Reaction of fibroblasts to various dental casting alloys

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The cytotoxicity of a series of dental casting alloys in the as-cast and polished condition was determined with cell culture techniques involving phase contrast microscopy to examine cell morphology and the succinic dehydrogenase histochemical reaction to measure any ring of inhibition of Balb/c 3T3 cellular respiration around alloys. Crown and bridge casting alloys and a nickel- and a cobalt-base alloy were biocompatible in the polished condition, but less so in the as-cast condition. The only two exceptions were casting alloys containing 50–60 wt % Cu. Porcelain-fused-to-metal alloys were biocompatible in either the as-cast or polished condition. This direct contact method appeared satisfactory for evaluating biocompatibility of dental casting alloys, especially since these materials are in contact with gingival tissues.

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The present study quantitates the *in vitro* cytotoxicity of a variety of dental casting alloys using cell culture techniques combined with phase contrast microscopy followed by histochemical staining and optical density determination to assess succinic dehydrogenase activity.

Kawahara et al. (1) used tissue culture methodology to test the cytotoxicity of pure metals and alloys. The cytotoxicity of pure metals to L-cells was related to the periodic table of elements.

Dissolution of elements in dental alloys has been considered essential for cytotoxic response to cells. Bergman and Ginstrup (2) measured the dissolution rate of cadmium from dental gold solders and found it to be 0.04 mg/yr/mm^2 or about 2 mg/yr for an average area of a soldered joint. The total intake limit for cadmium per year has been set at 21–26 mg. A later paper by Bergman et al. (3) established that in animals the cadmium released accumulated in the liver and kidney.

Table 1. Alloys, manufacturers, batch numbers and approximate compositions

Alloy	Manufacturer	Batch Number	Composition, wt %
CASTING			
Firmilay	Pennwalt-Jelenko	6693 001985	74.5 Au, 3.5 Pd, 11 Ag, 11 Cu
Rajah	Pennwalt-Jelenko	7645 031585	58 Au, 3.5 Pd, 27 Ag, 11.5 Cu
Midas	Pennwalt-Jelenko	0222 082885	46 Au, 6 Pd, 39.5 Ag, 7.5 Cu, 1 ×
Forticast*	Pennwalt-Jelenko	6693 001985	42 Au, 9 Pd, 26 Ag, 21.5 Cu, 1.5 Ni
Midigold	Williams Gold	873650 070185	49.5 Au, 3.5 Pd, 35 Ag, 10 Cu, 2 In
Minigold	Williams Gold	86715B 091385	40 Au, 4Pd, 47 Ag, 7.5 Cu, 1.5 ×
Satincast*	Jeneric	040385 27	26 Au, 10 Pd, 48 Cu, 16 Ag
Albacast	Pennwalt-Jelenko	8703 052485	25 Pd, 70 Ag, 3 In, 2 Zn
MS*		None	62 Cu, 27 Al, 5 Ni, 4.5 Fe, 1.5 Mn
PORCELAIN-FUSED-TO-METAL			
Jelenko "O"	Pennwalt-Jelenko	8629 062485	87 Au, 6 Pd, 4.5 Pt, 2 Fe, In, Sn
Cameogold	Pennwalt-Jelenko	7371 031885	52.5 Au, 27 Pd, 16 Ag, 4.5 ×
Olympia	Pennwalt-Jelenko	8987 073185	51.5 Au, 38.5 Pd, 8.5 In, 1.5 ×
PTM 88	Pennwalt-Jelenko	8282 052985	88 Pd, 5 Co, 7 ×
Will Ceram Y-1	Williams	10143A 092385	75 Au, 13 Pd, 10 Ag, 2 ×
Will Ceram W	Williams	77685H 062085	54 Au, 26.5 Pd, 15.5 Ag, 4 ×
Will Ceram W-2	Williams	86617A 090985	45 Au, 40.5 Pd, 6 Ag, 8.5 ×
Will Ceram Litecast B	Williams	86617A 090985	77 Ni, 12.5 Cr, 4 Mo, 1.7 Be, 4.8 ×
Biobond II	Dentsply	MB21	80 Ni, 14 Cr, 2 Be, 4 ×
Rexillium III	Jeneric	072785 43	76 Ni, 13 Cr, 5.5 Mo, 1.8 Be, 3.7 ×
PARTIAL DENTURE			
Ticonium 100	Ticonium	032185	66 Ni, 17 Cr, 5 Mo, Al, 5 Mn, 1 Be, 1 ×
Jelenko LG	Pennwalt-Jelenko	548	13 Ni, 27 Cr, 54 Co, 4 Mo, 2 ×

*Composition determined by ESCA.

