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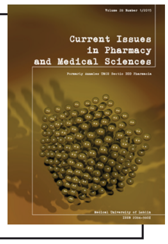
journal homepage: http://www.curipms.umlub.pl/




# The use of gold and gold alloys in prosthetic dentistry – a literature review

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**ARTICLE INFO**

Received 08 July 2015
Accepted 15 July 2015

***Keywords:***
gold,
gold alloys,
galvanoforming technique,
crowns,
dowels.

**ABSTRACT**

Gold is a noble metal with very good chemical resistance. It also does not become oxidized in water or air. Pure gold has a bright yellow color and shine, and it is a heavy, but soft metal with huge plasticity and ductility. For many years, gold and its alloys have been recognized as being great prosthetic material in dental practice. In current dentistry, the progress in materials science and galvanoforming techniques have made it possible to create precise restorations utilizing this metal. This pertains both to fixed and removable dentures. Galvanized gold has a range of advantages, among these being biocompatibility, proper marginal tightness, endurance, its esthetic design and the fact that it boasts bacteriostatic features.

## INTRODUCTION

The alloys which are still used in dentistry nowadays, are placed within several groups. These are the noble ones, that have a high content of noble metals (gold, platinum, palladium), and the non-noble metals (base metals). Gold alloys have been used in dentistry since 1932. Back in that time, after several attempts to mix gold with silver, copper or platinum, these alloys were categorized in the following way: soft, mid, hard, super-hard. It was quickly noticed that gold alloys (with gold content lower than 65%) corroded too quickly. This problem was solved in 1948, when palladium was added. Later, in the 1950s, gold alloys were supplemented with platinum. This lowered its expansion and improved the connectivity of metal and ceramics [2].

Gold is a metal that has been known for hundreds of years. Thanks to its properties, among these being specific weight of 19.3, melting point 1062°C, boiling point 2600°C, ductility and plasticity, as well as thermal or electric conductivity, it is frequently used in everyday dental practice, chiefly as a substructure for prosthetic restorations [2,17].

Today, gold is widely used in prosthetics. Its use ranges from being employed in the fabrication of removable dentures, where the inner surface permanently touching oral cavity tissues, through to fixed dentures, and even some structures of certain implantological systems. All such items can be made of galvanized gold [11,16,28]. Thus, new technologies has made gold and its alloys a kind of a universal material.

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## 1. INLAYS AND ONLAYS

Indirect restorations used to reconstruct posterior teeth were introduced into everyday practice in order to eliminate the disadvantages of direct composite restorations. In the case of restorations made by the indirect method, the polymerization takes place outside the oral cavity as this eliminates the direct polymerization shrinkage. This process improves the physical properties of the item, and hugely eliminates so-called microleakages. Among indirect restorations, there are: inlays, onlays, overlays, endo-crowns and partial crowns [7].

Restorations made of gold alloys proved to have excellent clinical indestructibility. The research of Erpenstein *et al*. reveals that as much as 73.4% of all golden inlays have a survival rate of 25 years [10], and the research of Donovan *et al*. have shown that almost 90% of the restorations had been in service for over 9 years, 72% for over 20 years, and 45% from 25 to 52 years [8]. In addition, Studner *et al.* suggest that 96.1% of all restorations employing gold alloys needed no replacement after 10 years in use. In the case of 20 years, the ratio was 87%, and that of 30 years, it was 73.5% [23]. The main contraindications of using gold inlays and onlays include:

 DOI: 10.1515/cipms-2015-0070 

- esthetics (a visible thin stripe of gold on the edge of the inlay, as well as the lack of "chameleon effect"),
- extensive cavities,
- bruxism,
- teeth loosening (3rd degree),
- periapical alterations,
- short crowns and too thin walls of cavity (weak retention of gold restorations).

