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Green Orthodontics: Environment Friendly Waste Disposal

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Abstract

Green orthodontics refers to the practice of orthodontics with an emphasis on environment friendly and sustainable principles. It combines the field of orthodontics with eco-conscious practices to minimize the environmental impact of orthodontic disposal. Some of the key aspects and practices associated with green orthodontics are- use of eco-friendly materials and waste reduction.

Orthodontists have to be mindful of how their work affects the environment. By conserving natural resources, significant amounts can be prevented from being exhausted. Materials used in orthodontics can be recycled and repurposed to help lessen waste and its detrimental impact on the environment. To improve patient, community, and environmental health, a focus on sustainability, prevention, and raising awareness are essential. Additionally, mandatory education on the significance of green orthodontics should be provided to orthodontists. By adopting green orthodontic practices, orthodontic offices can contribute to environmental sustainability and reduce their ecological footprint. It provides an opportunity for both orthodontists and patients to make conscious choices that benefit both oral health and the environment.

Keywords: Environment Friendly, Green orthodontics, Waste Disposal, Eco-friendly, Recycle, Re-use

Introduction

Pollution refers to the introduction of harmful substances or contaminants into the environment, resulting in adverse effects on ecosystems, human health, and well-being[1]. It can occur in various forms, including air, water, soil, and noise pollution. Pollution is often the result of human activities, such as industrial processes, transportation, agricultural practices, and waste disposal. Pollution has wide-ranging impacts on the environment and human health[2]. It contributes to climate change, biodiversity loss, respiratory and cardiovascular diseases, water scarcity, and ecological imbalances.

The most polluted country in 2022 (IQAIR) based on average PM2.5 concentration is Chad (Africa), while India is ranked 8th since the concentration exceeds by over 10 times the normal level given by WHO (0-5 μg/m^3). The Environmental Performance Index, compiled annually by Yale University's Center for Environmental Law & Policy, in 2022 ranked Denmark as the best and India as the least environmentally friendly country in the world[3].

In Orthodontics, from taking case history to the end of orthodontic therapy, a lot of waste materials are generated. What are these waste materials generated? How are they disposed? What happens after disposal? What best can be done by us as orthodontists? These are a few questions to ponder about. Green orthodontics refers to the practice of orthodontics with an emphasis on environment friendly and sustainable principles. It combines the field of orthodontics with eco-conscious practices to minimize the environmental impact of orthodontic disposal.

Some of the key aspects and practices associated with green orthodontics are:

Eco-Friendly Materials: Green orthodontics promotes the use of biodegradable, recyclable, and non-toxic materials whenever possible. This includes using orthodontic appliances, such as braces and aligners, made from sustainable materials or incorporating recycled components.

Waste Reduction: The focus is on reducing waste generation and promoting recycling. Orthodontic offices can implement recycling programs for paper, plastic, and other materials commonly used in the practice. Additionally, digital records and communication can help reduce paper waste (wood).

By adopting green orthodontic practices, orthodontic offices can contribute to environmental sustainability and reduce their ecological footprint. It provides an opportunity for both orthodontists and patients to make conscious choices that benefit both oral health and the environment.

Discussion

Orthodontic waste refers to consumables used during orthodontic treatment and needs to be disposed of properly. This waste can be generated in various stages of orthodontic procedures, including preparation, treatment and post-treatment phases. Examples of orthodontic waste include:

Preparation phase- Gloves, facemask, suction tip, radiographic film (iopa, opg, handwrist, cephalogram), lead foil, plastic pouches, radiograph developer and fixer, impression materials like alginate and silicones, gypsum products, dental wax, plastic containers, etc.

Treatment phase- etchant syringe, bonding agent, applicator tip, composite material, brackets, archwires, elastics, power chains, ligature wire, functional and orthopedic appliances made of heat cure or cold cure acrylic, syringe, mini implants, infected cotton, aligner trays, air rotor burs, headgear modules, strap and bow, etc.

