Review Article

Effect of Fixed Metallic Oral Appliances on Oral Health

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Abstract

There is a substantial proportion of the population using fixed metallic oral appliances, such as crowns and bridges, which are composed of various dental alloys. These restorations may be associated with a number of effects on oral health with variable degrees of severity, to review potential effects of using fixed metallic oral appliances, fabricated from various alloys. The MEDLINE/PubMed database was searched using certain combinations of keywords related to the topic. The search revealed that burning mouth syndrome, oral pigmentation, hypersensitivity and lichenoid reactions, and genotoxic and cytotoxic effects are the major potential oral health changes associated with fixed prosthodontic appliances. Certain oral disorders are associated with the use of fixed metallic oral appliances. Patch test is the most reliable method that can be applied for identifying metal allergy, and the simultaneous use of different alloys in the mouth is discouraged.

Keywords: *Burning mouth syndrome, dental alloys, fixed prosthesis, hypersensitivity, oral pigmentation*

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Introduction

A substantial proportion of dental patients worldwide use fixed metallic restorations. In Europe, for instance, Sweden reported the highest use of fixed restorations (45%) followed by Switzerland (34%).[1] Another study reported that 12.4% of Finnish men and 12.1% of women have crowns, whereas 4.8% and 8.0%, respectively, have fixed dental prostheses.[2] Although fixed metallic appliances greatly impact patients' lives,[3] unfortunately, they also alter and modify oral microbial flora.[4]

Many elements are used to form the various dental metal alloys that are cast and formed to be used as fixed oral appliances.[5] Dental casting alloys are widely used in fixed prosthodontic appliances, and they establish a long-lasting contact with adjacent oral mucosa for periods that may cover the remaining lifespan of the patient.[6] Ni-Cr is probably the most popular alloy used for the fabrication of fixed prosthodontic restorations, owing to its improved mechanical properties and relatively low cost.[7] The use of Ni-Cr was cited as one of the factors associated with better survival rates of resin-bonded bridges.[8] Consequently, Ni-Cr and Co-Cr base metal alloys have replaced the more expensive gold in the construction of fixed metal–ceramic restorations to a great extent.[9]

Unfortunately, these restorations are not without cost as these often extend into the gingival sulcus and come in contact with gingival epithelial cells.[9] The adaptation of dental crowns and bridges to the supporting prepared crowns is less than perfect, always creating a gap that promotes bacterial colonization. Microcracks in the structure of these restorations will also do the same.[10,11] The changes in oral microbial flora due to fixed restorations are well documented in literature; however, their effects may be underestimated in patients with systemic diseases.[12,13] Leaching by-products in the oral cavity of corroded metals of dental alloys can lead to adverse tissue reactions.[13] An immunological response may occur locally, leading to oral discomfort that may be manifested clinically as lichenoid reactions and stomatitis.[14] A systemic reaction may develop, eventually leading to delayed hypersensitivity.[14]

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Age-related changes in the oral mucosa may complicate the situation. Moreover, taking into consideration the fact that most fixed prosthodontics patients are in the older age range, a higher incidence of complications is anticipated. The decreasing ability of the tissue to repair with age increases the permeability of oral mucosa to toxic substances and makes it more sensitive to mechanical trauma. Furthermore, prosthetic-retained teeth in elderly are particularly susceptible to caries and a higher chance for prosthesis failure.[15]

Biologic nature of the oral cavity qualifies it to be an active environment for the corrosion of metallic alloys that have low mechanical and biological properties.[16] Leakage of ions will cause a wide range of biological interactions. The subsequent soft-tissue response can promote the adhesion of bacteria and lead to toxic or subtoxic effects or allergic responses.[13] Many studies and research works have already demonstrated these mechanisms. Mechanical trauma due to pressure and friction between appliances and tissues can also lead to local tissue reactions. Further, corrosion may adversely influence the mechanical integrity and biocompatibility, leading to compromised esthetics, physical weakness, and health hazards.[17]

Materials and Methods

A literature search was conducted in MEDLINE/PubMed database using the following keyword combinations: fixed dental prosthesis, fixed partial dentures, cytotoxic effects, oral pigmentation, burning mouth syndrome (BMS), allergy, and lichenoid reactions. Only English literature was included, and as it was not the aim of this review to allude to gingival/periodontal diseases as complications of fixed prostheses, all nonrelevant articles were excluded from the study.