Restorations made of gold require much more cavity preparation than do composite restorations. On the other hand, though, they have all the advantages of gold, among these being biocompatibility, good marginal fit and low corrosion risk. Unlike most alloys, gold (as a soft metal) has low elastic and firmness limits. One of the disadvantages in its employment is that it is impossible to connect gold adhesively with tissue [6]. These restorations are rather rarely done, since both gold material and the essential laboratory procedures are rather expensive [6,7].

## 2. DOWELS, POSTS AND CORES

Posts and cores are used to restore both single and multi-rooted teeth that have undergone successful endodontic treatment, yet they are wholly or partly destroyed subgingivally. Specialists use mainly 3 and 4 type gold alloys to produce individual cast post and core, but the most noble type 2 gold alloys could also be used [6].

The elasticity module, as well as corrosion, are the issues to pay attention to when creating prefabricated posts and cores [13,20]. The first prefabricated dowels were very susceptible to corrosion, and this led to discolorations of the root and the adjacent gum [12]. Modern prefabricated posts, made of noble metal alloys such as the platinum-gold-palladium alloy, no longer have that problem. The advantages of such inlays are as follows: durability, stress absorption, biocompatibility and no susceptibility to corrosion or any galvanic reactions. The disadvantages include huge production costs and the risk of overexposure (in case the biotype is thin) [25].

Individual cast posts and cores can be made through the traditional casting method, as well as the more recent galvanoforming technique. They are mostly used in difficult clinical situations, such as in repairing subgingival fractures where there is no space to put a prosthetic crown at a proper distance from the alveolar process [15]. Cast posts and cores made of gold alloys can be characterized by their high elastic module (70-95 GPa). This makes it possible to copy the shape of the canal, a circumstance which facilitates making it compatible [1] (Fig. 1).

***Figure 1.*** Post and core made of gold alloy

## 3. CROWNS

Crowns, being fixed prosthetic dentures, are used for restoring a part or the whole of the tooth's clinical crown. There are both all-metal crowns, as well as the porcelain-fused-to-metal crowns available in today's dental practices. The all-metal crowns are usually used for the posterior part of the oral cavity.

The clinical procedures in the case of gold crowns do not differ very much from the generally used techniques. However, the abutment tooth should have a chamfer (obtuse angle, depth of 1-1.2 mm), and also should ideally have a surface without sharp edges or undercuts [14].

The gold substructure of the crowns might either be made through the traditional casting method or through galvanoforming [17]. One of the advantages of the galvanoforming technique is the fact that the abutment tooth can be efficiently and economically prepared, since in such a case, the gold substructure is very thin (0.2 mm). Another advantage of using such crowns is the aesthetic effect they make. Also, it leaves enough space for furnaced porcelain (0.8 mm) [7,14,17]. The marginal fit of a galvanized crown is around 20 μm, thanks to which the crown is well adjusted to the walls of the abutment tooth, at the same time eliminating the risk of the leaking of cement, the risk of root caries and any inflammation of the marginal gingiva coming about [1,27]. The galvanized substructure is very hard (around 100-150 HV, according to the Vickers' scale) and after the veneering with porcelain, the rate is around 50 HV [5]. Veneering with porcelain should be done over a material in the case of which, the dentine firing temperature is not higher than 900°C. Various authors point to the fact that as galvanized substructures are characterized by poor resistance, some mechanical damages are observed due to the lack of oxides on their surface, hence, the connection with the veneering material is very poor [18] (Fig. 2,3).

***Figure 2.*** Metal substructure made of gold alloy

***Figure 3.*** Metal substructure made of gold alloy and veneering with porcelain

## 4. TELESCOPIC CROWNS

Telescopic crowns, also known as 'double crowns' [1], are used as retentive elements in overdenture prosthesis, skeleton dentures, movable bridges or implant suprastructures [4,9]. Their main advantage is the fact that they transfer the chewing forces over to the alveolar process through the periodontium of the abutment tooth, as well as through indirect splinting of the loosening abutment in periodontopathy [1].

A telescopic crown is made of an internal crown and secondary crown. An internal crown is cemented to the abutment tooth, whilst the secondary crown is an element of removable denture with a retention and stabilization function. Telescopic crowns are categorized into a number of groups, one of these according to the convergence criterion of the axial walls. There are two types of telescopic crowns, cylindrical and conical [1,9,22].