Waste disposal

Colour coding for biomedical waste management in orthodontics[4]. (Table- 1, 3) and their categories[5]. (Table- 2)

Mask and gown Soiled waste- items contaminated with blood, body fluids like cotton swabs, dressings, etc Plaster of paris casts Human anatomical waste- extracted teeth, bone fragments, etc. Expired or discarded medicines Chemical waste	Gloves All plastic equipment- plastic and ceramic brackets, e- chain, elastic ligatures, elastics, plastic suction tip, syringes, aligners, modules, retainer, primer bottle, etchant tube, etc. Wax bite registration.	Sharps and metals All orthodontic attachments including brackets abd bands, wires, steel ligatures, burs, blade,etc. Needles, syringes with fixed needles. Any other contaminated sharp object that may cause puncture and cuts.	Glassware – broken or discarded and contaminated glass including medicine vials and ampules except those contaminated with cytotoxic wastes. Metallic body implants such as micro implants and mini plates

Table 1: Colour coding for biomedical waste management in orthodontics

Category	Source of waste	Treatment and Disposal
1	Human Anatomical Waste (human tissues, organs, body parts)	Incineration /deep burial
2	Animal Waste (animal tissues, organs, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses)	Incineration /deep burial
3	Microbiology & Biotechnology Waste (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and industrial laboratories, wastes from production of biological, toxins, dishes and devices used for transfer of cultures)	Local autoclaving / microwaving incineration
4	Waste Sharps(needles, syringes, scalpels, blades, glass, etc. that may cause puncture and unused sharps)	Disinfection (chemical treatment /autoclaving/ microwaving and mutilation/ shredding"
5	Discarded Medicines & Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)	Incineration /destruction and drugs disposal in secured landfills
6	Soiled Waste (items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood.	Incineration autoclaving/ microwaving
7	Solid Waste (wastes generated from disposable items other than waste sharps such as tabbing, catheters, intravenous sets etc.)	Disinfection by chemical treatment autoclaving/ microwaving and mutilation/ shredding"
8	Liquid Waste(waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities)	Disinfection by chemical treatment and discharge into drains
9	Incineration Ash (ash from incineration of any bio-medical waste)	Disposal in municipal landfill
10	Chemical Waste (chemicals used in production of biological, chemicals used in disinfection, as insecticides, etc.)	Chemical treatment and discharge into drains for liquids and secured landfill for solids.

Source: Biomedical wastes (Management and Handling Rules, 1998)

Table 2: Categories of biomedical waste and disposal

Category	Waste class	Type of container	Colour
1.	Human anatomical waste	Plastic	Yellow
2.	Animal waste	-do-	-do-
3.	Microbiology and Biotechnology waste	-do-	Yellow/Red
4.	Waste sharp	Plastic bag puncture proof containers	Blue/White Translucent
5.	Discarded medicines and Cytotoxic waste	Plastic bags	Black
6.	Solid (biomedical waste)	-do-	Yellow
7.	Solid (plastic)	Plastic bag puncture proof containers	Blue/White Translucent
8.	Incineration waste	Plastic bag	Black
9.	Chemical waste (solid)	-do-	-do-

Source: http://isebindia.com/95_99/99-07-2.html

Table 3: Type of container and colour code for collection of biomedical waste

The dental industry produces a significant amount of gypsum waste (figure-1). This gypsum waste is dumped in landfills, where it breaks down and releases hydrogen sulfide, which has a smell like rotten eggs. The nervous system and respiratory system are the most vulnerable organ systems to hydrogen sulfide poisoning. A few symptoms of this include irritation of the throat, nose, or eyes, which can make breathing difficult for some asthmatics. Acute symptoms can also include headaches, fatigue, impaired memory, and balance issues. Headaches, short attention spans, memory problems, and impaired motor function are examples of long-term or permanent impacts[6].

Currently, gypsum and plaster waste–harbouring biomedical material is disposed by incineration which is very critical and environmentally unfriendly as it produces toxic gases and heavy metals. Applying a 20% concentration of ammonium bicarbonate solution to such waste is the suggested environmentally friendly and quick disintegration method. In 24 to 36 hours at room temperature, this solution breaks down the waste into high-value, non-toxic compounds like calcium bicarbonate and ammonium sulfate. The end product is sludge. Ammonium sulphate can be utilized as nitrogen fertilizer for crops, fire–extinguishing powder, and in industries like pharmaceutical, textile and wood pulp. Calcium carbonate can be used in metallurgy industry, mainly in steel manufacturing[7].

