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Biocompatibility of Soldered and Welded Appliances

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INTRODUCTION

An appliance is biocompatible if it causes no short or long-term damage to the tissue with which it is in contact, to organs or systems elsewhere in the body or to the individual's general health. A biocompatible material is thus never toxic, irritant, inflammatory, allergenic, mutagenic or carcinogenic ^[1].

Metal-derived toxicity is significantly lower when ions are released into the oral cavity from the alloys contained in orthodontic appliances than when released directly into the bloodstream or bone, as occurs when implants are in direct contact therewith ^[2].

Furthermore, fewer ions are released daily into the oral cavity due to the corrosion of an orthodontic appliance containing alloys than the ions present in an individual's diet ^[3].

However, local toxicity arises with a much lower concentration of ions than will trigger systemic toxicity. But the longer the exposure of oral tissue to these alloys, the lower the concentration of ions causing local toxicity ^[4]. Previous studies have shown that dental alloys may inflame gums even in patients whose oral health is good and who have a low plaque index ^[3].

This article discusses the most recent studies conducted in the field of soldering and welding and their biocompatibility.

Joining Of Orthodontic Appliances

Attachments can either be welded or soldered together. Corrosion-prone phases composed mainly of copper and zinc occurs within a soldered joint. Silver solders are more preferred in orthodontics than gold solders. However, as they are not inert, silver solders are prone for corrosion. They show changes such as darkening, to resemble a tarnished, corroded surface.

Welded appliances on the other hand, do not require a solder metal and seem to be a more biocompatible option.

There are different types of welding-

- Pressure welding
- Cold welding
- Fusion welding
- Gas
- Arc

- Resistance (Spot Welding)
- Laser
- Plasma

Corrosion Occurring in Soldered and Welded Appliances

Lucchese et al. ^[4] compared the corrosion resistance of stainless steel when traditionally soldered and when it was laser-welded. The wires were soldered/ welded to an orthodontic band and placed in artificial saliva. It was found that laser-welded samples have superior resistance to corrosion.

A study by Mueller ^[5] demonstrated the capability of mouth rinses, as corrosive agents for the deterioration silver-solder joints. Optical and SEM with energy-dispersive microanalysis were used for evaluation of surface characteristics. Both the microscopic and electrochemical data indicated that severe degradation reactions can occur due to release of metal ions. Hence, they recommend solders without Cd & Zn, but with higher fusion temperature and decreased flow.

In a recent study, Erdogan et al. ^[6] submerged samples which were silver soldered or laser welded into mouthwash containing: sodium fluoride (NaF), sodium fluoride and alcohol, chlorhexidine (CHX) and artificial saliva (AS). It was seen that the level of metal ion release from samples of silver soldering was higher than from samples of laser welding. Greater amounts of nickel, chrome, and iron were released from silver soldering. Also, lowest amounts of metal ions were released in CHX, and the highest amounts of metal ions were released in NaF and alcohol.

In a very recent study, Matos ^[7] studied corrosion in artificial saliva of a Ni-Cr-based dental alloy joined by TIG welding and conventional brazing. They concluded that tungsten inert gas is a suitable welding process, because the final microstructure does not reduce the corrosion resistance in artificial saliva at 370C, even in a corrosion-testing medium that facilitates galvanic corrosion processes.

Lucchese et al. also described how the corrosion occurs and leads to toxicity. The solder and flux employed in brazing are toxic, cause bimetallism, weaken the steel microstructure and make it more reactive to the external environment and so less resistant to corrosion. In being more or less noble than steel, the solder itself will dissolve if less noble and also leave the steel open to attack ^[4].

Furthermore, the silver contained in the solder creates a galvanic pair which has a negative influence on both the steel and the solder itself. When an orthodontic appliance corrodes, ions are released and oxides formed with the following consequences:

1. The appliance is gradually damaged and so its function is impaired; the metal loses its intrinsic characteristics, i.e. mechanical resistance decreases, it becomes porous, marginal integrity decreases and a band is perforated leading to weight loss
2. The body is affected locally and/or systemically.

Corrosion products containing zinc, copper, tin and silver can alter the elemental concentrations. The enzymatic reactions dependent upon these elements can be affected and hence cause biologic imbalances ^[4].

Effects on Biologic Tissues

Solmi et al. ^[8] investigated the reaction of human gingival fibroblasts cultured in vitro in direct contact with samples of soldered and laser-welded joints from orthodontic lingual arches. Contrast phase light microscopy was used to evaluate cell adhesion, morphology and proliferation after 6 and 24 hours and after 7 and 16 days. Scanning electron microscopy (SEM) was performed at 16 days. It was found that laser-welded orthodontic appliances have superior fibroblast biocompatibility.

In a study by Sestini et al. ^[9], joints obtained by electrical resistance welding, traditional soldering, and laser welding were tested. Traditional soldering caused a significant decrease in both osteoblast ALP activity and fibroblast viability, and prevented the growth of keratinocytes in vitro. Laser welding was the only joining process well tolerated. The clinical implication is that the presence of welds in the mouth can interfere with the healing of mucosal wounds by inhibiting keratinocyte migration in the last stages of the healing process. These findings are in agreement with a similar study conducted by Vannett et al ^[10].

Freitas et al. ^[11] have stated that the silver soldering used in orthodontics represents a highly cytotoxic material for the cells analyzed ^[12]. In a later study, the release of toxic ions from silver solder was quantified. This was, in decreasing order- copper, silver, cadmium, and zinc.

Recently, Atik et al. ^[13] compared the inflammatory effects of conventional and laser soldering methods on periodontal tissues. No significant difference between laser welding and conventional soldering methods in terms of periodontal tissue response.

Goncalves evaluated the cytotoxic, cytostatic, genotoxic and DNA damage-inducing effects of non-soldered bands (NSB) and silver soldered bands (SSB) on the HepG2 and HOK cell lines.

1. The SSB group induced stronger cytotoxic effects

2. Biomarkers of DNA misrepair and/or telomere end fusions, were significantly elevated in the SSB group.
3. The SSB eluates showed higher amounts of Ni and Fe than NSB ^[14].

CONCLUSION

The presence of welded or soldered attachments in the oral cavity is common during orthodontic treatment. Based on the literature, welding is more biocompatible than soldering since there is no filler metal involved. Though soldering is necessary when using stainless steel wires, using arch wires which can be welded is a biologically safer option.

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