

## The Decline of Precious Metal Demand in Dentistry

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### Introduction

The Golden Age of Dentistry is over in the sense that gold demand has peaked and continues to fall. From records going back to 1969, U.S. and worldwide dental gold demand peaked in 1978. Dental gold demand would not approach that lofty level again until the year 2000. Since 2000, precious metal demand has been declining due to a perfect storm of rising markets and technology. In the 15 years from 2000–2015, U.S. gold demand had decreased by 398,000 ounces, or 44%.

Combined U. S. gold and palladium demand shrank by 29% from the years 2000–2015 even as population census estimates have increased 14% during the same period.

Today, worldwide dental/medical gold demand is about 2% of total fabricated demand.<sup>1</sup> The U.S. dental/medical palladium demand is 8.4% of the demand sector.

It should come as no surprise that precious metal demand is price-sensitive and elastic. As well, gold and palladium substitute for each other to some extent, especially for porcelain-fused-to-metal (PFM) restorations, depending upon price spikes of the respective metals.

The following is a brief overview of gold in dentistry.

### Gold in the Early History of Dentistry

Pure gold as a dental restorative material has been around for centuries. Ancient Etruscans in the 7th Century B.C. fashioned dental prostheses with



*It could be said that the use of precious metals in dentistry is disappearing into the horizon even as the gold in a sunset fades.*

**U.S. and  
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thin strips of gold.<sup>2</sup> A dental gold appliance in the tomb of an ancient Egyptian mummy now rests in a Cairo museum. Gold foil was used in the Renaissance to fill cavities.

The lost wax method for dental casting alloys dates back to early in the 20th century. In 1907, W.H. Taggart's dental development of the lost wax method with investment would constitute the basis for modern casting of dental alloys and would revolutionize the prosthetic industry.

Early dental restorations used pure gold sponge or gold foil. The post-Taggart casting alloys tended to range from 75% to 95% gold, sometimes using 1%–3% platinum, the remaining alloy balance being silver, copper, and/or zinc.

### Gold in the Modern Era

Gold is a well-known noble metal for both tarnish and corrosion resistance, hence minimizing the spread of metal ions in the body, as studies have shown.<sup>3</sup> Gold is biocompatible, has a suitable hardness for opposing dentition, and is a long-lasting restoration. Unfortunately, the one minor drawback of gold is that some patients will not consider a yellow cast-gold crown because the restoration is not lifelike.

Precious metal alloys were developed with porcelains to match coefficients of thermal expansion. Dental porcelain, developed in the late 1950s, would find a home in the 1960s. Gold was still the early principal noble component of the alloy. The noble metal palladium, rather than

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platinum, became the minor platinum-group metal in the PFM alloy.

Esthetic PFM dental restorations for the anterior teeth would replace full cast anterior yellow crowns. Lifelike dental restorations for anterior teeth would become the norm in the dental industry, and they continue to be so today. The substitution of porcelain for gold yields a decline in gold use.

Dental insurance was not always a benefit offered by companies. Dr. Robert Casper of Eagan, Minnesota recalls that over time, perhaps in the early 1970s, dental insurance was offered by larger companies, and then the practice spread to smaller companies. The amount of gold used in dentistry would increase as dental insurance coverage became more acceptable and commonplace, thus offsetting gold demand decline caused by the use of porcelain in dentistry.

In 1971, Joseph J. Tucillo and John P. Nielsen would prove 42% gold alloys with 4%-9% palladium were as tarnish-resistant or more so than 75% jewelry alloys without palladium.<sup>4</sup> The Tucillo and Nielsen findings ushered in a new era of lower 42%-59% gold alloys with small amounts palladium for full-cast metals. Some remain popular today. These lower gold alloys would reduce the demand for high noble alloys and gold in dentistry, especially after the 1980 gold rush.

## The How and Why of Gold Pricing

To explain the reason why gold prices would rise, it should first be understood that from the time of Alexander Hamilton until that of Richard Nixon, that as of August 15, 1971, the dollar was defined as a weight of gold or silver. When President Nixon broke the Bretton

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## U.S., Worldwide Dental – Medical Fabrication Gold Usage Declining