Figure 1: Dental models

In dentistry, dental alginate is a common impression medium (figure-2). Waste from alginate impressions can be recycled by washing, drying, and meshing it till the material is approximately 2-3 mm in size. This regenerated alginate demonstrated enough quantity to contribute nutrients related to crop and soil fertility[7]. To enhance the quality of the soil, the high calcium content can be utilized as calcification material. Additional nutrients obtained from dental alginate waste were sulfur, calcium, sodium, phosphate, potassium, manganese, and nitrogen. These can effectively support crop yields[7]. Additionally, it was discovered that diatomite, which is derived from alginate gel, works well as the last polishing agent in denture base resin.

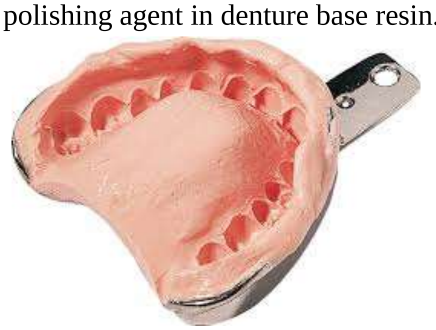

Figure 2: Alginate impression.

Unused radiographic film, which shouldn't be thrown in the general waste, is another waste product that is frequently found in dentistry[8]. Unreacted silver from discarded films can be hazardous to the environment. The films are cleaned in a chemical solution that extracts the silver during the recycling process. After melting, the silver is formed into bars. A recyclable PET (polyethylene terephthalate) plastic fragment remains after the silver has been extracted. This silver has numerous applications.

Natural wax, synthetic wax, plant wax, animal wax, and natural resins are the components used to make modeling wax. Wax is used and disposed off in majority of procedures. With a basic laboratory process, 80–90% of wax can be recycled while retaining its original qualities by eliminating adherent contaminants. As this is an in vitro process, biocompatibility is not a concern. Dental wax derived from natural resources can be recycled and reused, saving a significant amount of resources and preserving the balance of the ecosystem. Wax recycling process includes collection, sorting, cleaning, melting, reblending, cooling and solidification, and finally, quality control checks, to ensure that the recycled wax meets the necessary standards and specifications[9].

Intraoral films are shielded from secondary radiation and backscatter by lead foil. This foil has a lead concentration of 69% to 85%. According to a study, a full mouth radiography examination could result in the production of up to 11.2 grams of lead waste. Lead would end up in the soil when disposed of with regular trash, and in environments with low pH, lead from radiography foil dissolves and enters the ecosystem. As a heavy metal, lead is a very dangerous substance. In general, the risk associated with lead as radiography waste is prolonged low dosage exposure. Lethargy, delirium, convulsions, encephalopathy, continuous vomiting, and coma are the symptoms of chronic poisoning (40–60µg/dl). Used lead foil from intraoral film packages, lead aprons, and lead collars should be collected and transported for recycling, where it will be melted down and turned into ingots[10,11].

Used fixer is a dangerous waste because it contains high concentrations of silver (3,000 to 8,000 ppm) and anything over 5 ppm is dangerous waste. It is prohibited to dispose of used fixer in the trash, septic system, or down the drain because of the elevated silver levels. Silver thiosulphate complexes, which are incredibly stable and have very low dissociation constants, are the form of silver found in used fixer solutions. Used fixer solutions essentially contain no free silver ions. Silver sulfide, which settles in the sludge, is mostly produced in waste water treatment operations from silver thiosulphate. It is best to keep discarded processing solutions separated from other solutions and stored in containers with the proper labels before transferring them to an appropriate silver recovery service[8]. Reverse osmosis, ion exchange, chemical precipitation, metallic replacement, and electrolysis can all be used to recover silver from the waste fixer solution. The most effective method for extracting silver from waste solutions rich in silver is electrolytic silver recovery; metallic replacement cartridges must be used as a secondary (tailing) recovery method after the electrolytic recovery equipment[12]. (Figure-3)

