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International Journal of Current Research
Vol. 9, Issue, 09, pp.58231-58236, September, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

OCCUPATIONAL HAZARDS IN ORTHODONTICS

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ARTICLE INFO

Article History:
Received 26th June, 2017
Received in revised form
12th July, 2017
Accepted 09th August, 2017
Published online 30th September, 2017

Key words:
Occupational hazards,
Injuries, Mucoskeletal problems,
Dermatoses and allergies.

ABSTRACT

The purpose of this article was to review the occupational hazards related to the practice of orthodontics, including all the risks involved. The classification of hazards was based on major sources of risks by system or tissue and by orthodontic office area. Potentially hazardous factors in general practice setting are to specific materials and tools that expose the operator to vision and auditory risks; to chemical substances with known allergenic, toxic, or irritating actions; to increased microbial counts and silica particles of the aerosols produced during debonding; and to psychological stress with proven undesirable sequelae. The identification and elimination of these risk factors should be incorporated into a standard practice management program as an integral part of orthodontic education.

Citation: Mahesh, C. M., Jane Poornima, Mahendra, S., Arun, A. V., Bobby Joseph Babu and Araish Farzana, S. 2017. "Occupational hazards in orthodontics", *International Journal of Current Research*, 9, (09), 58231-58236.

INTRODUCTION

Occupational hazard is defined as a risk accepted as a consequence of a particular occupation (Simpson, 1989). Professionals in dentistry are exposed to many occupational hazards; their effects appear as ailments that tend to intensify with age. These problems include musculoskeletal conditions due to improper body posture; physical hazards from light, noise, and trauma; biological risks from irradiation and microorganisms; and chemical detrimental sources. Recent studies found that methacrylates, natural rubber latexproteins, rubber glove allergens, and glutaraldehyde caused reactions ranging from cell-mediated contact allergytourticaria and occupationalasthma (Hamann, 2004 and Rubel, 2000).

Sources of Hazards

A general classification of potential operator hazards in orthodontics includes the following.

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Health hazards impose threats to a person's biological balance from exposure to physical factors (lights, noise, vibration, heat, trauma), chemical irritating or toxic factors (latex, monomers, sterilization and radiology fluid, aerosols during debonding), and biological factors (infections from micro-organisms). Other hazards include risks to the professional's well-being, associated with physical or psychological factors such as ergonomic considerations (insufficient or inappropriate equipment, inappropriate work area design) and psychological stress (dealing with patients in general, difficult patients, employees, legal action, and work organization). Nikolaos Pandis *et al* categorizes the hazards of orthodontic practice by work area in Table I; the Figure gives a general classification of the hazards based on the source of risk (Nikolaos, 2007).

Health Hazards

Health hazards for clinical orthodontists include physical factors such as lights, noise, vibration, heat, and trauma. Lights affect the eyes and vision. Office lighting and dental chair light are critical for optimal working conditions in an orthodontic setting. Additionally, other forms of light are used during daily procedures; the most important is the curing light for polymerization of bonding materials.

Table 1. Hazards in orthodontic office by work area

	Respiratory	Muscoloskeletal	Hearing	Vision	Skin
Dental chair area	Inhaling of chemicals (composites) Allergens Infection	Neck, shoulder, upper and lower back pain CTS Tendinopathies Repetitive strain injuries	Handpiece noise High volume Suction Ultrasonic scaler	Dry-eye syndrome Maculopathies Cataract Eye trauma Eye strain Infection	Allergy (chemicals) Trauma Infection
Sterilization area	Inhaling of chemicals Allergens Infection	Neck, shoulder, upper and lower back pain	Ultrasonic cleaner	Dry-eye syndrome Eye trauma Chemical burn Infection	Allergy (chemicals) Trauma Infection Burning
Laboratory area	Inhaling of chemicals Allergens Infection	Neck, shoulder, upper and lower back pain CTS Tendinopathies Repetitive strain injurie	Model trimmer Vibrators Low-speed hand-pieces	Dry-eye syndrome Eye trauma Chemical burn Infection	Allergy (chemicals) Trauma Infection Burning
X-ray developer area	Inhaling of chemicals Allergens	Neck, shoulder, upper and lower back pain		Dry eye syndrome Eye trauma Chemical burn Infection	Allergy (chemicals) Trauma

