Iran J Ortho. 2018 March; 13(1):e10201. doi: 10.5812/ijo.10201.

Published online 2017 July 3. **Review Article**

Implementation of Recent Infection Prevention Procedures Published by Centers for Disease Control and Prevention: Difficulties and Problems in Orthodontic Offices

Livia Barenghi,[1,*] Alberto Barenghi,[1] and Alberto Di Blasio[2]

[1]Integrated Orthodontic Services S.r.l., Via Cavour 52 C, 23900 Lecco, Italy
[2]Department of Orthodontics, Department of Biomedical, Biotechnological and Translational Sciences, Parma University, Via Gramsci 14 - 43126 Parma, Italy

[*]*Corresponding author*: Livia Barenghi, Integrated Orthodontic Services Srl, Via Cavour 52 C, 23900 Lecco, Italy. Tel: +39-0341287252; +39-3384905792, Fax: +39-0341285268, E-mail: livia.barenghi@libero.it

Received 2016 December 26; **Accepted** 2017 June 06.

Abstract

Context: The Centers for Disease Control and Prevention has recently published its "Summary of Infection Prevention Practices in Dental Settings: Basic Expectations for Safe Care", but information concerning compliance, occupational hazards, and specific recommendations for orthodontic facilities is less widely available.
Evidence Acquisition: We searched electronic English articles published in PubMed and Google Scholar databases (2010- May 2016) using various combinations of the key indexing terms.
Results: 95 articles were selected for comprehensive reading according to the inclusion criteria. Problems and difficulties for orthodontic offices in applying the recommendations have been divided into nine focus areas concerning the quality of supplies, the procedures necessary to adhere to the standard precautions of hand hygiene, the use of personal protective equipment (PPE), respiratory hygiene/cough etiquette, sharps safety, orthodontic instrument reconditioning, cleaning and disinfecting clinical contact surfaces and dental unit water lines, and impression disinfection.
Conclusions: On the basis of our experience in a university department of orthodontics and private orthodontic offices, we believe that innovative thinking based on better knowledge, education and training, ergonomics, and task-specific, evidence-based guidelines and resources are required to improve compliance with infection control recommendations.

Keywords: Orthodontics, Patient Safety, Cross-Infection Control, Pliers

1. Context

The Centers for Disease Control and Prevention (CDC) has recently published its "Summary of Infection Prevention Practices in Dental Settings: Basic Expectations for Safe Care" (1), in which it states that: "All dental settings, regardless of the level of care provided, must make infection prevention a priority and should be equipped to observe Standard Precautions and other infection prevention recommendations contained in CDC's Guidelines for infection control in dental health-care settings - 2003." It also says: "Standard precautions are the minimum infection prevention practices that apply to all patient care, regardless of the suspected or confirmed infection status of the patient, in any setting where health care is delivered." Oosthuysen has reviewed compliance with infection-control recommendations in oral healthcare facilities (OHF) in developed and developing countries, but there is less information concerning specific recommendations for compliance and occupational hazards in orthodontic facilities (OF) (2-6). We adopted the infection prevention checklists of the CDC Summary (sections I: policies and practices; section II: direct observation of personnel and patient-care practices) to evaluate compliance, and found that we had some problems in applying the recommendations concerning the quality of supplies, and the procedures necessary to adhere to the Standard Precautions of hand hygiene, the use of personal protective equipment (PPE), respiratory hygiene/cough etiquette, sharps safety, orthodontic instrument reconditioning (7), cleaning and disinfecting clinical contact surfaces, impression disinfection, and dental unit water lines (DUWL). Difficulties and operative problems on these have been divided into nine focus areas supported by a vast body of recent literature and multidisciplinary connections.

2. Evidence Acquisition

The electronic literature search was conducted via the PubMed and Google Scholar databases (from January 2010 up to and including May 2016) using various combinations of the following key indexing terms: (a) orthodontics; (b) patient safety; (c) cross-infection control; (d) pliers; (e) sterilization; (f) reconditioning; (g) critical items; (h) semicritical items; (i) hand hygiene; (l) DUWL; (m) corrosion; (n) sharps safety; (o) PPE; (p) impression disinfection; (q) disinfection; (r) guidelines. Then, bibliographic material from the papers has been used in order to find other or older appropriate sources. A total of 95 English papers or documents from manufactures were found suitable to be included in this manuscript. Only few do not have a DOI or PubMed classification.

3. Results

3.1. Orthodontic Patient Safety

Orthodontic appliances and accessories are associated with a small proportion (0.7% -1%) of dental adverse events in two different databases (FDA's MAUDE database and the National Patient Safety Agency of England and Wales) (8, 9) but, if iatrogenic harm is considered by surgical specialty, the proportion of events associated with pedodontics and orthodontics increases to respectively 10.3% and 8.2%, which is significant, but lower than that associated with dental surgery (14.3%) (9). Meeran has recently published an overview of the iatrogenic risks associated with orthodontic treatment, and the roles of patients and orthodontists in preventing them (10). Orthodontic patients are at high risk of ingesting or inhaling orthodontic consumables, materials and appliances, sometimes due to the malfunctioning of the cutting tips of instruments (11). High volume suction and flushing with copious water prevent chemical burns from etching acids (10% - 37% phosphoric acid), and minimise the risk of accidental swallowing, but suitable suction tips should be selected particularly in the case of lingual orthodontics (dry field systems).

We fully agree that infection prevention is a priority in any OF because children and adolescents are still developing their immune systems, often have asymptomatic infections (due to MRSA, *S. pneumonia*, *S. pyogenes*, *H. influenza*, *Moraxella catarrhalis*, HBV, HIV etc), may be at high risk of developing infections (immunocompromised subjects and those predisposed to developing infective endocarditis), or be medically compromised (12-19). This accounts for the increasing discussion of the medical-legal liability of orthodontists, and underlines the need for established scientific proof concerning prophylactic antibiotic treatment and the prevention of the over-use of antibiotics (19, 20) when treating high-risk patients. Studies based on standard culture methods indicated that bacteremia prevalence is variable after different orthodontic procedures (20), but it is not known after a sequence of different orthodontic treatments. In OF, controlling cross-infections can be difficult for many reasons, including environmental contamination due to the high turnover of young patients, who are often accompanied by a relative. Acutely ill patients and relatives do not usually visit dental offices but, regardless of their current health status, they should be informed and taught about respiratory and hand hygiene and cough etiquette before entering an operating room in order to minimise environmental contamination. Two studies have reported variable effects of the prior use of 0.12% chlorhexidine as a mouthwash to decrease air contamination during dental prophylaxis or the removal of fixed appliances, but the importance of the time interval between mouth washing and prophylactic procedures needs further investigation (21, 22).