Results

The above search revealed that there are four major potential oral health effects of fixed prosthodontic appliances: BMS, oral pigmentation, hypersensitivity and lichenoid reactions, and genotoxic and cytotoxic effects as shown in the following Table 1.

Burning mouth syndrome

This is portrayed by the unremitting burning sensation and pain with undetectable oral mucosa changes.[35] Patients usually complain of a burning sensation that may affect various oral sites but mainly the labial mucosa and the tongue. Its etiology is poorly understood;[36] however, it may be classified into a primary variant that is related to underlying neuropathy and a secondary variant that may arise as a result of local precipitating factors such as contact hypersensitivity.[18] It has been stated that the prevalence of BMS may be difficult to determine precisely because of different clinical entities;[37] however, prevalence varies with age and gender, as it may reach up to 33% in postmenopausal women.[38]

Studies that investigated the association between BMS and fixed dental appliances presented contradictory results. Although Marino *et al*. stated that the findings of the patch test for metals were not significantly associated with BMS, they recommended investigating hypersensitivity when evaluating patients with symptoms of BMS.[18]

Another study showed the salivary concentration of Ni to be significantly higher in subjects with metal dental appliances, but they concluded that BMS is not correlated with higher metal ion concentration in saliva.[19] Significantly, another study reported that subjects reporting BMS are more likely to have a contact allergy to gold but not mercury.[20]

Hypersensitivity and lichenoid reactions

Lichenoid oral reactions are indistinguishable histologically or clinically from oral lichen planus. However, a known factor can be identified in case of the former lesions.[39] In some patients, oral lichenoid reactions appear as a result of chronic irritation or a delayed hypersensitivity reaction.[39] Although dental amalgam is the most commonly implicated dental material for causing lichenoid reactions,[40] other materials may also be involved. The material used in dental alloys should be biocompatible, and it should not cause toxic or injurious effects when it comes into contact with living tissue. In other words, biocompatible dental materials do not contain toxic elements, and substances do not leach or diffuse or get absorbed into the circulatory system, causing adverse systemic effects, i.e., teratogenic or carcinogenic.[9] Cobalt, chrome, nickel, palladium, and mercury are widely used in dentistry, and their allergic effect is documented.[5]

Nickel is known to cause allergy, and the use of alloys containing nickel in dentistry has been associated with allergic reactions.[9] Nickel dermatitis has also been reported extensively in literature, but the incidence of nickel allergy is reported to be high,[41] especially in women.[42] Intraorally, nickel allergy is manifested as a burning sensation, gingival hyperplasia, and lingual paresthesia.[21] Patients with nickel allergy are more likely to be allergic to cobalt and chromium.[22] Although gold is suggested as an alternative to nickel in allergic patients, there were sporadic case reports on the development of orofacial granulomatosis in response to gold dental crowns.[23] The extent of the allergic reaction has been found to correlate positively with the area of

