic concerns but can predispose to opportunistic microbial infection in susceptible individuals. Studies on the correlation between tooth wear and facial morphology vary in their conclusions due to the dynamic nature of the orofacial complex and compensatory mechanism (29)

Severe attrition can lead to a variety of dental issues. A study involving 500 participants—260 females and 240 males—found significant correlations between tooth sensitivity and the ridging of buccal mucosa and the presence of attrition. Moreover, an increase in attrition scores was notably linked to several symptoms of temporomandibular joint dysfunction, such as muscle tenderness, pain during mouth opening, and deviation of the mandible while opening. Generally, some degree of attrition was observed in patients with temporomandibular joint disorders. However, a definitive relationship between the severity of attrition and the symptoms of temporomandibular joint disorders cannot always be established. (30)

In the sixties, Glickman and Smulow described the various effects of occlusal trauma on the dento-alveolar complex and introduced the idea of buttressing bone as the development of thickened or exostotic alveolar bone in response to heavy occlusal forces. However, upon examining a sample of 416 selected teeth and investigating the bone in 52 modern skeletal specimens at the National Museum of Natural History, the findings indicated lack of anatomical evidence supporting the theory of buttressing bone formation. This suggests that other factors may play a more significant role in the etiology of buccal bone enlargements. Additionally, no correlation was found between widened periodontal ligament spaces or severe occlusal attrition and the presence of cervical loss of tooth structure. (31) Following this report, numerous studies indicated that exostoses develop due to an uneven distribution of mechanical forces. Singh (2010) argues that the stress and strain on the osteogenic periosteum would result in bone deposits at the sites of the mandibular and palatine tori; thus, the orientation and positioning of tori are a response to changes in mechanical loads. (32) Supporting the theory that oral exostoses developed as external buttressing of the trabecular bone when undergoing abnormal dental stress. (33) Presence of exostosis, depending on their size and location, can impede oral hygiene, speech, and diet choices. They can pose additional challenges to prosthetic replacement of missing teeth, requiring complicated dental treatment.

Chronic occlusal trauma can result in other complications such as tooth fractures, failure of restorations, dental implants and prosthesis, tooth mobility, pulp necrosis, traumatic ulcers, linea alba, as cited in a 2018 article on a guide of clinical management of attrition. (33) A study on 24 patients who had horizontal root fractures concluded that periodontal condition, occlusal wear, and patients' age at diagnosis were possible related factors for the fracture. (34) In an article about bruxism and its effect on natural teeth, it is mentioned that tooth mobility can lead to issues such as open contacts, food impaction, or the buildup of local irritants in the spaces between teeth and gingival crevices, which are secondary etiological factors for periodontitis. The accuracy of fixed restorations created from master casts taken from impressions of mobile abutments presents a significant challenge in prosthodontics. Achieving and maintaining ideal occlusion is challenging in dental arrangements that have mobile teeth. (35)

The Effect of Using Vibrating Machinery

Man may be exposed to two types of vibration: 1. Whole body, resulting from lying, sitting or standing on a vibrating surface; 2. Segmental, nearly always transmitted to the hands from a vibrating tool or material held against a machine, though very rarely to the foot, as stated in an article about the biological effects of segmental vibration. (36) Based on this

statement, construction workers who operate heavy machinery are going to experience whole-body or segmental vibrations. The article continues by explaining that the most commonly used vibrating tools are jack hammers, used for breaking up pavement, and quarries and mines; jack leg drill used in mines, sand rammer used in foundries in preparation of molds; chipping hammer or pneumatic chisel, used for dressing metal castings in foundries, rotary grinder, also used in foundries for finishing castings; sander and discs used in automobile body manufacture; power or chain saw used for felling, trimming and cutting timber; small, finger held high speed rotary grinder; scaling hammer and riveting hammer. The consequence of this vibration is pain in the fingers, hands, and arms. Numbness and tingling are quite common in the hands. Furthermore, the use of the jack-leg drill promotes a much more severe response, resulting in severe burning pain in the arms, interfering with sleep and persisting for several months after ceasing jack-leg drilling. (36)

A study from 2012 on rats exposed to either hind, limb, or tail vibration concurs with the findings. They concluded that research conducted on both animals and computational models aligns with findings from human studies, illustrating that exposure to vibrational frequencies ranging from 100 to 300 Hz results in an increase in the biodynamic response of the fingers. This demonstrates that there is a connection between increased tissue stress and strain and the development of vascular and sensoneural dysfunction. (37)

