Research Article

Cytotoxicity of orthodontic molar bands with silver solder joints

Sunita Sugumaran*, Ravindra Kumar Jain

ABSTRACT

Aim: The aim of this study was to evaluate the cytotoxicity of orthodontic molar bands with silver solder joints. **Materials and Methods:** Stainless steel metallic orthodontic bands soldered using silver solders were evaluated for cytotoxicity. The amount of solder alloy, flux used for soldering, and the polishing procedure were standardized. An *in vitro* cytotoxicity test using indirect contact method was performed using test sample as per ISO 10993:5. The culture medium from the l929 cell monolayer was replaced with fresh agar medium. Test sample and control in triplicates were placed on the cells. After incubation at 37 ± 1°C for 24–26 h, monolayer was examined microscopically to determine the cytotoxic effect before and after removing the test sample from the agar medium. **Results:** As per ISO 10993:5, the achievement of numerical grade >2 is considered as cytotoxic effect. The test sample showed no cytotoxic reactivity to l929 cells after 24 contacts. Control gave no cytotoxic reactivity as expected.

KEY WORDS: Cytotoxicity, Molar bands, Silver solder

INTRODUCTION

Orthodontic bands are very commonly used attachments in fixed appliances usually for the posterior teeth. They are made of stainless steel (SS) which consists of nickel, iron, chromium, carbon, molybdenum, and certain other metals, and it is considered as a fairly biocompatible alloy; however, in several clinical situations, it is necessary to solder SS bands to fabricate appliances. Silver soldering is frequently used to join parts of orthodontic appliances. It is known that soldered or welded areas may present the sites for corrosion due to galvanic action between the base and filler metals and changes in microstructure due to heating.[1,2]

Biocompatibility refers to the ability of a biomaterial to perform its desired function with respect to medical therapy, without eliciting any undesirable local or systemic effects in the recipient or beneficiary of that therapy but generating the most appropriate beneficial cellular or tissue response in that specific situation and optimizing the clinically relevant performance of that therapy.[1] Corrosion is the main concern when biocompatibility of orthodontic metallic materials is evaluated. The release of several metallic ions may lead to hypersensitivity and allergic reactions, either locally or systemically.[3]

Recently, work focusing on the biocompatibility of orthodontic materials has increased, and several studies have examined the release and cytotoxicity of orthodontic materials such as acrylic resins, composites, and metals. [4]

For soldering base metal alloys, silver solder is the alloy of choice, due to its effectiveness, low cost, and ease of use. However, the silver solder alloy contains silver, copper, and zinc.[5] These ions have a tendency to be released in the oral mucosa and they may have cytotoxic effects, resulting in a decrease of cell viability.

In the past, cadmium was added to silver solder alloys and cadmium exposure is known for hepatic, renal, and myocardial damage, also it is a known mutagen, and also zinc obtained from ores may have cadmium as a contaminant, hence causing cytotoxicity.[6]

An alternative to soldering with silver solder can be the laser welding. In this method, the use of a third metal or alloy, such as the silver solder, can be avoided,

Access this article online

Website: jprsolutions.info | ISSN: 0975-7619

Department of Orthodontics, Saveetha Dental College and Hospitals, Saveetha University, Chennai, Tamil Nadu, India

***Corresponding author:** Sunita Sugumaran, Department of Orthodontics, Saveetha Dental Institute of Medical and Technical Science, Tamil Nadu, India. E-mail: Sunita_eco@yahoo.co.in

Received on: 17-08-2018; Revised on: 19-09-2018; Accepted on: 25-10-2018

as the SS bands and orthodontic wires can be directly connected. With laser soldering, the energy generated promotes real fusion of the metals joined. It is claimed be less susceptible to corrosion and consequently more biocompatible.[7]

Nowadays, several *in vitro* cell culture tests can be used to assess the cytotoxicity of dental materials. Among these tests, some yield similar results, whereas some others reveal diverse or even opposing findings.

The aim of this study was to evaluate the induction of cytotoxicity by soldered molar bands.