Table 2. "Degassing" and heat treatment of porcelain-fused-to-metal alloys

Product	Degassing schedule
Jelenko "O"	1300→1900°F without vacuum, removed immediately, bench cooled
Cameogold	1300→1900°F without vacuum, removed immediately, bench cooled
Olympia	1300→1900°F without vacuum, removed immediately, air blasted with Al_2O_3
Will Ceram Y-1	1200→1850°F without vacuum, held 5 min., removed and bench cooled
Will Ceram W	1200→1850°F without vacuum, held 5 min., removed and bench cooled
Will Ceram W-2	1200→1850°F without vacuum, held 5 min., removed and bench cooled, air blasted with Al_2O_3
Litecast B	1200→1850°F without vacuum, held 5 min., removed and bench cooled, air blasted with Al_2O_3.
PTM 88	1300→1850°F without vacuum, removed and air blasted with Al_2O_3
Biobond II	1200→1740°F with vacuum for 10 min
Rexillium III	1200→1825°F with vacuum, color blue-gray→straw, no hold
Product	Heat treatment schedule (to simulate firing of ceramic)
All products above	1200→1800°F with vacuum, no hold, cooled to room temperature in~15 min.; sequence repeated 4 times.

Mjör et al. (4) and Wennberg et al. (5) evaluated the biocompatibility of dental filling materials using cell culture techniques, implantation tests and pulp studies. They found poor correlation between these tests, thus casting doubt on the validity of using cell culture tests to evaluate cytotoxicity of dental restorative materials. The development of *in vitro* methods that more closely simulate the *in vivo* condition was advocated by Browne and Tyas (6) and suggested that cell culture tests are acceptable if the effect is local. More recently publications by Hume (7), Pahley (8) and Hanks et al. (9) have established that the design of the cell culture test is important if correlations with usage tests for dental restorative materials are to be obtained. In this regard, Pizzoferrato et al. (10) found biocompatibility testing of prosthetic implant materials by cell cultures very useful.

Stenberg (11) measured the release of cobalt from cobalt-chromium dental alloy in human saliva and tongue scrapings. The amount in saliva varied from 200 ng/g at 2 days to 10 ng/g at 20 days. The amount of cobalt in tongue scrapings varied from about 400 ng/g at 2 days to 10 ng/g at 20 days. deMelo et al. (12) measured the release of chromium and cobalt from a partial denture in human saliva, and found more metallic Cr and Co from new than old dentures as well as a greater decrease in Cr than Co from new to old dentures. Covington et al. (13) measured Ni and Be leakage from base metal casting alloys and found high levels of Be in comparison to the concentration in the alloy and that Be was more cytotoxic than Ni.

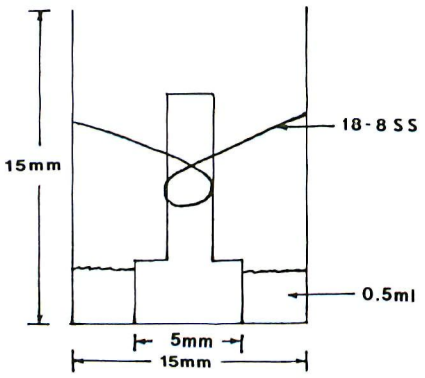

Fig. 1. Sketch of the cross section of a well in the culture dish with the alloy held in position with a stainless steel (SS) clip.

Wright et al. (14) determined the corrosion of Au-Cu-Ag ternary alloys by polarization and cytotoxicity using the Cr^{51} test and found a correlation between corrosion and the concentration of copper in the culture medium. Pourbaix (15) studied the electrochemical corrosion of silver-, gold-, and nickel-base biomaterials. Corrosion of silver- and gold-base alloys was from Ag-rich and possibly Cu-rich segregations. Au, Pt and Pd provided anodic film protection and addition of Pd to Ag-Cu greatly increased the corrosion resistance. In the Ni-base alloy Mo, Mn, Co, Ga, and above 20% Cr increased the corrosion resistance.

Geis-Gerstorfer and Weber (16) found that the presence of KSCN in artificial saliva increased the corrosion of Ni-Cr alloys and that those containing Be were the worst because of lack of passivation. They considered Co-Cr to be non-corrosive and Cu-Al to be so easily corroded that it should not be used in dental practice. Corso et al. (17) evaluated tarnish resistance of gold-base dental alloys and found the microstructure (e.g. 2-phases) was

Table 3. Ranking of the appearance of the Balb/c 3T3 cells after 24 hours on a 1–5 scale, 1 showing good attachment and 5 indicating rounded cells

Alloy	Condition	
	As-cast	Polished
CASTING		
Firmilay	4	2
Rajah	5	2
Midas	5	2
Forticast	4	2
Midigold	5	2
Minigold	5	2
Satincast	5	4
Albacast	3	1
MS	3	4
PORCELAIN-FUSED-TO-METAL		
Jelenko "O"	1	1
Cameogold	2	1
Olympia	2	1
PTM 88	1	1
Will Ceram Y-1	2	2
Will Ceram W	1	2
Will Ceram W-2	2	2
Will Ceram Litecast B	2	1
Biobond II	2	1
Rexilium III	2	2
PARTIAL DENTURE		
Ticonium 100	3	2
Jelenko LG	3	2

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