3.2. Task-Specific Evidence-Based Guidelines

Occupational health programmes often fail to include task-specific infection prevention education and training, and the presence of cross-infections and occupational risks in an OF is often underestimated (3, 4). There are relatively few recent task-specific evidence-based guidelines, regulations, standards or papers concerning the control of cross-infections (3-6) in OFs (the majority of studies mainly concentrate on maxillofacial surgery) (23), and there are unlike requirements for cross-infection control and sterilisation when placing different temporary orthodontic anchorage devices (24-26). Mini-plates and large titanium screws are inserted using pre-drilling methods, while self-drilling mini-screws are placed without making a mucoperiosteal incision or undertaking flap surgery, which significantly reduce patient pain and discomfort after implantation (27, 28). The quarrel arises because only pre-drilling methods are considered "oral surgical procedures" following CDC's criteria. Moreover, mini-screws are mainly packaged, sterile, single-use medical devices in developed countries, but parts or all of other devices (plates, expanders) could be reused after suitable sterilisation. Nevertheless, shared or detailed protocols are lacking. Recently, Estelita's group reported that torsional strengths of screws that underwent the recycling protocols were not changed (29). Unfortunately, the authors did not reported the detergent solution used for ultrasonic cleaning, details for Al2O3 blasting, the used steam autoclave (with fractioned pre vacuum air removal or not?) and its quality control (29).

3.3. Contamination of the Air and Clinical Contact Surfaces

Cross-infection control is not easy in an OF because of the environmental contamination of clinical contact surfaces caused by the high turnover of patients and by procedures such as the removal of fixed appliances and dental prophylaxis, and the use of contaminated "received from manufacturer" and/or "clinic-exposed" orthodontic materials (3, 5-7, 21, 22, 30, 31). Mean aerosol contamination is about 6 fold higher after the removal of fixed appliances than in control group (21). Dos Santos has more recently reported a mean of 9.05×10^2 CFUs during prophylaxis after the use of water as a mouthwash and under different experimental conditions (22). Many objects (gypsum casts; elastomeric chains; wires; multi use vials containing bonds, cements, pastes; composite syringes; tips; light curing units, etc.) are often touched with contaminated gloves. The extensive use of disposable materials (e.g. single-dose samples of bonding agent, adhesive-coated brackets) and accessories should be preferred. Electronic patient records, a touch-free patient record management system, and digital casts should be favoured in order to reduce the risk of cross-infection due to the frequent touching of gypsum casts (MRSA contamination 15.4%) (2) or patient records (32). Clinical contact surfaces (including those of digital devices) need to be cleaned, disinfected and protected against potential contamination by pathogens from the patients' mouths using suitable surface disinfectants as recommended by Rutala and Weber (33). We prefer particularly rapidly acting disinfectants with a broad spectrum of activity and limited health effects (few risk phrases in the safety data sheet). Impregnated wipes have many operational, occupational and ecological advantages as discussed elsewhere (30). In particular, sufficiently soaked wipes guarantee the optimal release of the disinfectant and the contact time appropriate to the treated area, and allows minor inhalation of and dermal exposure to components. In addition, there are disposable, purpose-made protective coverings ranging from cheap transparent food barriers to thin sheets of adhesive plastic; the latter give a smarter and more orderly look to a orthodontic office, but transparent food barriers are handy against the significant (40% - 60%) bacterial contamination of curing lights in dental facilities as reviewed elsewhere (30) (Figure 1). Oosthuysen has indicated how frequently such covers should be replaced on the basis of the high turnover of orthodontic patients, cost and environmental impact (2) but, in our view, the decision depends on the degree of risk posed by environmental contamination during the various dental procedures (the removal of fixed appliances vs the replacement of orthodontic elastomeric chains) and, particularly, the frequent poor oral hygiene of orthodontic patients. Terminal disinfection using a hydrogen peroxide-based, no-touch procedure based is very convenient and safe for use in an OF (34).

Modifying removable orthodontic appliances, using rotary instruments, at the side of the dental chair should be avoided because acrylic baseplates are always contaminated by mutant *Streptococci* colonies/biofilms after one week's use by children (3, 35, 36). Moreover, the niches of crazing or thinned-out areas on acrylic plates can favour the growth of various microbial species (including MRSA), and the formation of biofilm. The use of non-toxic antimicrobial sprays (isopropanol and ethanol; chlorhexidine gluconate; cetilpyridinium chloridine) should be preferred because soaking in chemical solutions can cause the decomposition of acrylic resin molecules (37). It is well known that the cleaning and disinfection (with effervescent tablets) of removable orthodontic appliances limits the biohazards of manual brushing. Nevertheless, taking advantages from the sensitivity of a bioluminometer microbiological analysis, Levrini, reported that biofilm continued to be present in low concentration of orthodontic clear aligners even after the cleaning with brushing and toothpaste and the use of sodium carbonate and sulfate tablet (38).

3.4. Percutaneous Injuries and Gloves

In 2000, McCarthy reported frequent percutaneous injuries to orthodontists (4.9 per year) (39). The frequency of percutaneous injuries caused by orthodontic wire is reported to be 10.7 % (about half that of injection needle injuries) in dentists, and 5.6% in nurses (40). However, the data are frequently under-reported (1% - 4%) or not considered significant even in the dental teaching environment (5, 6, 41-46). Nationwide data from The Netherlands show a small number of blood exposure incidents due to orthodontic wires, mainly considered low-risk incidents (45), but the percutaneous injury rate during intermaxillary fixation is 23% (47). Orthognathic surgery must therefore be considered at high risk of glove perforation in surgeon and first assistants (48). An orthodontist's skill, experience and attention are important because of the extensive use of cutting instruments and metallic ligatures during fixed orthodontics. Specific preventive strategies to reduce the risk of infection due to the puncture of a glove-covered hand include reducing the use of sharp objects by favouring elastomeric ligatures (when clinically possible), self-ligating brackets, pencil-type twisters (that reduce glove perforation and wire stick injuries), and surgical alternatives to rapid intermaxillary fixation (inter-maxillary fixation screws etc) (49). Damage to the intra-oral tissues of patients (mucosal trauma) must be prevented by using functioning instruments: any sign of "wear or work fatigue"

Figure 1. Disposable transparent food barriers (A,B) and purpose-made protective covering (C and D) are both handy against the significant bacterial contamination of curing lights, but the latter (C and D) give a smarter and more orderly look to an OF

Barriers must be pulled perfectly tight, be replaced regularly, removed safely and disposed as waste in compliance with National Laws. They should cause non-significant modifications of halogen lamps' emissions of light. To prevent contamination, curing lights selection should considered the "wand" design, whisper-quiet (A and C) or no fan (B and D), exterior made of a smooth high-performance materials and control buttons located on the hand-piece. Protective light shield and protective glasses are needed.

and any damage to the cutting tips of orthodontic instruments must be promptly identified, and the tip or instrument immediately replaced (10).

Puncture-resistant gloves and improved glove design based on test methods specific for orthodontic tasks will be very useful in the future. Two studies have shown that the use of textured latex gloves can help improve grip on instruments and orthodontic components (50, 51). More recently, Allahyari found that fine finger dexterity is increased by latex gloves because of their greater elasticity and viscosity in comparison with nitrile gloves, although the latter are more resistant to perforation and do not cause allergic reactions (52). Orthodontists should be aware that cleaning clinical gloves in any way is absolutely prohibited as it increases the size and number of pinholes, and is not at all approved by patients (1, 53). Further danger may come from the use of gloves with significantly higher defect rates (as high as 20%) than that considered acceptable (2.5%) according International regulations (54). In the future, orthodontists will probably have composite neoprene/nitrile/latex gloves, which are more flexible than latex gloves and offer a similarly effective bacterial barrier (55).