Dental – Medical Gold Demand

Average \$/oz. Gold	Range \$/oz. Gold	Year	World 1,000 oz.	U.S. 1,000 oz.	Europe 1,000 oz.	Japan 1,000 oz.
\$1064	\$1077-\$1294	2016p	1,866p	497p	418p	531p
\$1160	\$1049-\$1295	2015	1,887	502	422	537
\$1669	\$1540-\$1792	2012	2,060	550	471	575
\$1225	\$1058-\$1421	2010	2,200	605	513	635
\$445	\$411-\$537	2005	2,558	750	632	671
\$271	\$256-283	2001	2,646	765	780	669
<b>\$279</b>	<b>\$236-\$312</b>	<b>2000</b>	<b>2,786</b>	<b>900</b>	<b>842</b>	<b>682</b>
\$383	\$372-\$395	1995	2,346	654	909	638
\$384	\$345-423	1990	1,969	625	801	418
\$317	\$284-\$340	1985	1,795	444	936	390
\$612	\$481-\$850	1980	2,035	466	1251	206
<b>\$173</b>	<b>\$160-\$227</b>	<b>1978</b>	<b>2,946</b>	<b>811</b>	<b>1463</b>	<b>472</b>
\$41	\$41	1969	1929	707	772	321

Source: cpmgroup.com

p-projected

Worldwide demand for Dental-Medical fabrication gold demand has been declining consecutively since 2006 and has dropped considerably since 2000. Annual dental gold demand is co-mingled with medical gold usage. Per Jeff Christian of the CPM group<sup>1</sup>, the dental gold demand is about 80% of the total Dental-Medical figures. The CPM Group lists the following from the 2015 Annual Gold Yearbook. End-Uses of Total Fabricated Gold Demand is 96.1 million ounces. Of this total fabricated gold demand: jewelry demand accounts for 86.4%; Electronics 9.9%; 2.0% Dental-Medical; 1.6% Other.

Woods Accord in 1971, the price of gold, unanchored to the dollar, would consequently be allowed to rise.

On January 1, 1975, Franklin D. Roosevelt's 1933 ban on owning gold<sup>5</sup> was lifted. Thus the price of gold continued to rise as citizens could legally buy gold once again.

The first gold bull market surge began in 1979, peaked in 1980, and then collapsed.

The London gold peak of \$850 an ounce on January 21, 1980 would be the high watermark of the gold market for 30 years, until September of 2011.

## The Cause and Effect of Supply and Demand

U.S. and worldwide gold dental demand peaked in 1978 and would decline after the \$850 gold spike in January of 1980. As discussed initially, dental gold demand would not approach that lofty 1978 level again until the year 2000. The reason gold usage increased in the very late 1990s was that the price of palladium rapidly rose. The price of palladium spiked to more than \$1,000 an ounce

in 2001. Thus the dental community substituted gold use for palladium use. Since 2000, precious metal demand has been declining.

As gold prices rose, substitution and the use of alternatives to gold for dental prosthetic restorations took place, and in particular, substitution for lower percentage cast gold alloys found a footing for good.

Substituting palladium for gold occurred initially as a result of price. The price of palladium in 1980 was about \$200 an ounce, far less than the gold high of \$850 an ounce or the yearly gold average of \$612. This substitution of the noble metal palladium for gold in PFM alloys took a further hold in dentistry for practical clinical purposes as well as purely priced-based ones: Palladium-based PFM alloys reduced the cost of the coping — i.e., the metal understructure of the PFM.

Another price-saving benefit that occurred in substituting palladium for gold was that because the density of palladium (at 12 g/cc) is lighter than that of gold (19.3 g/cc), a dentist will yield more PFM palladium copings than the heavier PFM gold copings per ounce.

## The Decline of Precious Metals in Dentistry

### Dental – Medical Palladium Demand

Average \$/oz. Palladium	Range \$/oz. Palladium	Year	World 1,000 oz.	U. S. 1,000 oz.	Japan 1,000 oz.	Western Europe 1,000 oz.
\$691	\$831-\$524	2015p	727	226	255	216
\$526	\$395-\$797	2010	774	244	260	242
\$201	\$172-\$295	2005	948	225	475	226
<b>\$604</b>	<b>\$1090-\$398</b>	<b>2001</b>	<b>798</b>	<b>118</b>	<b>475</b>	<b>190</b>
\$681	\$433-\$970	2000	870	120	470	260
\$150	\$128-\$178	1995	1,245	198	576	438
\$114	\$135-\$87	1990	1,093	197	440	428
<b>\$116</b>	<b>\$101-\$140</b>	<b>1986</b>	<b>1,153</b>	<b>402*</b>	<b>309</b>	<b>420</b>
\$106	\$124-\$106	1985	956	339	214	387
\$201	\$271-\$	150	1980	533	244	22564
\$47	\$37-\$57	1976	368	139	177	52

The U.S. 2014 projected Palladium Demand is 2,706,646. The U.S. Demand by Sector is as follows: Auto-catalytic 69.2%; Electronics, 9.5%; Dental- Medical, 8.4%; Petrochemical, 5.3% and Other 7.6%. Per Jeff, about 80% of the Dental- Medical palladium demand is dental. Above listed demand records are courtesy of Jeff Christian, CPM Group, New York, NY. \* 402,000 was the peak U.S. Dental-Medical use in records going back to 1976. The 2016 Platinum Group Yearbook was scheduled to come out in June of 2016. Palladium peaked January 26, 2001 at \$1,090 an ounce London close.