Recently, lasers were introduced in orthodontics for ceramic bracket debonding (Strobl, 1992; Tocchio, 1999 and Rickabaugh, 1996) and cosmeticgingival contouring (Sarver, 2004; Sarver, 2005 and Sarver, 2005) The hazards as sociated with laser light range from corneal/lens to retinal damage depending on the wavelength of the beam produced by each appliance. Eyestrain can also be a problem, due to concentration, insufficient lighting, and inappropriate position of working light in relation to the orthodontist (Arai, 1983). Recent research, however, showed that some of our ganglioncells might perform as a third type of photoreceptor called "intrinsically photosensitive retinal ganglion cells." (Berson, 2002 and Hattar, 2002) These sparsely situated cells are most sensitive to blue light. They seem to exist principally to assist in differentiating between day and night, thus modulating the "sleep/wake" cycles, known as circadianrhythms (Wee, 2004; Van Gelder, 2004 and Pautler, 1990). When light hits aphotoreceptor, the cell bleaches and becomes useless until it recovers through a metabolic process called the "visualcycle." (Abbot, 2003).

Blue light is an important element in "natural" lighting, and it can also contribute to our psychological health (Gasyna, 2006). Research, however, shows that high illumination levels of blue light can be toxic to cellular structures, test animals, and human fetalretinas (Satrom, 1987). The eyes of people operating curing lamps are at risk from acute and cumulative effects, mainly due to back reflection of the bluelight. Satrom *et al* (Nomoto, 2004) evaluated 11 curing lights systems that produced visible blue light in the 400 to 500 nm range and found that no unitposed a health risk. A more recent and relevant study, comparing the effects of halogen, plasma, and light-emitting diode units on vision, reported that the exposure time required for plasma and light-emitting diode lamps to achieve curing depth similar to the tungsten-halogen light was longer than the irradiation times recommended by the manufacturers.

This is important to know because blue light or ultraviolet (UV) hazard is related to exposure time, and thus requirements for prolonged irradiation can adversely affect vision. Additionally, some plasma units were been found to emitlight in the ultraviolet-Aregion (Kanski, 1989). Infections can be caused by splashing material, aerosols, and trauma from wires, burs, and other projectiles. Trauma associated with microorganisms could cause various eye infections. Chemical burns come from acids or alkaline sub-stances. Acids are usually less dangerous than alkalis because they tend to precipitate tissue proteins, which form barriers and inhibit deeper penetration; therefore, lesions are limited to lids, conjunctiva, and cornea. Alkalis saponify lipids in the corneal epithelium and bind to mucoproteins and collagen in the corneal stroma. In this way, they disrupt the normal barriers of the cornea, gain rapid access to the more posterior parts of the eye, and can cause severe eye complications including cataract and secondary glaucoma (Katz, 1985).

