Prosthodontics

World at work: Dental laboratory technicians

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Artists at risk

The dental health of the population has improved worldwide due to fluoridation of drinking water and improved preventive dental care. In recent years, full dentures are less commonly used, with a wider application of bridges or crowns. During the last few years, demand for cosmetic prostheses has risen, especially among the aging population.

Dentures are made by laboratory dental technicians. This is a job with relatively stable tasks and the process is used worldwide, but the occupational exposure can vary, according to working conditions and materials used.

Rough data indicate that there are around 3800 dental technicians in Serbia, of which 30% are men and 70% women.

TASKS OF THE JOB

Dentists send to the technicians a specification of the item (that is, crown, bridge, prosthesis, etc) to be made, along with an impression (mould) of the patient's mouth or teeth. Dental technicians then create a model of the patient's mouth by pouring plaster into the impression and allowing it to set (fig 1).

The next step is to place the model on an apparatus that mimics the bite and movement of the patient's jaw. The model serves as the basis of the prosthetic device. Technicians examine the model, and on these observations and the dentist's specifications, build and shape a wax model, using small hand instruments called wax carvers. They use this wax model to cast the metal framework for the missing tooth or teeth.

Dental technicians then prepare the metal surface to allow the alloy and porcelain to bond, by using small hand-held tools and sandblasting (fig 2). They then apply porcelain in layers, to achieve the desired shape and colour of a tooth (fig 3).

Technicians place the tooth in a porcelain furnace to bake the porcelain onto the metal framework, and then adjust the shape and colour, with subsequent grinding and addition of

porcelain to achieve a sealed finish. The final product is a nearly exact replica of the lost tooth or teeth.

Orthodontic appliances are made of methacrylate polymer and steel wire. Removable dentures, such as partial and complete dentures, are made of methacrylate and pre-manufactured, fabric teeth (fig 4).

In some laboratories, technicians perform all stages of the work, whereas in others each technician does only a few. Dental technicians may be specialised in one of five areas: orthodontic appliances, crowns and bridges, complete dentures, partial dentures, or ceramics.

HAZARDS OF THE JOB

In general, dental technicians work in clean and well-lighted areas, although this may not always be the case. Technicians usually have their own workbenches, equipped with Bunsen burners, grinding and polishing equipment, and hand instruments.

The work is extremely delicate and time consuming. Salaried technicians usually work 40 hours a week, but

self-employed technicians frequently work longer hours. A high degree of manual dexterity, good vision, and the ability to recognise very fine colour shadings are necessary. An artistic aptitude for details and precise work is also important.

Chemical hazards

There are numerous chemical hazards in denture production. They include solvents, mineral acids, gases and vapours released during polymerisation, metal casting, and porcelain baking, as well as dust coming from plaster, metal alloys, ceramics, and acrylic resins. Maximum allowable concentrations (MAC) are sometimes exceeded, especially in the absence of engineering measures. A Korean study, for example, showed concentration of silica in the air to be up to 0.051 mg/m³, which slightly exceeds MAC according to NIOSH and ACGIH.¹ In addition, dental technicians often omit to wear personal protective devices, because they impede their precise work operations.

Among many chemicals, several should be mentioned including silica, butylene glycol, hexane, ethyl acetate, nitrocellulose, glutaraldehyde, benzoyl peroxide, hydroquinone, corundum, bisphenol-A, kaolin, oxides of titanium, iron, and boron. Within the group of acrylic compounds, the most important are: methyl methacrylate (MMA), triethyleneglycol di-methacrylate (TEGDMA), ethyleneglycol di-methacrylate (EGDMA), 2-hydroxy-ethyl-methacrylate (HEMA), etc. Metal alloys, such as vitallium, wisil, duralium, and vironite, are used in the production of

Figure 1 Impression (mould) and a plaster model.

Figure 2 Sandblasting of a metal framework.

crowns, bridges, and dental prostheses. These alloys consist of cobalt (35–65%), chromium (20–30%), nickel (0–30%), and small amounts of molybdenum, silica, beryllium, boron, tantalum, and other elements. Gold-palladium alloys are nowadays seldom used.