In a critical review of the health effects associated with occupational exposure to hand-arm or whole-body vibration, the review presented and cited several studies that suggest that exposure to segmental vibration may also produce systemic effects. For example, repeated exposure to hand-transmitted vibration has been associated with hyperactivity of the sympathetic nervous system, hearing loss (independent of noise), and an elevated risk of cardiovascular disease. It also presented evidence from studies that segmental vibration is associated with changes of the transcription of genes that can lead to cancer. Ultimately, it is stated that these data provide a basis for examining the risk associated with exposure to segmental vibration and the development of chronic diseases. (38)

Attrition has always been diagnosed clinically by a pattern of loss of vertical height of the tooth, creating an even line across all affected teeth. Not much reported about the pattern of attrition created by long term use of vibrating machines. Patterns of tooth loss recognized in those workers have a distinct feature, being irregular with varied levels of tooth loss and vertical crack lines, indicating that the damage is happening over multiple periods of time and different intensities of the causative factors. Figure 1 shows a pattern observed in a 60-year-old machine operator at a chocolate factory for a period of 15 years. Clinical exam reveals severe generalized teeth fractures and trauma with an extreme decrease in his vertical dimension of occlusion. Picture provided as a courtesy from the University of Illinois, dental clinics.

Figure 1

These studies conclude that long term exposure to excessive occlusal trauma can result in pulpal pathology, impaired function, occlusal disharmony, and esthetic disfigurement. A thorough, multispecialty approach is essential for effectively treating patients with severe tooth wear.

It is hard to categorize the traumatic factors based on physical and chemical, in majority of the time it is a combination of many factors affecting the overall work environment and resulting in damaging effects on the dental apparatus and oral health. A limitation of this review is that it did not include the work environment being outdoor versus indoor, weather and temperature, altitude, and air pressure, as these can all be contributing and exacerbating factors.

CONCLUSION

Based on the gathered information, certain jobs, if performed without appropriate safety measures, can pose an occupational hazard. This could be through physical or chemical repetitive exposure. Teeth trauma and trauma to the orofacial structure can be a result of this long-term exposure. Working in construction, where a combination of many potential hazards can put workers in a position to lose their healthy dentition and orofacial structures if protective equipment is not used. While the effects of acids, dust, and noise on dental health are well-documented, the influence of whole-body or hand-transmitted vibration on teeth remains insufficiently investigated. Although the systemic consequences of vibration on the body are acknowledged, further research needs to be done to understand its involvement in dental health.

Occupational Safety and Health Administration (OSHA) long-standing position is that fractured teeth are a significant injury and illness under Section 1904.7(b)(7), but these seem to relate to accidents and acute trauma, and not constant trauma over a period of time that causes tooth and surrounding structures loss over time. OSHA has implemented safety requirements pertaining to protecting the nose, eyes, mouth, and head from noise, fumes, and debris; protecting teeth from chronic work-related tooth trauma is not being implemented. (39, 40). Based on this review, a mouth guard to protect teeth against long-term exposure to trauma should be required.

REFERENCES

1. Tunji-Olayeni, Patience F., Adedeji O. Afolabi, and Obiora I. Okpalamoka. "Survey dataset on occupational hazards on construction sites." *Data in brief* 18 (2018): 1365.
2. Yang, Xiaodong, et al. "Occupational health risk assessment of construction workers caused by particulate matter exposure on construction sites." *Heliyon* 9.10 (2023).
3. Dement, John, et al. "A case-control study of airways obstruction among construction workers." *American journal of industrial medicine* 58.10 (2015): 1083-1097.
4. Gupta BN. Occupational diseases of teeth. J Soc Occup Med. 1990 Winter;40(4):149-52. doi: 10.1093/occmed/40.4.149. PMID: 2263081 (36)
5. Annette Wiegand, Thomas Attin, Occupational dental erosion from exposure to acids—a review, *Occupational Medicine*, Volume 57, Issue 3, May 2007, Pages 169–176,