MATERIALS AND METHODS

SS metallic orthodontic bands soldered using silver solders were evaluated for cytotoxicity. According to the manufacturer, the bands are composed of 17–20% Cr, 8–10% Ni, and a maximum of 0.60% Mo and Fe (Rocky Mountain Orthodontics). For the silver solder, a segment of SS 19-gauge wire (17–20% Cr, 8–10% Ni, and a maximum of 0.60% Mo and Fe) was soldered to the lingual side of each band using silver solder alloy (55–57% Ag, 21–23% Cu, 15–19% Zn, and 4–6% Sn), and solder flux was heated by a microtorch using propane gas. The amount of solder alloy, flux used for soldering, and the polishing procedure were standardized.

An *in vitro* cytotoxicity test using indirect contact method was performed using test sample as per ISO 10993:5. The culture medium from the L929 cell monolayer was replaced with fresh agar medium. Test sample and control in triplicates were placed on the cells. After incubation at 37 ± 1°C for 24–26 h, monolayer was examined microscopically to determine cytotoxic effect before and after removing the test sample from the agar medium. The reactivity was graded as 0, 1, 2, 3, and 4 based on the zone of lysis, vacuolization, detachment, and membrane disintegration as given in Table 1.

RESULTS

As per ISO 10993:5, the achievement of numerical grade >2 is considered as a cytotoxic effect. The test sample showed no cytotoxic reactivity to L929 cells after 24 contacts. Control gave no cytotoxic reactivity as expected [Figure 1].

DISCUSSION

Silver-soldered appliances also corrode, and among the wires, cobalt–chromium was more corrosion resistant than SS.[8] Although Ni and Cr could be released from the fixed appliances when placed in the mouth, the values in any period of the treatment do not reach toxic levels of salivary and serum nickel and chromium levels and are similar to those found in healthy individuals.[8,9,1]

Table 1: Zones of reactivity

Grading	Reactivity zone features
0 - None	No detectable zone around or under specimen
1 - Slight	Some malformed or degenerated cells under the specimen
2 - Mild	Zone limited to area under specimen
3 - Moderate	Zone extending specimen size up to 1 cm
4 - Severe	Zone extending farther than 1 cm beyond the specimen

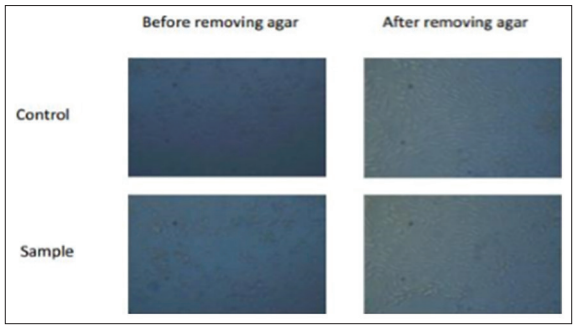

Figure 1: Cell culture changes in control and the sample group

An important part of the population undergoes orthodontic treatment during their lives. Orthodontic bands, composed of iron, nickel, and chromium, are frequently joined to orthodontic wires for the making of auxiliary appliances, and for this, it usually employs a filling material such as the silver solder alloy. This alloy contains silver, copper, and zinc and may even contains a little amount of cadmium. These ions, together with nickel and chromium, may elicit several undesirable reactions. Specifically, when these metals are heated, the corrosion process may be increased, leading to the elution of ions to the buccal cavity, with local and systemic effects.

Various auxiliary appliances such as the maxillary expansion appliance and lingual arches stay in the mouth for a very long period of time. A minimum of 13 months of appliance wear is considered necessary for visualizing effects. Lingual arches, which are commonly used as space maintainers, are given to the patient from a very young age of 6 years until 13–14 years when the orthodontic treatment is completed. Hence, it is utmost important to dwell on the cellular effects of the orthodontic bands and their joints.