3.5. Hand Hygiene

Alcohol-based hand sanitisers are the first choice because of the high turnover of orthodontic patients and the need for frequent hand hygiene (1, 6). When hands are not visibly soiled, they are faster, more effective and less drying/irritating than soap and water. Hand hygiene is obviously always required before and after patient dental care, and after removing and disposing of PPE. The factors leading to poor compliance with hand hygiene are insufficient time, understaffing or overcrowding, and a low perception of the possibility of acquiring infections from orthodontic patients. A survey has shown that 18% of respondents agreed with the statement that there is no need for hand hygiene in healthcare settings if gloves are used (56). In our experience, education and training need to be improved in an interactive and engaging manner in order to underline the fact that gloves are not a substitute for cleaning hands in a crowded OF. We use the CDC printable hand washing posters that are free for healthcare providers and public display, and those for boys, girls or both steal the show among our younger patients (57, 58).

3.6. Masks, Eye Wear and Face Shields

McCarthy reported blood splashes in the eyes, nose or mouth of oral surgeons (1.8 per year) (39). In OF, splash-

and airborne particles (with a diameter of < 2.5 μm) are produced by the removal of fixed appliances, and the air contains silica particles from adhesive resin fillers, various by-products of bur material, biological fluids, and potentially infectious agents (3, 5, 6, 21, 22). The danger of these or even smaller particles that can reach the alveoli of the lungs is largely unknown and underestimated. Their production can be minimised by using operating protocols (such as the mechanical removal of as much resin as possible before using rotary instruments), and an aspirator. A better understanding of the differences in the effectiveness of surgical masks and respirators is required in order to ensure their rational use during orthodontic interventions. Unfortunately, the use of a dental dam is impracticable in orthodontics.

The intensity of curing lights has increased significantly over the years, but orthodontists generally seem to be unaware of the associated hazard for themselves or their patients (3, 4). EN166-standard PPE for the eyes and face are available on the market to prevent accidental eye damage by physical or chemical agents and radiation. One study found that about 87% of the goggles in a stomatology hospital had bacterial contamination (54% due to gram-positive cocci), and three different disinfectants showed similar and excellent performances (59). Impregnated wipes for surface disinfection should be selected bearing in mind their compatibility with medical loupes, quite frequently used by orthodontists because of the need for meticulous precision in their work.

3.7. Instrument Reprocessing

Recently, the instrument reprocessing has been reviewed by Rutala and Weber (60). The reprocessing of orthodontic instruments (OIs), orthodontic supplies and accessories (cheek retractors, elastomeric chains, photographic mirrors, orthodontic markers, etc.) has become a matter of actual interest only recently (5, 6, 37, 61-68). In general, OIs (arch-forming pliers, ligature cutters, distal-end cutters, torquing keys, bracket positioning gauges, V-bend forming pliers, bracket placement tweezers, orthodontic scaler, etc.) are considered semi-critical items as they touch the mucous membrane or non-intact skin. Then, OIs minimally require cleaning and high-level disinfection using chemical disinfectants or the use of a washer disinfector (WD). Recently, we discussed if OIs have to be considered semicritical or critical items, following the recent statements on semicritical items reported by Rutala and Weber (7, 69).

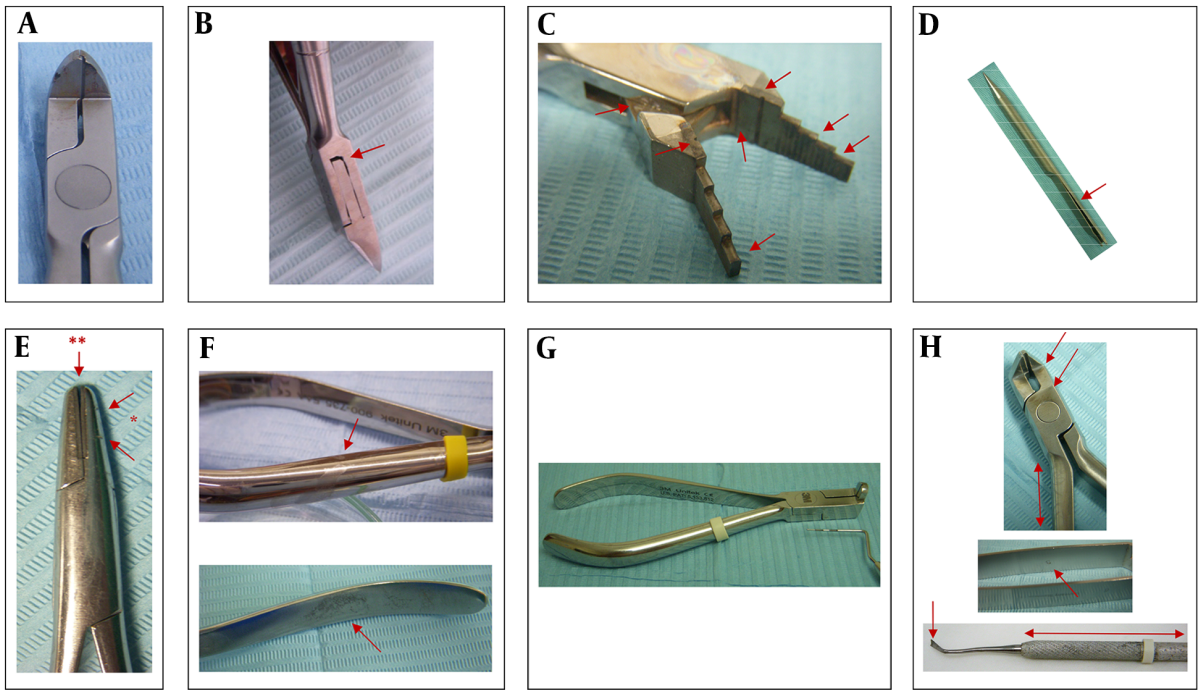
OIs are mainly single end sharp, heavy (cutters and pliers), and heat-tolerant. Cleaning solutions with additional anti-microbial compounds are needed, but we reported pitfalls of cleaning controls in ultrasonic washers (UW) (70) and cleaning in UW may damage tungsten carbide inserts of OIs. UW are the best choice in decontaminating orthodontic molar bands from manufactures or used after the trying practice of band selection (size determination) on patient's diagnostic casts or at the chairside (71, 72). Molar bands are quite expensive and their buccal tubes are very poorly accessible for cleaning (7). This accounts for potential medical-legal liability of orthodontists, since many manufacturers define molar bands as "single-use" according to EN standards and then their reconditioning is not allowed.