Respiratory effects

Dusts generated from composites and dispersed in the breathing zone show 54–70 mass per cent to be respirable.² The percentage of crystalline silica in the dust varies, ranging up to 30% (Institute

of Occupational and Radiological Health, Belgrade, 2003, unpublished data). According to NIOSH and ACGIH, both REL and TLV for pure silica dust are 0.05 mg/m^3 , while in Serbia and Montenegro the MAC is 0.1 mg/m^3 . The measurements in a dental laboratory, carried out by the Institute of Occupational Health, recorded the levels of respirable dust containing 10% of silica to exceed MAC by 3.6 times during sandblasting of metal, and by 2.6 times during ceramics grinding.

Figure 3 Application of porcelain layers.

Exposure to dust with high silica concentrations and cobalt–chromium–molybdenum alloys presents a risk of developing pneumoconiosis. The dental technician's pneumoconiosis seems to be the result of the combined effects of hard metal dusts and silica particles.³ So far, dozens of cases of pneumoconiosis have been reported.^{4–7} Interstitial inflammation and fibrosis may sometimes be associated with occupational asthma, or with rheumatoid syndrome.⁸ Even the chronic beryllium disease was seen in a dental laboratory technician.⁹

Main respiratory symptoms and findings among dental technicians are cough and phlegm, as well as decreased respiratory functions.¹⁰

Allergies, asthma, dermatitis

Some studies have reported that methacrylate monomers may cause a wide range of adverse health effects, such as irritation to skin, eyes, or mucous membranes, allergic dermatitis, asthma, as well as central and peripheral nervous system disorders (headache, pain in the limbs, nausea, loss of appetite, fatigue, sleep disturbances, neuropathy, loss of memory, etc). The use of gloves, face masks, and ordinary glasses does not give enough protection against vapours from monomers.¹¹ The aforementioned measurements in a dental lab revealed the concentrations of methacrylate monomer up to 2.4 times higher than MAC in Serbia, which is 410 mg/m^3 .

Benzoyl peroxide (BP) is an initiator of polymerisation used in the synthesis of methyl methacrylate dental materials, and is a known allergen that causes allergic contact dermatitis. The eyes of dental technicians are exposed first, and therefore eye complaints are usually noted. BP vapours are cytotoxic to human eye fibroblasts.¹²

Due to the exposure to various allergens and irritants, dental technicians often suffer from contact dermatitis. Dermal reactions are the second most frequent among self-reported health complaints.¹³ Metals and various acrylics lead to high rates of positive patch tests.¹⁴ The main irritant factors include wet work, contact with plaster, mechanical friction, and thermal changes.¹⁵

Physical hazards

The noise in the dental labs is mostly caused by grinding, cutting, and polishing operations and exhaust ventilation. It is discontinuous and wide-band, but often with predomination of high frequencies. The noise approaches and exceeds the action levels for harmful noise usually during cutting and grinding metal surfaces and plaster casts, up

Figure 4 Removable partial dentures.

to 92 dB(A), according to the measurements performed by the Institute of Occupational Health.

Dental technicians are exposed to hand/arm vibrations while working with various appliances and tools. Although the literature data are scarce, it seems that long term exposure may result in “white finger syndrome”. A study of 374 women with diagnosed hand–arm vibration syndrome in Sweden included many dental technicians. On average, the first symptoms appeared after seven years of exposure and the first visit to a doctor occurred after 11 years.¹⁶ In a Czech study there were 9% of dental technicians with deteriorated plethysmographic curve and 11% with pathological motor conduction in nervus medianus.¹⁷

During the work with metal and porcelain furnaces, dental technicians are intermittently exposed to heat (infrared) radiation.

Other hazards

Dental laboratory personnel are at risk of acquiring infections from dental prostheses that have not been properly disinfected. Studies on dental workers, including dental technicians, suggest that hepatitis A virus can be considered a hazard and that the risk increases with exposure duration.¹⁸ Among US military dental technicians, the probability of detecting hepatitis B virus core antibodies was significantly higher (2.7%), compared to general military population (0.8%).¹⁹ In Austria, 20% of dental technicians had *Legionella pneumophila* antibodies.²⁰

Sitting posture during work, with precise manual handling of small objects, may lead to back pain and strains of the musculoskeletal system. A study evaluating self-reported health complaints identified musculoskeletal problems as the most common complaints among technicians.¹³ Indeed, it was demonstrated that smaller loads on the low back and neck cannot be ignored due to their magnitude if their duration is long.²¹ Prolonged visual efforts due to inspection and shaping of small pieces, often using magnifying lenses, result in eyestrain.

