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TITANIUM IN REMOVABLE PARTIAL DENTURES - A REVIEW OF THE LITERATURE

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ABSTRACT
Although porcelain and zirconium oxide may be utilized instead of traditional dental metals for fixed partial dental prostheses in the near future, biocompatible metals will most likely continue to be used for RPD frameworks. Commercially pure (CP) titanium offers suitable mechanical qualities, is lighter (low density) compared to traditional dental alloys, and has excellent biocompatibility, preventing metal allergies. The laboratory conditions required for synthesizing titanium frameworks are described in this review, as well as the current status of titanium removable prosthesis. Titanium is progressively being used in the fabrication of cast RPD frameworks. There have been no reports of metallic allergies linked to CP titanium dentures. The long burn-out, inferior castability and machinability, reaction layer generated on the cast surface, polishing difficulty, and high initial costs are still some of its laboratory drawbacks. However, clinical issues such as discolouration of titanium surfaces, harsh metal taste, decreased clasp retention, plaque adhesion to the surface, denture base resin detachment, and severe wear of titanium teeth have gradually been rectified. There have never been any reports of titanium RPD frameworks failing severely. As a result, titanium is advised as a protection against metal allergy, particularly for large prostheses like RPDs or complete dentures.

KEYWORDS Titanium, removable dentures, metallic allergy, literature review, frameworks, CAD/CAM

INTRODUCTION

Titanium is well known as a biocompatible, inert metal, but its application in removable prostheses is limited due to casting challenges and a dearth of clinical research [1]. Commercially pure (CP) titanium and titanium alloys have been employed to manufacture removable denture frameworks occasionally for the past 20 years because of their great biocompatibility, superior corrosion resistance, and mechanical properties that are close to that of gold alloys [2, 3]. Many studies have been devoted to fundamental research on titanium, such as alloying titanium, casting technology, machinability, wear resistance, bonding to porcelain, prosthetic composites, and denture-base resins, to assure the laboratory success of titanium castings [4, 5]. The use of titanium for removable prostheses, maxillo-

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facial prostheses, and implant-supported superstructures has been described in various clinical papers. The advantages of titanium over other metals used for denture frameworks are its lightweight, superior fit accuracy, and excellent biocompatibility [6–13].

One of the inevitabilities of titanium casting is the formation of a hard, brittle reaction layer on the cast surface due to titanium's chemical reactivity with elements in the investment. When compared to traditional dental casting, titanium prosthesis would be better created utilizing computer-aided design computer-aided manufacturing (CAD CAM). RPD frameworks with clasps, on the other hand, cannot be fabricated using CAD/CAM for several reasons: (a) a one-piece framework requires a large number of ingots, (b) minute cutting is difficult due to tool size issues, and (c) cutting the clasp three dimensionally with an undercut is impossible.As a result, casting will continue to be used to construct RPDs. Although except for the clasps, which can be cast and then laser-welded to the framework, every RPD component can be fabricated using CAD/CAM technology [14].

Figure 1: Titanium RPD fabricated for a patient with metal allergy (Picture courtesy: Oluwajana et al [15])

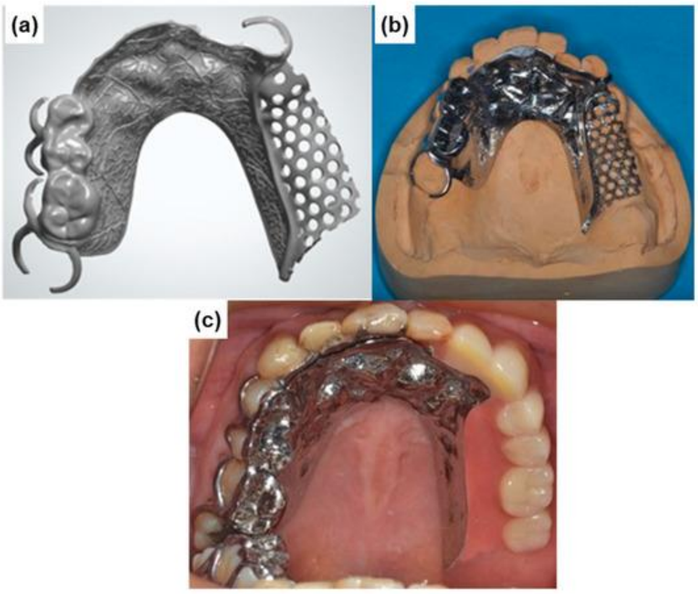

Figure 2: Partial dentures manufactured by laser sintering with CP Ti G 2 powder. (**a**) laser-sintered metal frame; (**b**) polished metal frame; (**c**) partial denture. (Picture courtesy: Okazaki et al [16])

LABORATORY SETBACKS

Even though titanium laboratory technology has advanced significantly, certain laboratory limitations of cast titanium frameworks remain unsolved. These disadvantages are: (a) extended burn-out time, (b) poor castability and machinability, (c) reaction layer on the cast surface, (d) difficult polishing, and (e) expensive initial prices as compared to other dental metals. There have been no studies in the literature claiming that cast titanium frameworks were less advantageous than Co–Cr alloy or gold alloy[17–22].