The optimal cleaning and thermo-disinfection of OIs (cutters, pliers, hand instruments etc.) with little occupational risk is possible using cassettes with modern hole patterns (1/3 more open area, and 59% less instrument contact) and WD. Cassettes can hold up to four pliers and three hand instruments, and are generally needed for fixed orthodontics. Another advantage is that the orthodontic kit is reassembled directly in the operating room and instruments are fixed in the open position. Using WD, there are the advantages of better automatic cleaning, no instrument contact or rubbing, and rinsing is less likely to leave rinse and drying shadows (Figure 2C and 2F). Routine quality control is possible by inserting appropriate controls for cleaning efficacy (STF, Browne; Wash-checks WD) and the moist heat process (Des-check, Browne) inside the cassette.

OIs minimally require chemical high-level disinfection, but packaging and steam sterilization seems to be nowadays more appropriate (7). We agree with this choice, since the difficulties during OI reconditioning due to the presence of joints, recesses, sharp tips, and not easily accessible zones of almost all OIs (Figure 2G), the heavy bacterial and occult blood contamination of saliva in orthodontic patients, and their developing immune system (7, 73-75). Up to now, there are no published data concerning the bio-burden of OIs, but this is not expected to be entirely negligible. In fact, recent molecular data show that the microbiota of the oral cavity is highly crowded with bacterial strains (73, 74), belonging to known and unknown genera. Saliva contains a lot of bacteria up to $\log_{10}$ 8 CFU/mL. This concentration is very higher than those present in stomach ($\log_{10}$ 3 - 5 CFU/mL) and small intestine (less than $\log_{10}$ 5 CFU/mL) (75). In addition, bacterial markers and occult blood (in the range of 1 - 2.5 mg/dL) in saliva worsen during fixed and removable orthodontic treatment, with a shift towards an increased prevalence of periodontal pathogens (*S. mutans* and *Lactobacillus*) (76, 77).

Taking into account working problems, chemical disinfection is more aggressive and more detrimental to the lifespan of orthodontic cutters than autoclave sterilisation, and is responsible for localised corrosion in the form of pitting, which is more dangerous than surface corro-

Figure 2. Some examples of corrosion and/or surface damage of OIs caused by: the low quality of A, stainless and joint fit; B low cost pliers; C, joint and not easily accessible zones of Nance loop forming plier; F, residues of the etching gel or bonding materials (F, up) widely used in orthodontics and of reconditioning products (F, bottom); E, cleaning in ultrasonic washers (*) and closed position during sterilization (**)



Some poorly accessible parts of a SpinTek opening/closing instrument (D) and distal end cutter during the reprocessing in closed position (G). A probe marked at 3, 6, 9, and 12 mm has been included to show how small parts are. Various stains and/or surface damage due to residues of cleaner, disinfectant, water etc (H, up). Corrosion on bracket placement tweezers (H, middle) and on ligature director (H, bottom).

sion (65). The widespread use of spray surface disinfectants on OIs is a risky error because their efficacy is insufficient and their pH and/or their composition may damage the chromium oxide layer (37, 62). In general, the corrosion of pliers is due to various factors: a) the quality and chemical profile of the stainless steel and joint fit (Figure 2A and 2B); b) drying biological fluids, etching gel, adhesive, or composite left on the surface (Figure 2C, 2F and 2H); c) chemical corrosion due to some disinfectants (es. peracetic-based disinfectant and surface disinfectants) (Figure 2H); d) a precise joint fit that inhibits rapid drying and leads to residues (water, cleaner, disinfectant); e) cleaning, rinsing and sterilisation in the closed position (Figure 2E); f) rubbing in an ultrasonic washer (Figure 2E and 2G) joint improper lubrication. In steam autoclave, plier corrosion is mainly ascribed to the quality of the water/steam, residual moisture after steam autoclave cycles, overshooting or wrong cycle selection, and expected more dangerous in old steam autoclave without fractioned pre-vacuum air removal compared to steam autoclave with a fractioned pre-vacuum air removal (es. class B autoclave following EN13060) and routine quality controls (63, 64, 67, 78). Nevertheless, steam sterilization have some disadvantages (overall working time, overall weight of OI kits, higher requirements of OIs) taking into account the orthodontic patient turnover. The use of sterile OIs certainly requires greater investments, but these can be reduced by using self-ligating brackets that do not require some OIs (ortho Mathieu pliers, ligature cutters, band pusher/scaler, ligature director, metallic ligatures) and are time-saving. If OIs are packaged in self-sealing sterilisation pouches or paper/plastic barriers for autoclaves, safe handling and a careful inspection of sterilised packaging integrity is necessary as the majority of orthodontic instruments are sharp and heavy and can break the paper. To avoid this problem, it is useful to put OIs into a cassette packaged for terminal sterilisation, or put them into containers for sterilisation (with perforations in the lid and bottom) with autoclavable silicon mats (7). Internal chemical monitors (integrators) should be placed within each package, tray or containment device to be sterilised (78), and the containers should be placed about one inch apart from each other.

There are indications (but no guidelines) concerning the reconditioning of “clinic-exposed” and “received from

manufacturer" orthodontic materials (e.g. orthodontics bands, buttons, ligatures, brackets, archwires etc) (6, 37, 71, 79, 80). We believe that single-patient packaged orthodontic materials are the best choice as the EN standards define them as "single-use" and prevent their contamination by hand and environmental exposure. The market of clinically used and recycled archwires and brackets is successful in many countries, although it is emerging that reconditioning changes their mechanical and physical properties, and it is unclear how producers can certify the absence of microbial contamination, unmodified bracket attachment ability and corrosion resistance (81). Recently, some difficulties on reconditioning of elastic chains and ligatures have been reported and discussed by different authors (7, 37, 68).

3.8. Alginate Impressions and Casts

Recent reviews have highlighted the poor compliance of impression disinfection (2, 82) which is very concerning because of the continuous coming and going of orthodontic appliances and impression trays between dental technicians and OFs. Alginate impressions are generally sprayed or wrapped in soaked gauze, and then placed in a plastic bag for the time it takes for the disinfectant to act in order to prevent it from evaporating. Karla suggested wrapping alginate impressions in gauze soaked in 1:10 sodium hypochlorite for 10 minutes, but did not undertake microbiological tests to prove it (6). It has been found that disinfecting an alginate impression by means of three minutes' immersion in a 3% Cavex ImpreSafe® solution (which has a bactericidal, virucidal and fungicidal effect, and complies with the DGHM guidelines and the European Directives) has no negative clinical effects (83). Pakdin found a similarly acceptable reduction in the contamination of gypsum casts made from alginate impressions (in terms of colony counts) when they were disinfected (10 minutes' contact time) by being sprayed with Micro10 (10%), sodium hypochlorite (5.25%) or Deconex, or being immersed in a glutaraldehyde solution (2%) (84).

Lingual orthodontics is an aesthetic, customised and expensive orthodontic treatment that needs high-quality impressions. The Incognito Lab order form states that "All impressions and models must be completely disinfected prior to despatch to TOP-Service", but does not describe the method of disinfection in detail (85). In the near future, the problem of impression and cast contamination can be eliminated using digital models produced by an intra-oral scan (86).