### Dynamics of Use Enter the Picture

Post-1980, non-precious PFM dental alloys entered the market as an alternative to gold or palladium, but the hardness for many non-precious alloys would technically prove them to be too hard for both the laboratory and dental clinicians.

Concurrently in the post-1980 era, biocompatibility studies also focused on non-precious metal components for the health of the patient as well as for the lab technician. As an example, nickel, an early NP alloy constituent, would later be stricken from the list of suitable metal constituents for alloy manufacturers due to allergenic dermatitis considerations for the patient.<sup>6</sup> Beryllium<sup>7</sup> and cadmium, also early formula components, would likewise be stricken from non-precious metal alloy charts for the sake of the lab technician due to toxic gases emissions when casting and fine dusts when grinding.

What followed was that the use of non-precious alloys declined for technical and biocompatibility reasons in the early 1980s. Later, re-engineered nickel-free, beryllium-free, and cadmium-free PFM NP alloys would appear and remain. These NP alloys, still high-fusing alloys, still hard and not ideal, would attain a noticeable but not dominant market share and be workable, marginal alloys in dentistry, and they remain so today.

Chuck Yenker, Executive Director of the IdentAlloy Council, states that Council certificate shipments indicate that approximately 45% of all restorations are currently some type of all-ceramic restoration.

2015 sales of certificate types from IdentAlloy Council are as follow:

- 21.9% High Noble (*minimum* 60% Gold & Platinum group metals)
- 47.2% Noble (25% *minimum* Gold & Platinum group metals)
- 17.9% Predominantly Base Crown and Bridge

### Combined Gold and Palladium Demand

U.S. Population Census	World 1,000 oz.	U. S. 1,000 oz.	U. S. Ratio Gold/Palladium	U. S. Ratio Gold/Palladium
<b>321,000,000 est. 2015</b>	<b>2,614</b>	<b>728</b>	<b>502/226</b>	<b>2.2/1</b>
308,745,000	2,974	849	605/244	2.5/1
	2010	2,974	849	605/244
	2005	3,506	975	750/225
	2001	3,444	883	765/ 118
<b>281,422,000</b>	<b>2000</b>	<b>3,656</b>	<b>1,020</b>	<b>900/120</b>
	1995	3,591	852	654/198
248,710,000	1990	3,062	822	625/197

Above listed demand records are courtesy of Jeff Christian, CPM Group, New York, NY in the sense that I merely combined CPM Group totals. The combined gold and palladium shrank 29% from 2000 to 2015. The estimated amount in the 2015 census is 3.9 million more people or 14% higher than the 2000 census.

- 12.8% Predominantly Base Partial<sup>8</sup>

The IdentAlloy Council fills the vital need of verifying the material content of the restoration prescribed by the doctor and filled by the laboratory.

### Results in Clinical Use

In 1994, Gordon Christensen, D.D.S., M.S., Ph.D., a nationally known and respected speaker, cited that porcelain restorations abrade opposing teeth in the oral cavity<sup>9</sup> and that the wear is more noticeable in patients who clench or brux. Some porcelain restorations fracture while masticating.<sup>10</sup> Cast gold restorations do not abrade natural dentition noticeably. Interestingly, while PFMs

may abrade opposing natural dentition, the majority, or 68%, of members of the Esthetic Academy in Christensen's survey are choosing metal-free restoration over 32% of the members preferring gold.

I attended the annual American Dental Association convention in San Francisco, California from September 27-30, 2007. I recall Gordon Christensen stating that according to the Academy of Cosmetic Dentistry, gold is still the preferred posterior restoration.

### Market Fluctuation

Palladium prices rose abruptly in the 2000-2001 time period as Russia either declined to sell palladium or

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did not have palladium stocks to sell. Thus, as the palladium supply was interrupted, dental gold demand rose as substitution took place. The London palladium price peaked at \$1,090 an ounce January 26, 2001. Gold averaged \$271 an ounce in 2001.

During the second gold bull market, occurring in 2005–2011, dental gold demand decreased again inversely to the price of gold. London gold peaked at \$1,895 an ounce on September 5, 2011. Once again, as gold prices rose, substitution and alternatives to gold and palladium for dental prosthetic restorations took place.

The 2011 cumulative average price of palladium was rather high, \$733 per ounce, versus the \$200 palladium price of the 1980 era. Thus, there was an added incentive for metal-free restorations as gold and palladium prices were exceedingly high in 2011.