In radiographic examinations using titanium frameworks, which are more prone to porosity than frameworks constructed of common dental casting alloys, a significant incidence of casting porosity in clasp assemblies has been documented. Internal porosity in cast titanium clasps might cause them to break[17]. As a result, several casting parameters have been examined in order to reduce porosity. The use of curved sprues and thicker auxiliary sprues appears to be a way to reduce porosity in the clasps. Low casting pressure and the use of air vents could also help to reduce porosity. CP titanium RPD frameworks were comparable to Co–Cr frameworks in terms of casting accuracy, internal porosity, and surface roughness[23, 24].Our team has extensive knowledge and research experience that has translated into high quality publications[25–44].

Chemical treatment, airborne particle abrasion, and rotary tools are commonly being used to remove the reaction layer from the casting surface. When tested using silicon carbide wheels, the reaction layer had no effect on the titanium's grindability. However, not all of the reaction layer on the inside surface of the clasp should be removed because this will damage the clasp's fit. To remove the reaction layer from the inside surfaces, only chemical treatment with hydrofluosilicic acid and sandblasting with Al_2O_3 powder can be used[45, 46].

CLINICAL PROBLEMS

Despite its excellent corrosion resistance, discoloration of the titanium surface was commonly seen. At the 1-week review, Sutton and Rogers[47] observed that a Ti–6Al–4V RPD framework had badly discolored to a medium brown tint. Once a day, a denture cleanser (Efferdent Plus) was used. While the discoloration on the titanium surface could be readily eliminated by polishing it again, it appeared all over the titanium alloy frameworks' surface within one week.

Yamamoto et al. [48] found that the frameworks of 101 titanium (CP and Ti–6Al–4V) dentures discolored after a 5-year follow-up in a clinical survey. Approximately 50% and 5% of the frameworks, respectively, had minor and severe discolorations. Metals other than titanium did not discolor intraorally. The RPD was produced again with grade 3 CP titanium after the Ti–6Al–4V lingual bar in one case became noticeably discolored at the bottom a short time after delivery, and no discoloration was noted after 18 months. Superplastically formed Ti–6Al–4V alloy palatal plates showed no discoloration. Based on SEM data, Yamamoto et al. theorized that the aluminium in Ti–6Al– 4V segregated on the cast surface and subsequently localized corrosion began and advanced.

Strong alkaline denture cleansers, notably those with a pH of more than 11, were found to be one of the causes of discoloration on the titanium surfaces in vitro [49]. To avoid such discoloration, a weaker alkaline denture cleaning should be used. When a less alkaline cleanser was utilized, the titanium surface lost its brilliance after short-term use but no actual discoloration was seen [50].

Only one patient reported a "bad metallic taste" and a "citrusy taste" after receiving a Ti–6Al–4V RPD framework [47]. Within one day of the framework being polished again, the patient complained of an unpleasant taste. The sensitivity of CP titanium in the mouth was studied by Yoshida et al. [51]. The reason for these observations remains unknown.

Plaque adheres more easily to titanium frameworks than to traditional metal frameworks [52, 53]. Because of the TiO_2 layer's high electrostatic binding potential and rough surface, bacteria colonize quickly[53–55]. Surprisingly, plaque buildup on titanium surfaces is comparable to or even higher than that on natural teeth [20], and the biofilm composition on Ti surfaces and natural teeth is strikingly similar. Plaque accumulated on the titanium surfaces even when patients followed proper oral hygiene. There is a need for more understanding and research into how to maintain titanium surfaces clean. Tschernitscheck et al. [20] on the other hand, highlighted titanium's possible toxicity. Although titanium is biocompatible, minute titanium particles created during the abrasive process or the worn titanium surface might elicit cytotoxic reactions in tissues close to titanium restorations. Detachment of the denture-base resin from the cast titanium framework was frequently seen in previous studies [56–58]. Microleakage was not prevented by conventional bonding between the acrylic resin denture base and the titanium framework. Using five metal primers, the shear bond strengths of polymethyl methacrylate to cast titanium and cobalt–chromium frameworks were investigated [56]. The shear bond strengths of the denture-base resin to both CP titanium and Ti–6Al–4V alloy were greatly increased by using any of the five primers evaluated, regardless of the brand. Denture displacement during mastication can cause resin fracture and debonding between the denture base resin and the framework. As a result, titanium frameworks should be designed and manufactured to be strong enough to minimize deflection.