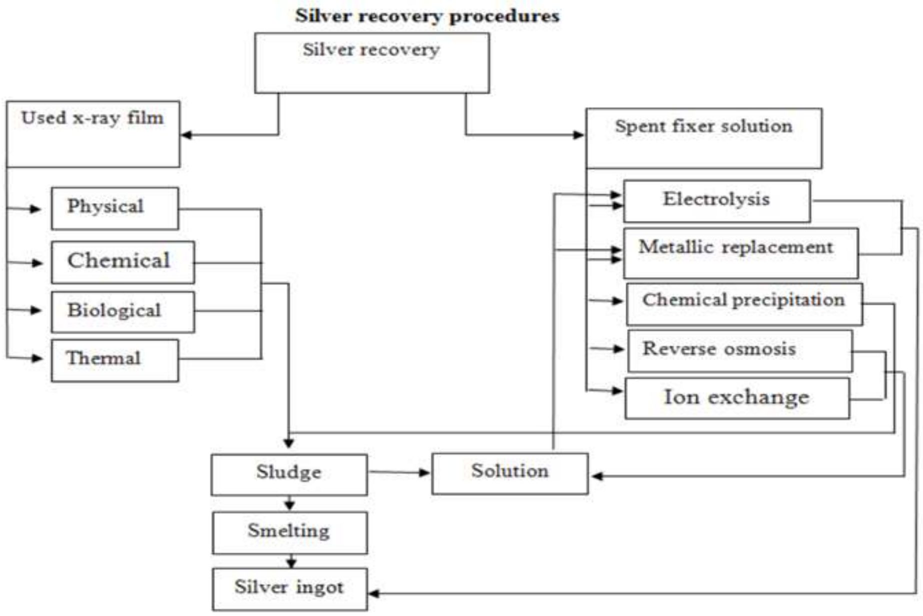

Figure 3: Silver recovery procedures.

Generally, used developer is not considered a hazardous waste. If dumped, unused developer may be dangerous due to its high corrosive pH of 12.5 or higher. Its COD, or chemical oxygen demand, is likewise roughly twenty times higher than what is permitted by law for disposal. COD is an analytical technique used to measure an effluent's oxygen demand. Because it contains many components or produces environmentally hazardous compounds during its reactions, this solution should also be treated before being disposed of in the sewage[8,13].

Various alternatives for treating radiography effluent have been put forth, including reverse osmosis, chemical oxidation, carbon adsorption, chemical precipitation and sedimentation, and biological oxidation. Chemical-biological, chemical-electrochemical, and oxidation-separation processes are examples of combinations of approaches that have also been used. A variety of techniques, including Cl2-biological treatment, filtration-chelation treatment, and adsorption-reverse osmosis, have also been used to recycle radiographic effluents[13].

Using the pyrolysis-thermogravimetric analysis mass spectrometry (Py-TGA-MS) approach, methyl methacrylate (MMA) was recovered from waste acrylic or polymethyl methacrylate (PMMA) scraps through depolymerization. The findings showed that a significant amount of MMA was retrieved along with minute amounts of byproducts, which were previously thought to be 2,3-butanedione and methyl pyruvate, and which were in charge of the disagreeable odor found in the recycled MMA/PMMA. The re-precipitation process was used to remove these byproducts from the repolymerized PMMA. It was discovered that the acquired rPMMA and purified PMMA shared many of the same physical and chemical characteristics as the commercial virgin PMMA. This process made it possible to recycle and reuse the acrylic that was used to make different orthodontic appliances[14].

The used mini-implants had a worn surface and scratch marks, but no flaws or corrosion was seen (figure-4). The mini-implants need to be cleaned and sterilized before they can be used again. They are immersed in 0.3cc phosphoric acid for 10 minutes after being fully soaked in 37% phosphoric acid gel (Ultradent Product, Inc., USA). They are then dried for five seconds and washed with 10 cc of distilled water using a syringe.