6. Etiology and Diagnosis of Tooth Wear: A Literature Review and Presentation of Selected Cases. Hattab, Faiez N., and Othman M. Yassin. "Etiology and diagnosis of tooth wear: a literature review and presentation of selected cases." *International Journal of Prosthodontics* 13.2 (2000).
7. Baig, Moghees A., Umair Dastgir Bhatti, and Muhammad Aslam Sheikh. "OCCUPATIONAL DENTAL EROSION AMONG CHEMICAL FACTORY WORKERS OF LAHORE." *Pakistan Oral & Dental Journal* 36.4 (2016).
8. Assessment of Tooth Wear Among Glass Factory Workers: WHO 2013 Oral Health Survey. J Clin Diagn Res. 2015 Aug;9(8): ZC63-6. doi: 10.7860/JCDR/2015/13904.6352. Epub 2015 Aug 1. PMID: 26436050; PMCID: PMC4576644.
9. Chatterjee, Silpi; Tiwari, Sonia1; Saxena, Sudhanshu; Kumari, Aarti; Singh, Reshu2. Association between Occupational Exposure to Acidic Chemicals and Occupational Dental Erosion in the Workers of a Battery Company in Bengaluru City: A Case–control Study. International Journal of Oral Care and Research 8(1): p 1-4, Jan–Mar 2020. | DOI: 10.4103/INJO.INJO_41_19
10. Tooth surface loss and exposure to organic and inorganic acid fumes in workplace air Maija Leena Tuominen, Risto Juhani Tuominen, Frank Fubusa, Nigodemus Mgalula First published: August 1991. https://doi.org/10.1111/j.1600-0528.1991.tb00149.x
11. Hattab, Faiez. "Occupational Hazards for Workers in The Battery Factories and Phosphate Fertilizers: Brief Review and Case Presentation." *The Indonesian Journal of Community and Occupational Medicine* 3.2 (2023): 82-7.
12. Ahuja, Nikhil, and Nirmal Ahuja. "Prevalence of tooth wear and its associated risk factors among industrial workers in Daman, India: a cross-sectional study." *Int J Community Med Public Health* 4.12 (2017): 4445-51.
13. Bamise, Cornelius Tokunbo, et al. "Dental erosion in a road-side battery technician: case report and a review of the literature." *Oral Health & Preventive Dentistry* 6.3 (2008).
14. Occupational exposure to airborne proteolytic enzymes and lifestyle risk factors for dental erosion—a cross-sectional study, *Occupational Medicine*, Volume 51, Issue 3, 1 May 2001, Pages 189–197, https://doi.org/10.1093/occmed/51.3.189
15. Kumar A, Puranik MP, Sowmya KR, Rajput S. Impact of occupational dental erosion on oral health-related quality of life among battery factory workers in Bengaluru, India. Dent Res J (Isfahan). 2019 Jan-Feb;16(1):12-17. PMID: 30745913; PMCID: PMC6340224.
16. Gamble J, Jones W, Hancock J, Meckstroth RL. Epidemiological-environmental study of lead acid battery workers. III. Chronic effects of sulfuric acid on the respiratory system and teeth. Environ Res. 1984 Oct;35(1):30-52. doi: 10.1016/0013-9351(84)90112-9. PMID: 6386452.
17. DENTAL EROSION IN WORKERS EXPOSED TO INORGANIC ACID. Lynch, James B., and John Bell. "Dental erosion in workers exposed to inorganic acid fumes." *British journal of industrial medicine* 4.2 (1947):
18. Kim HD, Douglass CW. Associations between occupational health behaviors and occupational dental erosion. J Public Health Dent. 2003 Fall;63(4):244-9. doi: 10.1111/j.1752-7325. 2003.tb03507. x. PMID: 14682649.
19. Chen, WL., Chen, YY., Wu, WT. *et al*. Examining relationship between occupational acid exposure and oral health in workplace. *BMC Public Health* 20, 1371 (2020).
20. Manuel, S. T., P. Abhishek, and M. Kundabala. "Etiology of tooth discoloration-a review." *Nigerian Dental Journal* 18.2 (2010): 56-63.

21. Petersen, Poul Erik, and Poul Henmar. “Oral Conditions among Workers in the Danish Granite Industry.” *Scandinavian Journal of Work, Environment & Health* 14, no. 5 (1988): 328–31.

22. Prpić-Mehicić G, Buntak-Kobler D, Jukić S, Katunarić M. Occupational tooth-wear in clothing industry workers. Coll Antropol. 1998 Dec;22 Suppl:241-9. PMID: 9951170.