Noise

The effects of occupational noise in the orthodontic office can lead to noise-induced hearing loss (NIHL); symptoms can include difficulty with speech communication and other auditory signals, fatigue, and tinnitus. The symptoms of NIHL increase gradually with continual exposure (Nikolaos Pandis, 2007). NIHL, currently not treatable, occurs when expo-sure to harmful sounds causes damage to the tiny hair cells in the cochlea and to the acoustic nerve. The greatest damage is usually caused at 3000 to 6000 Hz. NIHL can be caused by repeated exposure to sounds at various loudness levels, measured in decibels (dB), over an extended time or by a 1-time exposure to an intense sound. Exposure to noise over a long time can cause a temporary threshold shift, which is a temporary elevation in the hearing threshold that gradually recovers. It might range from a change of a few decibels to a change that temporarily renders the ear severely impaired. A noise induced permanent threshold shift occurs after a long period of continual exposure to hazardous noise combined with the effects of aging (Sampaio, 2006). According to the National Institutes of Health, sounds above 85 dB are potentially hazardous. To determine which sounds are hazardous, the frequency and the duration of the sound must be specified. Generally, a noise level of 85 dB (A) in the normal range of hearing, for an 8-hour per day exposure, over a period of years, might be damaging. Sound levels less than 75 dB (A) are considered unlikely to cause permanent hearing loss. DB (A) refers to the decibel scale usually used to measure sound to which people are exposed. Several studies on used and new dental equipment recorded the sound levels of common sources of noise in dentistry; Table II shows their findings (Berger, 2006; Sorainen, 2002; Bono, 2006 and Siegelaub, 1974). The degree of risk might depend on several factors including age, personal susceptibility, total daily exposure, exposure measured over many years, smoking, medication, and noise exposure outside the dental office (Siew, 1992).

Table 2. Noise levels from dental equipment

Device	dB (A)
Air turbine handpiece	65.5-93
Micromotor handpiece	61.9-77
Scaler	73-88
Irrigator	76
Power suction tube	75
Saliva suction tube	73
Ultrasonic scaler	72-81
Gypsum cutting equipment	93.5
Vibrator	98.5
Aspirator and engine	81.7-86.5

Injuries

Occupational injuries of health professionals are another area of interest, due to the increased awareness of patient-doctor cross contamination. In 1995, a survey sponsored by the American Dental Association (Cleveland, 1995), found injuries at a yearly rate of 3.4% among dentists; this agreed with the 3.6% reported by a similar study (Siew, 1995 and Bagramian, 1998). Amongspecialists (McNamara, 1999) orthodontistshad the second lowest prevalence (1.9%) after endodontists (1.3%); pedodontists had 5.5%, prosthodontists 4.5%, and oral surgeons 2.6% (Cleveland, 1995). Bagramian and McNamara [McNamara, 1999] Conducted a survey of Orthodontists targeting specifically orthodontists and their staffs. The study identified a mean percutaneous injury rate of 0.085 during a 20-day period for practicing orthodontists, an injury rate that can be extrapolated to slightly less than one (0.99) percutaneous injury per orthodontist per year. The majority of these injuries (84%) occurred outside the mouth.

Most injuries occurred to the index finger and thumb and during wire changes. Other injuries were caused by burs, explorers, rotary disks, scalers, and other sharp instruments. No needle stickinjuries were reported. Under the same program, McNamara and Bagramian (Sims, 1993), investigated injuries to orthodontic staff. Their findings showed similar injury rates (1.4% per year) and pat-terns compared with the orthodontists. In a study of ocular trauma among orthodontists, it was found that 43% of the respondents reported ocular injuries, mainly during debonding and trimmingacrylic (Jacobsen, 1989). Other procedures included ligating materials, pumicing, and acid etching. Most of the injuries (83.5%) were treated on site without long-term effects. Extra caution should be used during laboratory procedures, when injuries from projectiles are possible.

Dermatoses and Allergies

These dentists and orthodontists thought that 21.5%, or 9% overall, of the dermatoses were related to the materials used in the profession, with methacrylates and natural rubber latex gloves as the 2 most common materials giving rise to complaints. Another survey of Norwegian orthodontists showed that 40% had hand or finger dermatoses. The meanage was 46 years, and 18% were female. It was found that these complaints were often mild and were related to seasonal variations and temperatures. Occupational Safety and Health Administration (OSHA) believes that 8% to12% of health care workers are sensitive to latex and states that, between 1988 and 1992, there were more than 1000 reported adverse health effects from exposure, including 15 deaths (Ireland, 2003). There appears to be good evidence for the increasing prevalence of latex allergy caused by more occupational exposure to latex products (Toroglu, 2003).