Table 1: Studies presenting oral health effects of fixed metallic appliances

Study	Type	Method	Results
Baričević *et al*.[6]	*In vivo*, analytic case–control	*n*=30 with fixed prosthodontic appliances for 5 years or more, 25 controls	Evidence of DNA damage in buccal cells adjacent to prostheses
Imirzalioglu *et al*.[9]	*In vivo*, analytic case–control	*n*=60 high noble and 20 base metal samples of new and recast alloy	Reuse of cast alloy results in reduced cellular activity of culture cells
Faccioni *et al*.[16]	*In vivo*, analytic case–control	55 orthodontic patients and 30 controls	DNA damage in oral mucosal cells with fixed appliances
Marino *et al*.[18]	Cohort	*n*=124 Mean age=57	Allergy (patch test) is not associated with BMS
Baričević *et al*.[19]	Cross-sectional, analytic, case–control	*n*=85 with and without fixed oral appliances.	Salivary Ni is higher in subjects with appliances but do not correlate with BMS
Koch and Bahmer[20]	Cross-sectional analytic	*n*=194 with amalgam or Au or Pd restorations	High sensitization to Au and Pd. Subjects with BMS have contact allergy to Au
Noble *et al*.[21]	Review and report of 2 cases	*n*=2	Ni allergy manifests as: BMS, gingival hyperplasia and lingual paresthesia
Syed *et al*.[22]	Systematic review		Ni allergy is also linked to Co, Cr allergy The dental material causing most oral mucosal reactions is amalgam
Lazarov *et al*.[23]	Case report	*n*=2	Au is linked to cases of orofacial granulomatosis
Ahlgren *et al*.[24]	Cross-sectional analytic study	*n*=102	74.2% of patients with contact dermatitis to gold had gold fillings Significant association between gold surfaces and allergy
Durosaro and el-Azhary[25]	Retrospective study	*n*=910 tested, of them: 106 (12.1%) were sensitized to Pd	15.1% had a lichen planus-like eruptions; 13.2%, burning mouth; 27.4%, stomatitis; and 29.2%, hand and body dermatitis
Ditrichova *et al*.[26]	Cross-sectional	*n*=25 with lichenoid lesions	Pd linked to lichenoid reactions in 13%-15% of cases
Tian *et al*.[27]	Case report	*n*=1	Traces of O, C, and Na in gingival pigmentation around Ni-Cr crowns
Joska *et al*.[28]	Cross-sectional in vivo		Oral pigmentation is related to corrosion of alloys. Also, traces of Au in root with Au crowns
Yamada and Sato[29]	Case report	*n*=1	Gingival stains around Au crowns contain Ag
Garhammer *et al*.[30]	*In vivo*, cross-sectional	*n*=28	Gingival stains around crowns contain Pd, Cu, Au and Ag
Wataha *et al*.[31]	Laboratory, analytic	Cell cultures of macrophages with/without LPS and added metal ions	Ni was the most to induce the release inf. Mediators and tumor necrosis factor-alpha with or without LPS
Qiao *et al*.[32]	*In vivo* laboratory study	Cell cultures of fibroblasts to study cytotoxicity and DNA damage	Ions induce RNA and DNA changes and apoptosis
Geurtsen[33]	Review		Mutagenic and genotoxic effect on prokaryotic cells *in vitro*
Westphalen *et al*.[34]	*In vivo* lab analysis of buccal cells of orthodontic patients	*n*=20 Investigate genotoxicity	DNA damage in oral mucosal cells after fixed ortho. appliances

BMS=Burning mouth syndrome, LPS=Lipopolysaccharide

exposed gold surfaces inside the oral cavity; the more the quantity in the oral cavity, the more the risk of gold allergy.[24] Populations differ in the prevalence of dental gold use. In Sweden, for instance, more than 25% of the population use dental gold.[43]

Palladium is another metal that is extensively reported to cause oral lichenoid reactions in some palladium-sensitive patients. The frequency of lichenoid reactions was reported to be approximately 13%–15% among patients with palladium sensitivity.[25,26]

Oral pigmentation

Ever since prices of gold increased since the 1980s, nickel-based alloys were introduced as a replacement for their substructure. The complexity of the oral environment causes alloys to continuously corrode;[27] nickel ion (Ni^{+3}) among other ions can leach for a prolonged time.[44]

It has been claimed that the development of oral pigmentation is closely related to the occurrence of corrosion of dental alloys. In this case, visible areas of linear pigmentation surrounding the restored tooth become evident.[28] Yamada and Sato reported that gingival stains around the margins of gold crowns contain silver.[29] Further, Garhammer *et al*.[30] reported that such stains around restorations of different alloys contain palladium, copper, gold, and silver. Joska *et al*.[28] also reported the detection of copper and silver in the root of a tooth restored with a gold-based alloy dental crown.