3.9. DUWL

Here, we briefly face the burning problem of the contamination of DUWLs as reviewed previously by others authors (87-89), but to our best knowledge, never associated to OF. In our opinion, recent infections among patients in a paediatric dental practice, and emerging molecular dental epidemiology data make mandatory to use drinking water in DUWL (1, 90, 91). Briefly, the bacterial contamination of drinking water ranges from two regulatory standard, from EN (i.e., < 100 CFU/mL at 22°C, < 20 CFU/mL at 37°C, and the absence of pathogens) and US Environmental Protection Agency (i.e., ≤ 500 CFU/mL of heterotrophic water bacteria) (1). Except when removing fixed appliances and practising dental hygiene, OFs do not usually use large quantities of water. Then, continuous disinfection and periodic shock treatment of DUWLs is probably the best choice to limit the consequence of stagnation and then microbial colonization. Water quality monitoring is needed according American Dental Association indication using commercial self-contained test kits (92). In addition, DUWL treatment solutions should be checked to avoid any interference with bonding procedures during fixed orthodontics (93, 94).

4. Discussion

We urgently need specific evidence-based guidelines (mainly concerning the recycling of screws), regulations and research studies (typing of contamination on clinical contact surfaces in OFs, bioburden of OIs etc.) based on molecular methods, technological improvements (mainly alloys that are more resistant to reconditioning, and PPE), and task-specific coordinators of OFs. Cross infection prevention is a priority because it is unknown the level of microbial contamination that could cause outbreaks and infections among young orthodontic patients, because are still developing their immune systems. We think that nowadays OIs have to be considered critical items, considering the recent statements on semicritical items reported by Rutala and Weber (7, 69), the reported problems associated to OI reconditioning, the need to select high-level aldehyde-free disinfectants for OIs according to European law governing occupational safety, and manufacturers' restrictions concerning peracetic disinfectants for high cold disinfection. In addition to legal, ethical and quality requirements, preventing the risk of infection is a priority to improve the image of OFs. Females are generally more sensitive to the risk of infection than males, and female orthodontic patients are less satisfied with the barrier techniques used by orthodontists (53, 95). This should alert orthodontists to review their infection control strategies (particularly hand hygiene and the use of gloves) as mothers frequently accompany their offspring to OFs. We believe that innovative thinking based on better knowledge, education and training, and consumable material re-

sources are required to improve compliance with infection control recommendations and more ergonomics, other than the quality of care and patient safety in OFs.

Acknowledgments

We would like to thank Prof. Mauro Gandolfini (Department of Orthodontics, Department of biomedical, biotechnological and translational sciences, Parma University, Parma, Italy) for the cooperation, support, and critical discussions.

References

1. *Summary of Infection Prevention Practices in Dental Settings: Basic Expectations for Safe Care*. Atlanta: National Center for Chronic Disease Prevention and Health Promotion Division of Oral Health; 2016.Centers for Disease Control and Prevention; US Department of Health and Human Services; Centers for Disease Control and Prevention.
2. Oosthuysen J, Potgieter E, Fossey A. Compliance with infection prevention and control in oral health-care facilities: a global perspective. *Int Dent J*. 2014;**64**(6):297–311. doi: 10.1111/idj.12134. [PubMed: 25244364].
3. Pandis N, Pandis BD, Pandis V, Eliades T. Occupational hazards in orthodontics: a review of risks and associated pathology. *Am J Orthod Dentofacial Orthop*. 2007;**132**(3):280–92. doi: 10.1016/j.ajodo.2006.10.017. [PubMed: 17826595].
4. Srivastava SC, Tandon R, Verma K, Goel A, Bhardwaj M. Ocular Hazards in Orthodontics: An Overview. *Asian J Oral Health Allied Sci*. 2013;**3**(1):14.
5. Bhatnagar S, Bagga DK, Sharma P, Kumar P, Sharma R, Singh V. Infection control strategy in orthodontic office. *Eur J General Dent*. 2013;**2**(1):1.
6. Kalra S, Tripathi T, Rai P. Infection Control in Orthodontics. *J Orthodontics Endodontics*. 2015;**1**(1):1–12.
7. Barenghi L, Di Blasio A. Orthodontic instruments and supplies: Are they semicritical or critical items?. *Am J Infect Control*. 2017;**45**(2):210–1. doi: 10.1016/j.ajic.2016.09.028. [PubMed: 27856075].
8. Hebballi NB, Ramoni R, Kalenderian E, Delattre VF, Stewart DC, Kent K, et al. The dangers of dental devices as reported in the Food and Drug Administration Manufacturer and User Facility Device Experience Database. *J Am Dent Assoc*. 2015;**146**(2):102–10. doi: 10.1016/j.adaj.2014.11.015. [PubMed: 25637208].