After 30 minutes in 10cc sodium hypochlorite 5.25%, the screws are rinsed and dried. Following this procedure, the screws are autoclave-sterilized. The mini-screws' insertion, removal, and fracture torque (FT) are not adversely affected. If the self-drilled mini-implant is to be reused, prior bone drilling may be necessary due to the possibility that its altered tip will affect its qualities[15].

Figure 4: Mini-implant

- In orthodontics, braces are composed of a variety of materials. These materials, which can be recycled and reconditioned, include metal and polymeric/plastic materials. This allows for more cost-effective treatment that is advantageous to both the patient and the orthodontist.[16] There are 3 ways of recycling orthodontic brackets: The thermal reconditioning method involves heating the bracket base to between 420° and 500° Celsius, turning the composite or adhesive substance into a white powder that is readily removed[16,17,18].
- Using 80% orthophosphoric acid, the bracket is electropolished as part of the chemical solvent-stripping procedure. Electrochemical polishing removes material from a work piece's surface in a targeted manner, giving a dull metal a mirror-like sheen. The ions on the metal surface oxidize and dissolve when an electric driven current (DC) is applied, leaving a reflecting surface[16,17,18].
- Sandblasting with 50 micron aluminum abrasive particles for 15 seconds at a distance of 10 mm is the mechanical way of reconditioning[16,17,18].

Recycling the brackets and other materials used in the patient's mouth is made easier and more realistic with the help of the orthodontic techniques mentioned above. Recycled orthodontic materials have both environmental and financial benefits. However, the disadvantages include a decrease in adhesive strength, a loss of discriminating ability, and low-quality materials.

Since posterior teeth vary in size, molar bands are frequently used to hold orthodontic attachments in place. Usually, multiple bands must be "tested in" before the ideal one is chosen. It is possible to effectively disinfect these bands and reuse them without running the danger of spreading infections to other people. After being tried in the patient's mouth but not cemented into place, orthodontic molar bands were cleaned with an enzymatic cleaner/disinfectant and sterilized in a downward displacement or vacuum cycle autoclave (134°C for 3 minutes)[19].

After being used in therapeutic settings, NiTi, TMA, and stainless steel arch wires are sterilized or decontaminated using iodophor, autoclave sterilization, cold sterilization, or dry heat sterilization. There was a decline in corrosion resistance but no clinically meaningful difference between the as-received and used-then-disinfected/sterilized wires in load/deflection and tensile tests. Arch wires made of nickel and titanium can be recycled at least once. Broken archwires are gathered and thrown away in a white or blue bag, which is subsequently cleaned and torn apart[20,21].

In orthodontics, polyurethane elastomers are utilized as chains, modules, and ligatures. One of the most crucial parts of orthodontic therapy is elastomeric ligatures, which attach the archwire to the brackets and produce the force required to shift teeth. The US Department of Labor's Occupational Safety and Health Administration (OSHA) and the Centers for Disease Control and

Prevention (CDC) advise sterilizing unused parts of elastomeric ligatures and chains using cold sterilization techniques (for instruments that cannot take heat). The elastomeric modules are sterilized by immersing in 5% bibforte solution for 30 Minutes. Vapoclave (ethylene oxide) is preferred for E-chain and ligatures. Used elastomeric ligatures are not reusable and are weak. They are collected and discarded into the red bag, and later incinerated[22].

In orthodontic treatment, medical grade plastics are an inevitable necessity and are used frequently in products like plastic/PVC sheets, face shields, suction tip orthodontic material packing, spectacles, and PPE kits. Eventually, a lot of medical plastics find their way into marine environments and threaten their survival. Frequently employed techniques for recycling plastics include:

- Chemolysis recycling, in which plastics are processed chemically by thermal cracking via hydrogenation and are converted into monomers[23].
- Pyrolysis or Gasification, is recycling process that adds oxygen or steam in a hot, enclosed environment, resulting in synthetic gas that can be used as a raw material and fuel[24].