Biologic Factors

Biologic factors include microorganisms and particles. In the dental office and orthodontic practices the main source of infection is through interaction of the patient with the healthcare giver. This can occur from direct contact with blood, body fluids, secretions, and excretions (except sweat), regardless of blood presence, non-intact skin and mucous membranes regardless of blood presence. Infection can occur indirectly by contact with contaminated instruments, surfaces, equipment, and materials. Contact of sensitive body areas with

Table 3. Nikolaos Pandis *et al* suggested precautions and measures to reduce the exposure to hazardous materials and procedures are listed (Nikolaos Pandis, 2007)

	Respiratory	Muscoloskeletal	Hearing	Vision	Skin
Dental chair area	Fresh air access Ventilation Use masks, aspiration during debonding Follow guidelines for infection control	Adopt proper body posture during dental chair work Use ample lighting and in direction that does not produce awkward body posture Arrange intermittent work load Handle instrument properly Use stretching before Work	Check noise level of operatory	Avoid prolonged concentration and if necessary use assisting appliances Always use protective shield for photopolymer -ization Use protective eyewear for bonding and debonding (patient and staff also) Avoid splashes during rinsing and spraying	Use powder-free, silicone gloves if irritated by conventional powdered latex Exercise measures suggested by Centers for Disease Control for infection control Cover cuts in exposed body areas (face) to avoid contamination by splashed liquids
Sterilization area	Use ventilation and masks Follow guidelines for infection control	Ergonomically designed area and appropriate bench height Easy access to instruments/equipment	Use insulation for ultrasonic baths	Use protective eyewear	Cover all skin areas (wear long sleeves, gloves, mask)
Laboratory area	Masks, ventilation (preferably fresh air access) Follow guidelines for infection control	Ergonomically designed area and appropriate bench height Adopt proper body posture Easy access to frequently used instruments and equipment Take frequent breaks	Use insulation when possible Use ear plugs during model preparation and trimming	Disinfect impressions Exercise measures as in other areas for eye protection	Avoid contact with methacrylates Use ventilation

infected droplets expelled from infected persons at short rangeor inhalation of suspended microorganisms that cansurvive for long periods can occur in the office environment. Other possible sources of infectious contamination are dental unit waterlines, hand-pieces, salivaejectors and suctions, other devices attached to air and waterlines, and radiology equipment (especially digital sensors). Impression materials and orthodontic appliances transported between the clinical area and the laboratory could be a source of infection. Toroglou *et al* (Toroglu, 2001 and Ireland, 2003) in specialty-specific studies, evaluated the contents of aerosols produced during debonding procedures in an orthodontic office. They concluded that orthodontists are exposed to high levels of aerosols and contaminants, and that debonding procedures are potentially hazardous to their health. Apart from microorganism contamination, a concern was recently expressed on the composition of aerosol produced during the use of rotary instruments. Research indicated that these aerosols contain silica particles from the adhesive resin fillers and various bur material byproducts. The sizes of these particles have been estimated between 2 and 30, thus falling within the hazardous-product particle range of2.5.[40]Thus, ventilation, use of masks and aspirators, and mechanical removal of as much resin as possible before using rotary instruments are suggested.

Other Hazards

Musculoskeletal Problems

Lalumandier *et al*. (Nikolaos Pandis,, 2007) surveyed more than 5000 active dental personnel, including orthodontists. The self-reported survey asked the respondents to indicate which body parts frequently gave them pain or soreness. These areas were the neck, arms, shoulders, back, and legs. It was emphasized that occasional pain or soreness would not constitute a positive response. Most general dentists (n647) and orthodontists (n59) worked about 40 hours per week, and both groups treated similar numbers of patients each week (41-50). The42.6% of orthodontists who reported back pain was the largest positive response of any group for any location. General dentists reported the second highest positive response (35.1%) of any group for any location. This prevalence difference of back pain was also the largest difference in the highest and second highest responses among all groups for any location. In a self-reported survey of Finnish dentists (n =147) and orthodontists (n =81), Kerosuo *et al* (www. unumprovident.com/consumers/tools). Found that 70% and 72%, respectively, reported "life-time prevalence" of musculoskeletal complaints. Among orthodontists, the most frequent age range was 40-50 years, with 40% older than 50 years. The proportion of men to women was 1:3.76. In order of frequency, the sites most involved were the shoulders (56%), the neck (53%), and the back (28%).