9. Thusu S, Panesar S, Bedi R. Patient safety in dentistry - state of play as revealed by a national database of errors. *Br Dent J*. 2012;**213**(3). E3. doi: 10.1038/sj.bdj.2012.669. [PubMed: 22878337].
10. Meeran NA. Iatrogenic possibilities of orthodontic treatment and modalities of prevention. *J Orthod Sci*. 2013;**2**(3):73–86. doi: 10.4103/2278-0203.119678. [PubMed: 24987646].
11. Umesan UK, Chua KL, Balakrishnan P. Prevention and management of accidental foreign body ingestion and aspiration in orthodontic practice. *Ther Clin Risk Manag*. 2012;**8**:245–52. doi: 10.2147/TCRM.S30639. [PubMed: 22701326].
12. Slots J, Slots H. Bacterial and viral pathogens in saliva: disease relationship and infectious risk. *Periodontol 2000*. 2011;**55**(1):48–69. doi: 10.1111/j.1600-0757.2010.00361.x. [PubMed: 21134228].
13. Petti S, Sofan A, Messano G. Streptococcus pneumoniae carriage rate in healthy preadolescent dental patients. *Acta stomatologica Naissi*. 2013;**29**(67):1249–54. doi: 10.5937/asn1367249P.
14. Gamblin J, Jefferies JM, Harris S, Ahmad N, Marsh P, Faust SN, et al. Nasal self-swabbing for estimating the prevalence of Staphylococcus aureus in the community. *J Med Microbiol*. 2013;**62**(Pt 3):437–40. doi: 10.1099/jmm.0.051854-0. [PubMed: 23222858].
15. ECDC. *HIV/AIDS surveillance in Europe 2013. .See Figure E: Percentage of new HIV diagnoses in people between 15 and 24 years old, by country, EU/EEA, 2013 (n=29 157). Mean EU is about 12% (range 6-25% in different countries)*. Available from: http://ecdc.europa.eu/en/publications/Publications/hiv-aids-surveillance-report-Europe-2013.pdf.
16. Khattri S, Bhardwaj M. Orthodontic management in medically compromised patients. *Int J Dent Clin*. 2012;**4**(3).
17. Maheshwari S, Verma SK, Ansar J, Prabhat KC. Orthodontic care of medically compromised patients. *Indian J Oral Sci*. 2012;**3**(3):129. doi: 10.4103/0976-6944.111174.
18. Leong JW, Kunzel C, Cangialosi TJ. Management of the American Heart Association's guidelines for orthodontic treatment of patients at risk for infective endocarditis. *Am J Orthod Dentofacial Orthop*. 2012;**142**(3):348–54. doi: 10.1016/j.ajodo.2012.05.002. [PubMed: 22920701].
19. Siddharth S, Ganesh P, Kumar S. Is orthodontic treatment causes bacterial endocarditis? A Review based random study. *Int J Mol Med Sci*. 2013;**3**(2). doi: 10.5376/ijmms.2013.03.0002.
20. Livas C, Delli K, Karapsias S, Pandis N, Ren Y. Investigation of bacteremia induced by removal of orthodontic mini-implants. *Eur J Orthod*. 2014;**36**(1):16–21. doi: 10.1093/ejo/cjs099. [PubMed: 23321850].
21. Toroglu MS, Haytac MC, Koksal F. Evaluation of aerosol contamination during debonding procedures. *Angle Orthod*. 2001;**71**(4):299–306. doi: 10.1043/0003-3219(2001)071lt;0299:EOACDDgt;2.0.CO;2. [PubMed: 11510639].
22. Santos IR, Moreira AC, Costa MG, Castellucci e Barbosa M. Effect of 0.12% chlorhexidine in reducing microorganisms found in aerosol used for dental prophylaxis of patients submitted to fixed orthodontic treatment. *Dental Press J Orthod*. 2014;**19**(3):95–101. [PubMed: 25162572].
23. Pigadas N, Whitley SP, Roberts SA, McAlister K, Ameerally P, Avery CM. A randomized controlled trial on cross-infection control in maxillofacial trauma surgery: a comparison of intermaxillary fixation techniques. *Int J Oral Maxillofac Surg*. 2008;**37**(8):716–22. doi: 10.1016/j.ijom.2008.05.005. [PubMed: 18599271].
24. Elias CN, de Oliveira Ruellas AC, Fernandes DJ. Orthodontic implants: concepts for the orthodontic practitioner. *Int J Dent*. 2012;**2012**:549761. doi: 10.1155/2012/549761. [PubMed: 23209470].
25. Cook A. Sterilization requirements for the placement of temporary anchorage devices. Interview by Robert P Scholz. *Am J Orthod Dentofacial Orthop*. 2009;**135**(4 Suppl):S20–2. doi: 10.1016/j.ajodo.2009.01.015. [PubMed: 19362266].
26. Cleveland JL, Kohn W. CDC weighs in on TADs. *Am J Orthod Dentofacial Orthop*. 2009;**136**(5):622–3. doi: 10.1016/j.ajodo.2009.09.008. [PubMed: 19892264].
27. Giuliano Maino B, Pagin P, Di Blasio A. Success of miniscrews used as anchorage for orthodontic treatment: analysis of different factors. *Prog Orthod*. 2012;**13**(3):202–9. doi: 10.1016/j.pio.2012.04.002. [PubMed: 23260530].
28. Kuroda S, Sugawara Y, Deguchi T, Kyung HM, Takano-Yamamoto T. Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. *Am J Orthod Dentofacial Orthop*. 2007;**131**(1):9–15. doi: 10.1016/j.ajodo.2005.02.032. [PubMed: 17208101].
29. Estelita S, Janson G, Chiqueto K, Ferreira ES. Effect of recycling protocol on mechanical strength of used mini-implants. *Int J Dent*. 2014;**2014**:424923. doi: 10.1155/2014/424923. [PubMed: 25136368].
30. Barenghi L. *Clean, disinfect and cover - Top activities for in dentistry clinical contact surfaces*. 2016. Available from: http://www.kerrdental.eu/catalog-files/clinical-articles/0/588/files/EN_Dr-Livia-Barenghi.pdf.
31. Barker CS, Soro V, Dymock D, Sandy JR, Ireland AJ. Microbial contamination of "as received" and "clinic exposed" orthodontic materials. *Am J Orthod Dentofacial Orthop*. 2013;**143**(3):317–23. doi: 10.1016/j.ajodo.2012.09.020. [PubMed: 23452965].

