

Palladium in Restorative Dentistry

SUPERIOR PHYSICAL PROPERTIES MAKE PALLADIUM AN IDEAL DENTAL METAL

By Roy Rushforth

Charles Booth Ltd, 49–63 Spencer Street, Birmingham B18 6DE; E-mail: royrushforth@bettsmetals.co.uk

For the last century or so the first stage of treating a decayed tooth has involved ‘drill and fill’ procedures: the decay within a tooth is cleaned out by drilling and the tooth ‘restored’ by filling the clean cavity with a mercury based amalgam or more recently with a non-metallic filler. However after several such treatments the tooth can no longer be repaired by this technique and more radical restorative procedures are necessary. The dentist must now prepare a clean tooth stub that can be capped or crowned with a tailor-made metal crown manufactured by a dental technician using specialised processes. A bridge is formed when two or more adjacent teeth are to be restored by this means. The alloys used to produce these restorations are crown and bridge alloys.

Since the late 1970s, palladium has been a key metal used worldwide by the dental industry in the development of alloys for the manufacture of crown and bridge restorations constructed by den-

tal technicians. The price of palladium, now significantly less than that of either gold or platinum, coupled with its much lower specific gravity, (12.02 compared to 19.3 or 21.45 g cm⁻³, respectively) ensures that palladium-based alloys are very economic (the same weight of palladium has a larger volume than gold or platinum).

Palladium also has a good range of solubility with several metals (helpful for alloying) and an ability to impart good mechanical properties. It has excellent tarnish/corrosion resistance and biocompatibility in the oral environment. These properties make it ideally suited for use in dental crown and bridge alloys (those fitted in the as-polished state), see Figure 1. Generally such palladium-based alloys are ‘white’. However, many gold-based alloys also contain small amounts of palladium (typically 1–5 %) to improve resistance to tarnishing and corrosion without significant loss of colour (1).

These properties are also important for the



Fig. 1 A four-unit bridge in metal of two molar and two premolar teeth in the left-hand side lower jaw. The dental technician built up the mould using lost wax casting from impressions of the jaw made by the dentist. As our jaw structures are unique, each bridge or crown has to be individually made



Fig. 2 A four-unit bridge for the right hand side of an upper jaw. The bridge is of 2 molars and 2 premolars. The teeth have been mostly made in ceramic with some metal being permitted to be seen in the less noticeable rear molar. The dental porcelain and the dental alloy will be heat and expansion-compatible

Properties of a Typical Palladium and a Typical Gold Dental Alloy												
Porcelain alloy	Composition, %								Specific gravity, g cm ⁻³	Melting range, °C	0.2% Proof stress, MPa	Thermal expansion, K ⁻¹
	Au	Pd	Pt	Cu	Ag	In	Ga	Sn				
Pd alloy	2.0	78.0	–	10.5	–	–	9.47	–	10.7	1170–1190	727	13.9
Au alloy	75.0	7.6	3.0	–	10.8	2.5	–	1.0	16.2	1100–1150	453	14.9

development of lightweight palladium alloys intended for coating with porcelain, where the final restoration has to match the surrounding (natural) teeth (2). Such alloys, called porcelain, bonding or ceramic alloys, need to be compatible with the dental porcelains in terms of high temperature stability and coefficients of expansion.

The high melting point of palladium is an essential property contributing to this form of restorative dentistry, as the high firing temperatures of most porcelains (950–1020°C) require that the alloy has a higher melting point so it does not melt or collapse. This temperature clearly needs to be higher than those of the alloys (palladium or otherwise) used for conventional crowns and bridges. Even more important is the low thermal coefficient of expansion of palladium. This value is lower than that of most other metals including silver, gold and platinum, and is helpful when developing lightweight porcelain alloys compatible with currently-used dental porcelains that are fired in several layers onto the prepared metal crown, see Figure 2.

The porcelain alloys must typically possess thermal expansivities of 13.7 to 14.9 K⁻¹ over the range 0–500°C if ‘blowing off’ or cracking of the porcelain during the cooling cycle of layer build-up is to be avoided. Properties of a typical palladium and comparable gold-based dental alloy are shown in the Table. Many gold porcelain alloys also benefit from the attributes that palladium additions impart and as such can contain between 7–40% Pd.

Together with the current advantageous price of palladium (~ U.S.\$198/troy oz in December 2003) (3) compared to gold (~\$409/troy oz), the valuable combination of intrinsic mechanical and

physical properties that palladium possesses make it unique among the precious metals. Only its anomalous price (4) between Spring 2000 and mid-2001, peaking at ~ \$1094/troy oz in January 2001 before falling to its current level, has impacted on the use of palladium-based alloys. Less-favoured non-precious metal alloys, based on nickel, chromium and cobalt-chromium, gained ground during this period. However with the current stability in prices, the continuing use of palladium in precious metal restorations seems assured.

There is yet another type of palladium alloy compatible with lower temperature fusing porcelains with expansions in the range 15.8–16.9 K⁻¹ and which is fired at ~ 800 to 850°C. These alloys can be used for either ordinary crown and bridge restorations or be subsequently coated in the lower temperature porcelains. These are more popular in the U.S. and Europe but not yet in the U.K.

References

- 1 H. Knosp, R. J. Holliday and C. W. Corti, *Gold Bull*, 2003, 36, (3), 93
- 2 K. F. Leinfelder, ‘Porcelain Esthetics for the 21st Century’, *J. Am. Dent. Assoc.*, 2000, 131, 478
- 3 www.platinum.matthey.com/prices/price_charts.html
- 4 ‘Platinum 2003 Interim Review’, Johnson Matthey, London, 2003

Standards

- BS EN ISO 9693:2000 Metal-ceramic dental restorative systems
 BS EN ISO 8891:2000 Dental casting alloys with noble metal content of at least 25% but less than 75%
 BS EN ISO 1562:1995 Dental casting gold alloys

The Author

Roy Rushforth is Managing Director of Charles Booth (Stephen Betts Group) a U.K. dental alloy manufacturer supplying precious and non-precious materials for crown and bridge restorations. His 38 years’ experience in platinum group metals and gold has been first at Johnson Matthey where he developed new alloys and processes for the jewellery and dental businesses, then at the Birmingham Assay Office, U.K., as Development Director.