Galvanoforming should be definitely used for laboratory purposes. This process makes it possible to create very precise, durable and fracture-resistant dental crowns. Between the secondary and internal crown, there is always a fissure (8 to 12 μm). This space is always filled with saliva, there is an adhesive power inside (5-10 N) and friction does positive work [1]. Galvanized telescopic crowns also have a homogenous structure made of gold cations that are tightly packed [1,4].

## 5. BRIDGES

There is a very limited scope for using galvanized gold in creating dental bridges. In fact, employing this material makes sense in the case of short bridges only, among these, three-point ones. This is due to the fact that making a pontics is not possible when using a galvanization technique. The galvanization process would create only 0.3 mm of metal surface, and a galvanized span would not be hard enough. This means a huge deformation risk. A two-step process is the only solution here. In the first stage, the bridge pontics is made by way of a traditional casting method. Later, in the molding process, the pontics and galvanized crowns are covered with pure gold (earlier, being connected with a special ceramic glue or a laser) [1]. Of note: the fitting points are the weakest parts of the whole structure, which means that this technique would work only in case of three-point bridges. However, the fact is only the galvanized parts touch the oral cavity tissues and other parts are covered with ceramic [14]. In addition, the gold surface improves the material's resistance to wearing and protects it against corrosion [3,21,27].

## 6. REMOVABLE DENTURES

Using metal alloys (gold alloys included) to make the framework for removable dentures is much better than using acrylic resin. This because the alloys have almost no destructive influence over the dentures bearing area. Due to the precise way it is made, the stability of shape, the lack of internal stresses and the close contact with the dentures bearing area, it is possible to achieve very good retention of the denture over a long span of time. Another advantage is that the metal framework conducts temperature changes and this facilitates keeping the tissues in good health. Also, a denture metal framework makes it much easier for the patient to maintain good oral hygiene by lowering the risk of plaque accumulation. However, a metal framework has a disadvantage as well - prosthesis relining cannot be made.

Gold and its alloys are used to make the palatal plate of a complete dentures, the skeleton of the partial dentures, as well as some precise elements in the fabrication of all types of dentures.

From the laboratory point of view, in the case of skeletal dentures, after casting the metal elements, they are galvanized. The galvanization process start right after the metal structure is put in a solution of gold-sulphite, and then it is covered with gold (10 μm thick) [24]. The gold surface fits really well with the non-noble alloys. In the case of implants, galvanized gold is used for covering the sub mucosal surface [24] (Fig. 4).

***Figure 4.*** Skeleton dentures covered by galvanized gold

## 7. IMPLANTS

Currently, modern dental prosthetics relies on rehabilitating patients through the use of implants and prosthetic appliances such as crowns, bridges or implants. The electro galvanoforming technique makes it possible to obtain gold that is of homogenous structure, without any pollution or any casting contraction [19].

The use of double dental crowns made by way of the galvanization technique has caused new prosthetic constructions to appear. These are large and non-distorted constructions that can be used in implant supraconstructions. In all implantological systems, a galvanized superstructure of either cemented or bond crowns can be used [14,26]. Of note: the galvanoforming technique makes it possible to build secondary crowns.

Using implants in treating edentulous patients offers several advantages, including ensuring enhanced comfort and the opportunity to have a very esthetic prosthesis. One of the ways to do this is using an overdenture with a bar joint. Precise elements on the implants are made of gold and the dentures contains fitted matrices.

## CONCLUSIONS

Gold and gold alloys have been commonly used in dentistry. Even though other new materials have started to appear, gold and gold alloys are still used very often. When working with gold or gold alloys, prosthetic restorations can be made either through the traditional casting method or the modern galvanoforming technique. In terms of their features, they are definitely better than those made from non-noble metals. Their main advantages include: high biocompatibility, aesthetics and less plaque accumulation.

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