32. Wan Hassan WN, Abu Kassim NL, Jhawar A, Shurkri NM, Kamarul Baharin NA, Chan CS. User acceptance of a touchless sterile system to control virtual orthodontic study models. *Am J Orthod Dentofacial Orthop*. 2016;**149**(4):567–78. doi: 10.1016/j.ajodo.2015.10.018. [PubMed: 27021461].
33. Rutala WA, Weber DJ. Selection of the ideal disinfectant. *Infect Control Hosp Epidemiol*. 2014;**35**(7):855–65. doi: 10.1086/676877. [PubMed: 24915214].
34. Weber DJ, Rutala WA, Anderson DJ, Chen LF, Sickbert-Bennett EE, Boyce JM. Effectiveness of ultraviolet devices and hydrogen peroxide systems for terminal room decontamination: Focus on clinical trials. *Am J Infect Control*. 2016;**44**(5 Suppl):e77–84. doi: 10.1016/j.ajic.2015.11.015. [PubMed: 27131140].
35. Lessa FC, Enoki C, Ito IY, Faria G, Matsumoto MA, Nelson-Filho P. In-vivo evaluation of the bacterial contamination and disinfection of acrylic baseplates of removable orthodontic appliances. *Am J Orthod Dentofacial Orthop*. 2007;**131**(6):705 e11–7. doi: 10.1016/j.ajodo.2006.09.042. [PubMed: 17561044].
36. Pathak AK, Sharma DS. Biofilm associated microorganisms on removable oral orthodontic appliances in children in the mixed dentition. *J Clin Pediatr Dent*. 2013;**37**(3):335–9. [PubMed: 23855182].
37. Aksoy A, Kilic G , Hussein E, Aboukhalil D. Sterilization and Disinfection in Orthodontics. *Principles in Contemporary Orthodontics*. InTech; 2011.
38. Levrini L, Mangano A, Margherini S, Tenconi C, Vigetti D, Muollo R, et al. ATP Bioluminometers Analysis on the Surfaces of Removable Orthodontic Aligners after the Use of Different Cleaning Methods. *Int J Dent*. 2016;**2016**:5926941. doi: 10.1155/2016/5926941. [PubMed: 27242901].
39. McCarthy GM. Risk of transmission of viruses in the dental office. *J Can Dent Assoc*. 2000;**66**(10):554–5. 557. [PubMed: 12584777].
40. Ebrahimi SF, Shadman N, Ghaempanah I. Needlestick injuries in dentists and their assistants in Kerman, Iran: Prevalence, knowledge, and practice. *J Oral Health Oral Epidemiol*. 2013;**2**(1):23–7.
41. Lee JJ, Kok SH, Cheng SJ, Lin LD, Lin CP. Needlestick and sharps injuries among dental healthcare workers at a university hospital. *J Formos Med Assoc*. 2014;**113**(4):227–33. doi: 10.1016/j.jfma.2012.05.009. [PubMed: 24685298].
42. Hughes A, Davies L, Hale R, Gallagher J. Adverse incidents resulting in exposure to body fluids at a UK dental teaching hospital over a 6-year period. *Infect Drug Resist*. 2012;**5**:155–61. doi: 10.2147/IDR.S30814. [PubMed: 23118545].
43. Ali FM, Patil A, Prasant MC, Tahasildar S, Patil K. Needle Stick injuries in Dental Clinics: A Review. *J Evol Med Dent Sci*. 2014;**3**(2):374–8.
44. Sedky NA. Occupational bloodborne exposure incident survey management of exposure incidents in a dental teaching environment. *Int J Health Sci (Qassim)*. 2013;**7**(2):174–90. [PubMed: 24421746].
45. van Wijk PT, Meiberg AE, Bruers JJ, Groenewold MH, van Raalten AL, Dam BA, et al. The risk of blood exposure incidents in dental practices in the Netherlands. *Community Dent Oral Epidemiol*. 2012;**40**(6):567–73. doi: 10.1111/j.1600-0528.2012.00702.x. [PubMed: 22712586].
46. Gatto MR, Bandini L, Montevecchi M, Checchi L. Occupational exposure to blood and body fluids in a department of oral sciences: results of a thirteen-year surveillance study. *Scientific World Journal*. 2013;**2013**:459281. doi: 10.1155/2013/459281. [PubMed: 23476136].
47. Bali R, Sharma P, Garg A. Incidence and patterns of needlestick injuries during intermaxillary fixation. *Br J Oral Maxillofac Surg*. 2011;**49**(3):221–4. doi: 10.1016/j.bjoms.2010.04.010. [PubMed: 20488595].
48. Kuroyanagi N, Nagao T, Sakuma H, Miyachi H, Ochiai S, Kimura Y, et al. Risk of surgical glove perforation in oral and maxillofacial surgery. *Int J Oral Maxillofac Surg*. 2012;**41**(8):1014–9. doi: 10.1016/j.ijom.2012.02.010. [PubMed: 22446068].
49. Chhabra N, Chhabra S, Thapar D. Evaluation of two different methods of arch bar application: a comparative prospective study. *J Maxillofac Oral Surg*. 2015;**14**(2):432–40. doi: 10.1007/s12663-014-0658-0. [PubMed: 26028870].
50. Chua KL, Taylor GS, Bagg J. A clinical and laboratory evaluation of three types of operating gloves for use in orthodontic practice. *Br J Orthod*. 1996;**23**(2):115–20. [PubMed: 8771334].
51. VanMeter BH, Aggarwal M, Thacker JG, Edlich RF. A new powder-free glove with a textured surface to improve handling of surgical instruments. *J Emerg Med*. 1995;**13**(3):365–8. [PubMed: 7673631].
52. Allahyari T, Khanehshenas F, Khalkhali H. An Investigation of the Impact of Using Latex and Nitrile Gloves on Hand Dexterity. *Int J Occup Hygiene*. 2015;**7**(1):22–6.
53. Bhayya DP, Shyagali TR. Parental attitude and knowledge towards the usage of barrier techniques by pediatric dentist. *International Journal of Infection Control*. 2012;**8**(3):1–8.
54. Al-Swuailem AS. Prevalence of manufacturing defects in latex examination gloves used in selected dental practices in central Saudi Arabia. *Saudi Med J*. 2014;**35**(7):729–33. [PubMed: 25028231].
55. Bardorf MH, Jager B, Boeckmans E, Kramer A, Assadian O. Influence of material properties on gloves' bacterial barrier efficacy in the presence of microperforation. *Am J Infect Control*. 2016;**44**(12):1645–9. doi: 10.1016/j.ajic.2016.03.070. [PubMed: 27388267].
56. John A, Tomas ME, Cadnum JL, Mana TS, Jencson A, Shaikh A, et al. Are health care personnel trained in correct use of personal protective equipment?. *Am J Infect Control*. 2016;**44**(7):840–2. doi: 10.1016/j.ajic.2016.03.031. [PubMed: 27181222].
57. CDC. *Handwashing*. 2016. Available from: http://www.cdc.gov/handwashing/posters.html.
58. Clean Hands Count campaign. *Clean Hands*. 2016. Available from: http://www.cdc.gov/handhygiene/campaign/promotional.html.
59. Yang D, Zhou F, Hu M, Lai L, Yang J, Xiao D. Contamination of dental goggles and effectiveness of 3 disinfectants in a stomatology hospital. *Am J Infect Control*. 2015;**43**(9):1003–5. doi: 10.1016/j.ajic.2015.05.001. [PubMed: 26072715].
60. Rutala WA, Weber DJ. Disinfection, sterilization, and antisepsis: An overview. *Am J Infect Control*. 2016;**44**(5 Suppl):e1–6. doi: 10.1016/j.ajic.2015.10.038. [PubMed: 27131128].
61. Vendrell RJ, Hayden CL, Taloumis LJ. Effect of steam versus dry-heat sterilization on the wear of orthodontic ligature-cutting pliers. *Am J Orthod Dentofacial Orthop*. 2002;**121**(5):467–71. [PubMed: 12045764].
62. Wichelhaus A, Brauchle G, Mertmann M, Sander FG. Corrosion of orthodontic pliers using different sterilization procedures. *J Orofac Orthop*. 2004;**65**(6):501–11. doi: 10.1007/s00056-004-0417-9. [PubMed: 15570408].
63. Kangane SK. Instrument sterilization in the orthodontic clinic: A review. *Int J Clin Dent Sci*. 2011;**1**(1).
64. Reddy VP, Reddy GY, Hegde N, Priyadarshini A. Sterilization Methods in Orthodontics-A Review. *Int J Dent Clin*. 2011;**3**(1).
65. Benyahia H, Merzouk N, Ebn Touhami M, Zaoui F. Effects of sterilization and disinfection procedures on the corrosion of orthodontic ligature cutters. *Int Orthod*. 2012;**10**(1):1–15. doi: 10.1016/j.ortho.2011.12.007. [PubMed: 22244107].
66. Almeida C, Carvalho A, Duarte DA. Evaluation of disinfection methods of orthodontic pliers. *Dent Press J Orthodont*. 2012;**17**(4):105–9. doi: 10.1590/s2176-94512012000400020.
67. George O, Rapin C, Benoit F, Filleul MP. Study of corrosion and wear of surgical instruments during sterilization. *Bull Group Int Rech Sci Stomatol Odontol*. 2011;**50**(2):39–41. [PubMed: 22750710].
68. Mirhashemi AH, Farahmand N, Borujeni ES. Application of Elastomeric Chains in Orthodontics: Past, Present and Future. *Iran J Orthodont*. 2016;**11**(2).
69. Rutala WA, Weber DJ. Reprocessing semicritical items: Current issues and new technologies. *Am J Infect Control*. 2016;**44**(5 Suppl):e53–62. doi: 10.1016/j.ajic.2015.12.029. [PubMed: 27131136].
70. Di Blasio A, Barenghi L. Pitfalls of cleaning controls in ultrasonic washers. *Am J Infect Control*. 2015;**43**(12):1374–5. doi: 10.1016/j.ajic.2015.08.020. [PubMed: 26440594].