It has been claimed that the presence of such restorations correlates with the appearance of soluble compounds in the gingival sulcus. The sulcus forms a protected environment for such compounds, facilitating their transport to adjacent soft tissues. Meanwhile, some of these compounds get deposited, producing the typical tissue pigmentation.[28] The mechanism of tissue pigmentation though needs more explanation and further research is needed in this aspect. In a patient with such tissue pigmentation around the Ni-Cr dental crown, another study used energy-dispersive X-ray analysis and reported the identification of C, O, and Na, but no traces of Ni or Cr could be identified.[27]

Regardless of the mechanism behind oral pigmentation around fixed dental appliances, there were no reports on the potentially harmful consequences of these pigmentations, apart from the esthetic complaints of the patients. Recently, Ristic *et al*. indicated that gingival pigmentation seemed to be linked to the impaired periodontal condition of abutment teeth and they recommended careful preparation of abutment teeth to minimize the chance for the occurrence of gingival pigmentation.[45]

Genotoxic and cytotoxic effects

Ni^{3+}, Cr^{3+}, and other similar metal ions reported to be released from cast alloys are believed to affect gingival fibroblast behavior, altering its proliferation behavior and modifying its metabolism.[31] These ions are also believed to raise the levels of inflammatory mediators and tumor necrosis factor-alpha.[31] DNA and RNA changes and the appearance of protein synthesis promoting oxidative DNA damage could also be detected following the exposure to these leaching ions from cast dental alloys, indicating obvious cytotoxicity.[32] Apoptosis was also noticed.[32] Many studies confirmed the genotoxic and mutagenic effects in prokaryotic and eukaryotic cells of these ions *in vitro*;[33] however, there are only a few *in vivo* studies documenting the damage of DNA of oral mucosal cells as a result of such metal release from fixed orthodontic appliances.[16,34]

Leaching ions from fixed prosthodontic restorations possess genotoxic effects as reported by Baričević *et al*.[6] Cobalt-chromium-molybdenum and nickel-chromium dental casting alloys were investigated. Results indicated that leached ions might influence the DNA damage of mucosal cells.[6] Another study indicated that Ni-Cr alloys are more cytotoxic than Co-Cr or Au-Pt alloys.[9] The degree of cytotoxicity has been linked to the frequency of melting and casting processes where degenerative changes in cell morphology have been noticed, leading to the recommendation of some researchers to avoid using dental alloys that contain nickel.[46]

All researches that could be found in the literature have reported interactions in relation to well-known widely used dental alloys. Little is known or reported about the interaction of oral tissues with the introduction of low-quality material or alloy.

Conclusion

It can be concluded that fixed metallic oral appliances have potential effects on oral health. Patients complaining of the above-mentioned disorders should be screened by their general dental practitioners for oral prosthetic appliances. A recommended approach is to use patch test, which is the most reliable method for identifying metal allergy.[5] Using a patch test entails the preparation of an ointment or solution that contains a certain concentration of the assumed allergen and its application on the patient's skin.[5] For example, if a nickel allergy is suspected, diagnosis can be established by patch test using 5% nickel sulfate in petroleum jelly.[21]

The knowledge of allergy and corrosion rates of fabricated alloys is required in dentists to minimize the risk of allergic reactions. A previous history of metal allergy entails performing a patch test for the hypersensitive patient, and caution is needed when planning to use different alloys in the mouth.[5] It may be useful to modify the treatment plan of the patient when any of the above diseases is encountered, following the fabrication of fixed dental appliances utilizing metallic components.

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Conflicts of interest

There are no conflicts of interest.

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