Neither study asked whether the musculoskeletal pain or soreness was directly or indirectly related to the practice of the specialty or whether there were other precipitating risk factors for the symptoms such as aprevious or simultaneous injury or a genetic disposition. Overall, orthodontists and general dentists reported a high prevalence of musculoskeletal problems. The higher rates in the Finnish cohort might be because the participants were likely to be older and female. Both factors carry a higher risk for musculoskeletal symptoms compared with being younger and male (Hamann, 2001).

Carpal Tunnel Syndrome

Carpal tunnel syndrome (CTS) is the most common nerve entrapment syndrome. It involves entrapment of the median nerve at the level of the wrist. In the work environment, CTS results from rapid, repetitive, and daily use of the hand and fingers for many hours at a time. The problem is compounded when working with a bent wrist, exerting force, working with vibratory tools, and in cold environments. Rapid movement of tendons in the synovial tube causes inflammation and fluid buildup. This can result in atrophy of the thenarmuscles; tingling in the thumb, index, middle, and half of the ring finger; night pain; and pain when handling tools. Hamann *et al*. (CDSPI, 1994) reported a prevalence both by self-reported screening and as evidenced by positive electro-diagnostic testing for symptoms. A total of 2197dentists participated in health screening programs during the ADA's annual conventions in 1997 and 1998.The aggregate group (n2197) reported a higher prevalence of CTS symptoms (36%) than the group that volunteered (n1079) to be screened for CTS, who reported a 28% prevalence. The cohort was 84% male with a mean age of 49.8 years. The average doctor had practiced for 22.2 years, worked 35.5 hours a week, and practiced 47.3 weeks per year. Although 28% of the dentists participating in the CTS screening reported hand or finger numbness, and tingling or pain at the end of the day.

Psychosocial Problems

Twenty percent of the dentists on long-term disability through the Canadian Dentists' Insurance Plan were diagnosed with mental or nervous problems. Based on a mailed questionnaire to a group of Swedish dentists and specialists, Rundcrantz *et al* (Myers, 2004). reported that specialists were more satisfied with their work environment, were more stimulated by their work, had more self-confidence, and experienced less anxiety than general dentists. The reasons for these findings have not been explored but might be related to extra years of training or income differences. Several studies identified issues related to finances and job growth, time and scheduling, dentist-patient relations, and staff and technical problems as stress sources in dentistry (Moller, 1996; O'Shea, 1984; Murtomaa, 1990 and Rankin, 1990). High levels of occupational stress among dentists are correlated with hypertension, coronary artery disease, and suicide. A study of burnout and its causes among dentists in Finland identified psychological fatigue, loss of enjoyment for work, and becoming insensitive toward patients. (Rankin, 1990) Comparisons of stress and coping in male and female dentists found that stress levels were similar, although the women experienced more personal and domestic problems. Regarding coping style, both sexes responded similarly in most respects, except that the women were more inclined to discuss their problems. Brand and Chalmers (Murtomaa, 1990). Compared stress patterns of dentists of various ages and concluded that older practitioners had less stress than their younger colleagues. However, for some issues related to finance and patient management, both groups were equally affected.

Conclusion

Contemporary orthodontics involves many potentially hazardous factors related to the general setting ofpractice; to specific materials and tools that expose the operator to vision and hearing risks; to chemical sub-stances with known

allergenic, toxic, or irritating actions; to increased microbial counts and silica particles of the aerosols produced during debonding; to ergonomic considerations that might have an impact on the provider's muscoleskeletal system; and to psychological stress with proven undesirable sequelae. The identification and elimination of the foregoing risk factors should be incorporated in a standard practice management program as an integral part of orthodontic education. Professional organizations can also assist in informing practitioners of potential hazards and methods to deal with them.

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