Solmi *et al.*[10] investigated an *in vitro* culture of fibroblast and studied its reaction to contact with samples of soldered and laser-welded joints from orthodontic lingual arches. Proliferation, adhesion, and morphology of the cells were studied under contrast phase light microscopy and scanning electron microscopy, and a conclusion was made that laser-welded joints were highly superior in biocompatibility. It is important to keep in mind that the oxidation

reaction occurs on the entire surface of the band which remains in contact with saliva during the treatment, leading to corrosion all over the band, which includes the silver solder joint as well as the SS components.[4]

Sestini *et al*.[11] studied orthodontic wires and their effects on fibroblasts, osteoblasts, and keratinocytes in various *in vitro* cytotoxicity tests. It was found that silver solder joints showed high cytotoxicity compared to the laser solder joins, which corresponds to the finding of Solmi *et al*.[10]

Studies by Sestini *et al*.[11] and VandeVannet *et al*. investigated orthodontic wires with three-dimensional oral mucosal cell. It was found that silver-soldered wires caused higher loss of viability than laser-and electric-welded joints. SS wires as well as laser-soldered wires alone were tested for biocompatibility and were found to be biocompatible. Similarly, VandeVannet *et al*. found a lower cell viability with the silver-soldered wires.

In our study, the cytotoxicity of soldered molar bands was tested with L929 cell line. As per ISO 10993:5, the achievement of numerical grade >2 is considered as cytotoxic effect. The test sample showed none cytotoxic reactivity to L929 cells after 24 contacts. Since the test sample achieved a numerical grade not >2, none of the samples are considered as cytotoxic [Figure 1]. Control gave none cytotoxic reactivity as expected.

CONCLUSION

Soldered molar bands used in laboratories do not seem to produce cytotoxicity to the expected level; however, we need to perform further studies to confirm the results, as the current study was performed over 24–26 h and is an *in vitro* study.

REFERENCES

1. Gardiner JH, Aamodt AC. Some aspects of soldering stainless steel. Dent Pract 1969;20:65-76.
2. Laird WR, von Fraunhofer JA. Silver soldered ioints in stainless steel. A comparative evaluation of techniques. Br Dent J 1972;132:263-7.
3. Menezes LM, Quintão CC. The release of ions from metallic orthodontic appliances. Semin Orthod 2010;16:282-92.
4. Mockers O, Deroze D, Camps J. Cytotoxicity of orthodontic bands, brackets and archwires *in vitro*. Dent Mater 2002;18:311-7.
5. Freitas MP, Oshima HM, Menezes LM. Release of toxic ions from silver solder used in orthodontics: An *in-situ* evaluation. Am J Orthod Dentofacial Orthop 2011;140:177-81.
6. Huff J, Lunn RM, Waalkes MP, Tomatis L, Infante PF. Cadmium-induced cancers in animals and in humans. Int J Occup Environ Health 2007;13:202-12.
7. Lucchese A, Carinci F, Brunelli G, Monguzzi R. An in vitro study of resistance to corrosion in brazed and laser-welded orthodontic appliances. Eur J Inflamm 2011;9:67-72.
8. Eliades T, Pratsinis H, Kletsas D, Eliades G, Makou M. Characterization and cytotoxicity of ions released from stainless steel and nickel-titanium orthodontic alloys. Am J Orthod Dentofacial Orthop 2004;125:24-9.
9. Freitas MP, Oshima HM, Menezes LM, Machado DC, Viezzer C. Cytotoxicity of silver solder employed in orthodontics. Angle Orthod 2009;79:939-44.
10. Solmi R, Martini D, Zanarini M, Isaza Penco S, Rimondini L, Carinci P, *et al*. Interactions of fibroblasts with soldered and laser-welded joints. Biomaterials 2004;25:735-40.
11. Sestini S, Notarantonio L, Cerboni B, Alessandrini C, Fimiani M, Nannelli P, *et al*. In vitro toxicity evaluation of silver soldering, electrical resistance, and laser welding of orthodontic wires. Eur J Orthod 2006;28:567-72.

Source of support: Nil; Conflict of interest: None Declared