Aligners are composed of thermoplastic materials that are not biodegradable, particularly Polyethylene Terephthalate, which has a high degree of resistance to degradation (figure-5). Furthermore, when harmful chemicals such as dioxins and polychlorinated biphenyls are discharged into the atmosphere, they endanger all living things. According to studies published in the Environmental Health Perspective, these particles can cause immune system abnormalities, prostate enlargement, diabetes, hyperactivity, infertility, obesity, precocious puberty, and breast cancer, and even minute amounts in the environment can be hazardous. Therefore, standard protocol for the proper disposal of aligners should be followed[25]. (Figure-6)

Figure 5: Clear aligner

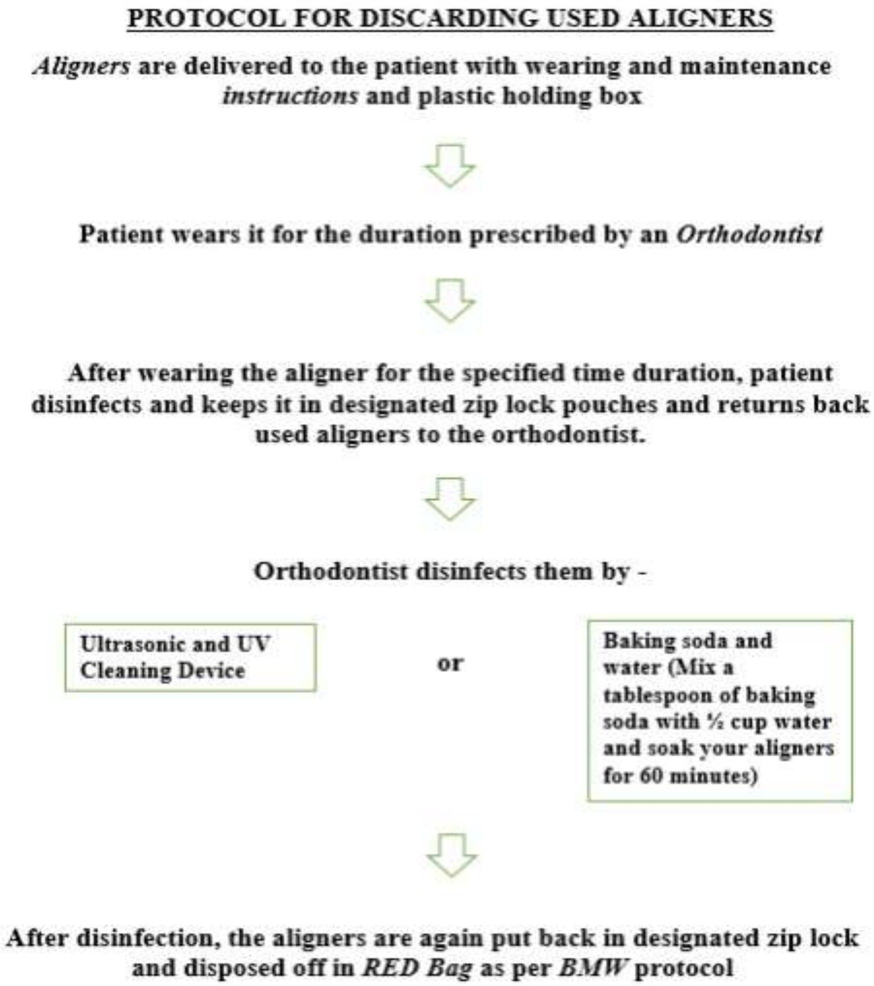

Figure 6: Protocol for discarding used aligners

An effective substitute is mechanical recycling, also known as secondary recycling, which involves converting leftover plastic aligner waste into pellets or granules that may be used again to make different kinds of materials[25].

Conclusion

Orthodontists have to be mindful of how their work affects the environment. By conserving natural resources, significant amounts can be prevented from being exhausted. Materials used in orthodontics can be recycled and repurposed to help lessen waste and its detrimental impact on the environment. To improve patient, community, and environmental health, a focus on sustainability, prevention, and raising awareness are essential. Additionally, mandatory education on the significance of green orthodontics should be provided to orthodontists.

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