Cobalt–chromium–nickel alloys have some cytogenetic damage potential, regarding lymphocytes and exfoliated nasal cells in dental technicians.²² These alloys, or methyl methacrylate, or both, could be responsible for occasional development of persistent olfactory disorders in dental laboratory workers.²³

The carcinogenic risk of dental technicians has not been evaluated, although some of compounds in metal alloys used are carcinogenic, such as chromium, nickel, and beryllium. Long term exposure to crystalline silica at levels higher than those usually occurring in dental technicians is also considered to increase the risk of lung cancer in humans.²⁴

Safety

According to some studies, dental technicians are prone to ocular injury. They reported a high prevalence (42%) of foreign bodies in their eyes during a one month period, therefore protection of the eyes should be emphasised.²⁵ Due to the manual handling of objects pre-

viously baked, flamed, or boiled, there is a constant risk of skin burns.

MEASURES TO PROTECT WORKERS

Toxic, irritant, and sensitising working materials should be replaced by less harmful alternatives, where possible. For example, metal alloys containing no nickel or beryllium should be chosen to be on the market.

Local ventilation systems must be properly constructed in dental laboratories to prevent respiratory and skin exposure to airborne contaminants. Adequate general ventilation and enclosure systems are also important.

Protective clothing should be made available and worn, including eye and respiratory protection, and gloves. Properly selected gloves are of vital importance among control measures. Nitrile rubber and synthetic rubber gloves have been reported to give the longest protection from methacrylate monomers.²⁶ Another study showed that 4H gloves and nitrile gloves offer the best protection.²⁷

Eating, drinking, and smoking should be prohibited in workplaces. Personnel must adopt standard procedures for manual handling of various substances and objects.

Hearing protection must be worn during critical operations, when the noise reaches the harmful levels—that is, 80 dB(A) and above. Job rotation can be used to reduce the exposure time while working with vibrational tools. Special anti-vibration gloves could be of some help.

A 4% chlorhexidine scrub for 15 seconds followed by a 3-minute contact time with a chlorine dioxide solution is effective in disinfecting contaminated dentures.²⁸ Chair-side disinfection of dental prostheses before laboratory procedures is the key to keeping microbial contamination out of the dental laboratory.

To prevent musculoskeletal and repetitive strain disorders, improvement of height relationships of a chair and different work surfaces should be considered. Apart from one longer rest in a silent and well-ventilated area, personnel are encouraged to have at least two 10-minute breaks more, preferably performing some exercise for arms and spine.

Dental technicians should wear protective goggles with side-shields during the work to avoid injuries, and appropriate gloves when handling heated objects.

Occupational health services

Dental technicians should regularly undergo specific medical examinations

with the aim of assessing their fitness for work. The emphasis is on lung function, skin disorders, ear, nose, and throat disorders, hearing, and peripheral circulation. During the check-ups, they should also be educated about the potential health hazards, recognition of early health effects, and safety practice.

Dental technicians working with dental prostheses should be patch tested with MMA, HEMA, dimethacrylates, epoxy acrylates, and urethane acrylates, but never with dental acrylics "as is", because of possible contact vitiligo and other adverse effects.

CONCLUSION

Although not always apparent, numerous occupational health hazards are present in manufacturing dental prostheses. Along with introduction of new dental materials, there is an ever-growing need for occupational health practitioners to be aware of the work processes in this occupation, to recognise possible hazards, and to implement appropriate preventive measures to protect the workers' health. Further studies are needed to evaluate the occupational carcinogenic risk of exposure to a variety of chemical agents.

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Video clips can be viewed on the OEM website (<http://www.occenvmed.com/supplemental>)

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APPENDIX

Video clips (which can be viewed on the OEM website (<http://www.occenvmed.com>))

com/supplemental) are intended to show how work is usually done, and to illustrate that in most cases there is room for improvements in ergonomics, personal protection, and safety.

- Video clip 1: *Operation of grinding plaster casts*. The plaster dust is almost completely trapped by the presence of water on the grinding surface, but the noise levels are substantial. There is also exposure to hand/arm vibration.
- Video clip 2: *Preparation of metal framework for porcelain bonding*. During this operation dental technicians are exposed to metal alloy dust, local vibration, and noise, and there is the potential for eye injuries.
- Video clip 3: *Polishing methacrylate surfaces of dental prosthesis*. This step in prosthesis manufacture generates methacrylate polymer dust, local vibration, and high levels of noise.

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