71. Purmal K, Chin S, Pinto J, Yin WF, Chan KG. Microbial contamination of orthodontic buccal tubes from manufacturers. *Int J Mol Sci*. 2010;**11**(9):3349–56. doi: 10.3390/ijms11093349. [PubMed: 20957099].
72. Dowsing P, Benson PE. Molar band re-use and decontamination: a survey of specialists. *J Orthod*. 2006;**33**(1):30–7. doi: 10.1179/146531205225021366. [PubMed: 16514131].
73. Grassl N, Kulak NA, Pichler G, Geyer PE, Jung J, Schubert S, et al. Ultra-deep and quantitative saliva proteome reveals dynamics of the oral microbiome. *Genome Med*. 2016;**8**(1):44. doi: 10.1186/s13073-016-0293-0. [PubMed: 27102203].
74. Belstrom D, Paster BJ, Fiehn NE, Bardow A, Holmstrup P. Salivary bacterial fingerprints of established oral disease revealed by the Human Oral Microbe Identification using Next Generation Sequencing (HOMINGS) technique. *J Oral Microbiol*. 2016;**8**:30170. doi: 10.3402/jom.v8.30170. [PubMed: 26782357].
75. Kleessen B, Bezirtzoglou E, Matto J. Culture-based knowledge on biodiversity, development and stability of human gastrointestinal microflora. *Microb Ecol Health Dis*. 2000;**12**(2):53–63.
76. Freitas AO, Marquezan M, Nojima Mda C, Alviano DS, Maia LC. The influence of orthodontic fixed appliances on the oral microbiota: a systematic review. *Dental Press J Orthod*. 2014;**19**(2):46–55. [PubMed: 24945514].
77. Lara-Carrillo E, Montiel-Bastida M, Sánchez-Pérez L, Alanís-Tavira J. Changes in the oral environment during four stages of orthodontic treatment. *Korean J Orthodont*. 2010;**40**(2):95. doi: 10.4041/kjod.2010.40.2.95.
78. Seavey R. Troubleshooting failed sterilization loads: Process failures and wet packs/loads. *Am J Infect Control*. 2016;**44**(5 Suppl):e29–34. doi: 10.1016/j.ajic.2016.03.001. [PubMed: 27131132].
79. Dos Santos Gerzson DR, Simon D, Dos Anjos AL, Freitas MP. In vitro evaluation of microbial contamination of orthodontic brackets as received from the manufacturer using microbiological and molecular tests. *Angle Orthod*. 2015;**85**(6):992–6. doi: 10.2319/100414-711.1. [PubMed: 25723070].
80. Buchman DJ. Effects of recycling on metallic direct-bond orthodontic brackets. *Am J Orthod*. 1980;**77**(6):654–68. [PubMed: 6992589].
81. Bavikati VN, Singaraju GS, Mandava P, Killamsetty SS, Nettam V, Karnati PKR. Evaluation of Mechanical and Physical Properties of Clinically Used and Recycled Superelastic NiTi Wires. *J Clin Diagnos Res*. 2016;**10**(7):ZC35.
82. Almortadi N, Chadwick RG. Disinfection of dental impressions - compliance to accepted standards. *Br Dent J*. 2010;**209**(12):607–11. doi: 10.1038/sj.bdj.2010.1134. [PubMed: 21169966].
83. Dreesen K, Kellens A, Wevers M, Thilakarathne PJ, Willems G. The influence of mixing methods and disinfectant on the physical properties of alginate impression materials. *Eur J Orthod*. 2013;**35**(3):381–7. doi: 10.1093/ejo/cjs031. [PubMed: 22581479].
84. Pakdin M, Soufiabadi S, Shahrakipour M. Evaluation of Contamination Reduction on Gypsum Casts from Alginate Impressions Disinfected with Four Different Materials. *Glob J Health Sci*. 2016;**8**(12):127.
85. Incognito. *Incognito Lab order form. TOP-Service für Lingualtechnik GmbH*. 2016. Available from: www.incognito.net.
86. Dawood A, Marti Marti B, Sauret-Jackson V, Darwood A. 3D printing in dentistry. *Br Dent J*. 2015;**219**(11):521–9. doi: 10.1038/sj.bdj.2015.914. [PubMed: 26657435].
87. O'Donnell MJ, Boyle MA, Russell RJ, Coleman DC. Management of dental unit waterline biofilms in the 21st century. *Future Microbiol*. 2011;**6**(10):1209–26. doi: 10.2217/fmb.11.104. [PubMed: 22004039].
88. Szymańska J, Sitkowska J. Bacterial hazards in a dental office: An update review. *Afr J Microbiol Res*. 2012;**6**(8). doi: 10.5897/ajmr11.1002.
89. Kanamori H, Weber DJ, Rutala WA. Reply to Petti. *Clin Infect Dis*. 2016;**63**(9):1270–1. doi: 10.1093/cid/ciw535. [PubMed: 27501840].
90. Peralta G, Tobin-D'Angelo M, Parham A, Edison L, Lorentzson L, Smith C, et al. Notes from the Field: Mycobacterium abscessus Infections Among Patients of a Pediatric Dentistry Practice–Georgia, 2015. *MMWR Morb Mortal Wkly Rep*. 2016;**65**(13):355–6. doi: 10.15585/mmwr.mm6513a5. [PubMed: 27054966].
91. Ditommaso S, Giacomuzzi M, Ricciardi E, Zotti CM. Cultural and Molecular Evidence of Legionella spp. Colonization in Dental Unit Waterlines: Which Is the Best Method for Risk Assessment?. *Int J Environ Res Public Health*. 2016;**13**(2):211. doi: 10.3390/ijerph13020211. [PubMed: 26861373].
92. ADA. *Dental Unit Waterlines*. 2016. Available from: http://www.ada.org/en/member-center/oral-health-topics/dental-unit-waterlines.
93. Murthy BS, Manjula K, George JV, Shruthi N. Evaluation of effect of three different dental unit waterline antimicrobials on the shear bond strength to dentin - An ex vivo study. *J Conserv Dent*. 2012;**15**(3):289–92. doi: 10.4103/0972-0707.97963. [PubMed: 22876021].
94. Bishara SE, Soliman M, Ajlouni R, Laffoon J, Warren JJ. Waterline disinfectant effect on the shear bond strength of orthodontic brackets. *Angle Orthod*. 2005;**75**(6):1032–5. doi: 10.1043/0003-3219(2005)75[1032:WDEOTS]2.0.CO;2. [PubMed: 16448251].
95. Thomson WM, Stewart JF, Carter KD, Spencer AJ. Public perception of cross-infection control in dentistry. *Aust Dent J*. 1997;**42**(5):291–6. [PubMed: 9409043].