23. Cavacas MA, Tavares V, Borrecho G, Oliveira MJ, Oliveira P, Brito J, Águas A, Dos Santos JM. Industrial noise and tooth wear - experimental study. Int J Med Sci. 2015 Feb 27;12(3):264-9. doi: 10.7150/ijms.11309. PMID: 25798052; PMCID: PMC4366631.

24. Cavacas MA, Tavares V, Oliveira MJ, Oliveira P, Sezinando A, Martins dos Santos J. Effects of industrial noise on circumpulpar dentin--a field emission scanning electron microscopy and energy dispersive spectroscopy analysis. Int J Clin Exp Pathol. 2013 Nov 15;6(12):2697-702. PMID: 24294356; PMCID: PMC3843250.

25. Milorad KOVACEVIC, Goran BELOJEVIC, Tooth Abrasion in Workers Exposed to Noise in the Montenegrin Textile Industry, Industrial Health, 2006, Volume 44, Issue 3, Pages 481-485, Released on J-STAGE August 28, 2006, Online ISSN 1880-8026, Print ISSN 0019-8366, https://doi.org/10.2486/indhealth.44.481

26. Hmaidouch R, Weigl P. Tooth wear against ceramic crowns in posterior region: a systematic literature review. Int J Oral Sci. 2013;5(4):183-190. doi:10.1038/ijos.2013.73

27. Occupational dental health hazards: A review Tarulatha R. Shyagali, Nidhi Rai

28. Shyagali, Tarulatha R., and Nidhi Rai. "Occupational dental health hazards: A review." *Int J Contemp Dent Med Rev* 6 (2015): 32-7.

29. Sierpinska T, Kuc J, Golebiewska M. Morphological and Functional Parameters in Patients with Tooth Wear before and after Treatment. Open Dent J. 2013; 7:55-61. Published 2013 May 17. doi:10.2174/1874210601307010055

30. Andrew Crothers, Andrew Sandham, Vertical height differences in subjects with severe dental wear, *European Journal of Orthodontics*, Volume 15, Issue 6, December 1993, Pages 519–525,https://doi.org/10.1093/ejo/15.6.519

31. Yadav, Sangeeta. "A study on prevalence of dental attrition and its relation to factors of age, gender and to the signs of TMJ dysfunction." The Journal of Indian Prosthodontic Society 11 (2011): 98-105.

32. Horning, Gregory M., Mark E. Cohen, and Todd A. Neils. "Buccal alveolar exostoses: prevalence, characteristics, and evidence for buttressing bone formation." *Journal of periodontology* 71.6 (2000): 1032-1042.

33. Lease, Loren R. "Correlations between dental wear and oral cavity characteristics: Mandibular torus, palatine torus, and oral exostoses." *American Journal of Human Biology* 33.2 (2021): e23446.

34. Rees, J. S., and S. Somi. "A guide to the clinical management of attrition." *British dental journal* 224.5 (2018): 319-323.

35. Tsai, Y-L., et al. "Horizontal root fractures in posterior teeth without dental trauma: tooth/root distribution and clinical characteristics." *International endodontic journal* 50.9 (2017): 830-835.

36. Pavone, Ben W. "Bruxism and its effect on the natural teeth." *The Journal of prosthetic dentistry* 53.5 (1985): 692-696.

37. Williams, Norman M.D. Biological Effects of Segmental Vibration. Journal of Occupational Medicine 17(1): p 37-39, January 1975.

38. Krajnak, K., D. A. Riley, J. Wu, T. McDowell, D. E. Welcome, X. S. Xu, and R. G. Dong. 2012b. Frequency-dependent effects of vibration on physiological systems: Experiments with animals and other human surrogates. Ind. Health 50:343–53. doi:10.2486/indhealth.MS1378.

39. Krajnak K. Health effects associated with occupational exposure to hand-arm or whole-body vibration. J Toxicol Environ Health B Crit Rev. 2018;21(5):320-334. doi: 10.1080/10937404.2018.1557576. Epub 2018 Dec 25. PMID: 30583715; PMCID: PMC6415671.

40. Occupational Safety and Health Administration. (n.d.). *Construction industry*. U.S. Department of Labor. Retrieved August 30, 2025, from https://www.osha.gov/construction

41. Occupational Safety and Health Administration. (n.d.). *Occupational noise exposure – Exposure & controls*. U.S. Department of Labor. Retrieved August 30, 2025, from https://www.osha.gov/noise/exposure-controls