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Exposure to nickel and palladium from dental appliances

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Summary

This thesis focused on three general aspects of the application of metals of nickel and palladium in dental appliances for orthodontic retention and fixed prosthodontics. First, the metal release on itself when submersed in corrosive solutions such as stated by ISO norms, intending to reproduce oral conditions (*Chapters 2 and 3*). All the materials tested released metal ions. Mechanical load and pH influenced the release from the orthodontic wires tested while for the Pd-alloys casting manipulation to shape a crown and surface polishing, determined the release of metal ions. The ions of Ni, Cr and Mn from orthodontic wires and Pd, Ga, Cu and Ag from Pd-alloys were the most released. Considering the composition of each material these results are not surprising. It is of interest though, that *a)* Pd-Ag alloys released less palladium than Pd-Cu ones, and *b)* nickel from wires commercialized as "nickel-free" was released in measurable amounts and higher than that considered by the Ni Directive for the skin.

Second, the effect of those ions at cellular level was tested in a very simplistic approach for testing eventual cytotoxicity (*Chapters 4 and 5*). The mitochondrial activity of mouse fibroblasts was tested when in contact with eluates of orthodontic wires and metallic crowns and, with metallic salt solutions in concentrations equivalent to the reported ion release for those appliances. While the appliance when tested as a whole was not considered cytotoxic, the metal salts of Ni, Cu, Ag, Pd and Ga where able to induce cellular damage in concentrations within the reported release range. This means that with the permanent character of the metallic dental appliances, sometimes life-long, the value of the continuous release of metallic ions from dental appliances must not be underestimated.

Finally, one suggested alternative to the use of metals in orthodontic retention, the fiber-reinforced composite, was tested for load and deflection at failure (*Chapter 6*). The rigidity of that system prevents its long-term successful clinical use. Deflection of the wires is of utmost importance to maintain teeth position while accompanying physiologic movement. Influencing flexibility, the length of the wire not covered with composite during bonding to the teeth plays a critical role for the success of the retainer system.

In sum, all metallic devices release metal ions in concentrations that might have biological implications in the long term. Palladium-based and other metal alloys can, in an increasing number of situations, safely and successfully be replaced by zirconia in the construction of fixed dental prosthesis. Yet, in orthodontics, metal alloys are still the gold-standard and until now, irreplaceable in it's whole.

Conclusions

- Both nickel-containing and "nickel-free" orthodontic retention wires release Ni when submersed in a solution, in a pH-dependent manner (corrosive solution > water > culture medium). Further, mechanical loading also has a strong effect on the ion release. This release occurs in considerable amounts and mostly higher than what considered by the EU Nickel Directive for the skin.
- Pd-Cu crowns submersed in a corrosive solution release higher amounts of Pd than Pd-Ag alloys. This release is mainly influenced by the surface finishing of the alloy, with polishing being a determinant factor, but also by the shape of the alloy (disks > crowns).
- The cumulative effect of the continuous release of ions from alloys for oral application may contribute to cellular damage. Concentrations of metallic salts equivalent to those reported to be released from dental alloys were able to induce cellular toxicity (10ppm for Ni, Cu and Ag; 100ppm for Pd and Ga), although the material is not considered cytotoxic and, as such, safe for clinical application.
- Fiber-reinforced composite retainers are not reliable alternatives for (long-term) orthodontic retention. To accompany physiologic teeth movement and prevent relapse, flexible multistranded wires bonded to the teeth with minimal amounts of composite (2-4mm) are the most efficient.

New from this thesis

- "Nickel-free" orthodontic retention wires are not free of release of Ni. FRC are not reliable alternatives for orthodontic retention. Metal-free bonded orthodontic retention is not yet feasible.
- The deflection of the retainer is of prime importance to accompany physiologic teeth movement and as such prevent relapse. But, the length of "free wire", i.e. the amount of wire not covered with composite, is the most critical factor for the success of the retainer system.
- Shape, as well as surface finishing, influences the corrosion trend of Pd-containing dental alloys.
- Concentrations of metallic salts equivalent to those reported to be released from dental appliances have a cytotoxic effect. Remaining in place for years or even life-long, the continuous release of ions from orthodontic retainers and palladium crowns may have a cumulative effect and lead to biological implications.