When the same grades of CP titanium were utilized for both the maxillary and mandibular teeth, severe wear was frequently observed. The wear resistance of CP titanium teeth was compared to that of ordinary gold alloy teeth using a wear testing machine. Grades 2 or 3 CP titanium, which were used

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for both maxillary and mandibular teeth, showed the most wear. When compared to all of the CP titanium teeth examined, conventional gold alloy exhibited the best wear resistance.

Among the titanium teeth studied, Ti–6Al–4V and Ti–6Al–7Nb showed much less wear [59, 60]. Although CP titanium grade 4 or Ti–6Al–7Nb is currently recommended for metal teeth, more research is necessary exploring new titanium alloys and cases where titanium wears against human enamel.

DISCUSSION

Commented [1]: add few points on titanium rpd with metal ceramic crowns in full mouth rehabilitation

Titanium dentures are lighter than traditional metal-base dentures due to their low density. When compared to conventional dentures, the weight disparity between well-fitting maxillary and mandibular titanium complete dentures had no effect on jaw movements, denture stability, or patient choice [61, 62]. The preconceived notion that a heavy denture adds to mandibular denture stability and that light maxillary dentures are difficult to remove influenced the patients' preferences. Patients with such preconceived views about maxillary dentures may prefer titanium maxillary dentures. Facial prosthesis, on the other hand, should be made as light as possible because they cannot be given enough retention [62].

Titanium has a high rate of laser beam absorption [63–65] and a lower thermal conductivity value, making it ideal for laser welding. These qualities enable titanium framework fabrication and repair easier using laser welding. Dentures with metal bases are usually remade if the frameworks fail severely. The damaged frameworks are joined by torch soldering in such dentures, and the denture teeth and denture-base resin must be removed. Titanium dentures, on the other hand, can be easily rejoined using laser welding since the heating is limited to a tiny area. Because of advancements in the technique, laser welding has become the preferred method of framework repair.

Computer-aided design and computer-aided manufacturing will be the preferred method for making titanium prosthesis in the future [66, 67]. Fabrication processes for titanium RPD components will include a combination of casting, superplastic forming, and CAD CAM for titanium RPDs with clasps. It's also worth noting that there are four grades of CP titanium [68–71], each with varied mechanical qualities ranging from flexible to rigid, which is useful because each RPD component has different mechanical requirements. Hence, these parts can be manufactured individually from the appropriate CP titanium grade. After casting, each component can be joined using laser welding. Because all restorations in the mouth should be ideally made from only one metal to prevent metal corrosion caused by the contact of different metals, Titanium with its different grades and respectively different properties can be used to fabricate the different components of prostheses [72].

There have been a lot of studies in the recent past to encourage the use of titanium removable partial denture with metal ceramic crowns in full mouth rehabilitation cases. SLM-fabricated RPD frameworks had better fit precision than traditional lost-wax casting, according to Bajunaid and colleagues [73]. Peng and her colleagues compared the trueness of RPD frameworks cast with Co-Cr, SLM with Ti-6Al-4V, and SLM with Co-Cr, and found that the SLM with Ti-6Al-4V group had the fewest surface deviations [74]. Lee et al. demonstrated the successful employment of an RPD framework SLM with Ti-6Al-4V for a full mouth rehabilitation case. The prostheses were found to have functioned well after a year of clinical follow-up, and all abutment teeth were periodontally stable and free of problems [75]. Piermatti and colleagues demonstrated the use of CAD-CAM machined titanium frameworks to eliminate the technical issues associated with excessive interridge space and allow retrievable metal-ceramic crowns to be used in atrophic jaws to solve the issues of a full-mouth, fixed, implant-supported restoration [76]. For completely edentulous individuals, implant-supported fixed prosthesis has proven to be a promising therapeutic choice. Gurav and colleagues found that the

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use of CAD-CAM technology for milling of titanium bars gives passive fitting, screw-retained retrievable prosthesis, and that individual metal-ceramic crowns provide unmatched esthetics [77].

Although laboratory and clinical setbacks remain as explored in this review, Titanium is increasingly being used in cast RPD frameworks [1]. Titanium is also indicated for protection against metal allergy, especially for large-scale prostheses like RPDs or complete dentures. Hence, titanium removable prostheses have the potential to be used more extensively than traditional alloys.

CONCLUSION

According to a review of the literature, the laboratory and clinical aspects of titanium removable prosthesis are as follows:

1. Titanium is progressively being used in the fabrication of cast RPD frameworks.
2. There have been no instances of metallic allergies linked to CP titanium dentures.
3. Long burn-out, inferior castability and machinability, reaction layer formed on the cast surface, polishing difficulty, and high initial costs are still concerns in the lab.
4. Clinical issues such as discoloration of titanium surfaces, harsh metal taste, decreased clasp retention, plaque adhesion to the surface, denture-base resin detachment, and severe attrition of titanium teeth are being gradually addressed.
5. Titanium RPDs have never been reported to have failed severely.

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