## The Impact of Advancing Technology

The intra-oral scanner, computer-aided design, and computer-aided manufacturing (CAD/CAM) milling devices began to appear in dental clinics. Chairside CAD/CAM dentistry afforded the practitioner the ability to produce tooth-colored prosthetic restorations on site.

## The outsourcing emphasis tends to be on metal-free esthetic dentistry.

Saint Paul dentist Mark Malterud, Region 10 Academy of General Dentistry (AGD) Trustee and Past President of the Minnesota Academy of General Dentistry, believes that the digital revolution that started in the 1980s found good growth and momentum around 2010 and has matured enough so that now in 2016, with state-of-the-art software design, tolerances, equipment, and materials, we are poised for the Digital Age to really blossom as competition starts to drive the prices down.

Digital scanning and milling have also come to the laboratory. For example, the 2006 introduction of the Lava Milling device by 3M (Maplewood, Minnesota) brought us an effective, albeit expensive, CAD/CAM device producing metal-free restorations. 3M's Lava helped launch the dental laboratory industry into the Digital Era for large labs around the country. Thus, the exponential rise of metal-free restorations for not only anterior but posterior teeth as well is creating substitution and thereby decreasing the use of precious metals in dentistry.

Selective laser milling (SLM), 3D wax printing, and digital milling of full gold crowns and precious PFM copings by companies have

come of age. The SLM has primarily have been geared to the laboratory industry. Maturation of the digital era is continuing and lowering prices for the digital restorative devices in the lab industry as well.

## Impact at the Laboratory Level

Metal-free restorations are increasing and trending in the dental lab industry, further limiting precious metal usage. In 2005, LMT magazine (Business Strategies For Dental Laboratory Decision-Makers) did a survey showing that 83% of laboratories indicated their restorations were metal-based, which correlates to 17% of restorations being metal-free. Ten years later, in 2015, the LMT survey of labs indicated 40% metal-based restorations, thus leaving 60% metal-free. Gary Iocco, former president of both the National Dental Laboratory Association and the Midwest Dental Laboratory Association and board member of the Identalloy Council, indicates his lab is 75% metal-free.

Gary Iocco and Chuck Yenker also indicate that metal-free zirconia restorations tend to be replacing PFM restorations in general.

George Noesen, D.D.S., from Red Wing, Minnesota, also agrees that zirconia is tending to replace PFMs now and in the near future. He states, "The only problem with zirconia is that making an access opening for root canal therapy or to remove a crown made of zirconia is rather hard

## Precious Metals in Dentistry Timeline

Circa 7th Century BC – Ancient Egyptians and Etruscans fashion early dental devices from gold

1907 – WH Taggart Develops method for casting Dental Alloys containing 75-95% Gold using Lost Wax Process

1971 – Tucillo and Nielsen prove 42% Gold/9% Palladium alloys resist tarnish as well as previous 75%+ Gold Alloys

Renaissance – Gold Foil used to fill cavities

1950's and 60's – Gold/Palladium alloys and Porcelain Fused Metal (PFM) Restorations Developed

August 15, 1971 – US Dollar comes off Gold Standard

on diamond burs. It would be very difficult to remove four to five zirconia crowns on one patient if I found recurrent decay under the crown margins. You would surely go through a supply of diamond burs that are not cheap.”

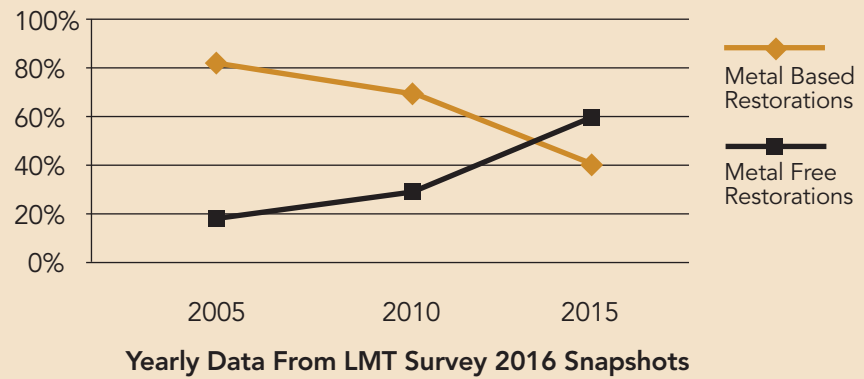
### Follow the Flow

As these options developed and matured in use, due to better dental digital devices to make teeth beginning about 2010, laboratory and dental clinician outsourcing of digital dental fabrication to China, Mexico, and elsewhere has occurred. Outsourcing was done to reduce costs associated with lab work on the dental restoration. As well, the outsourcing emphasis tends to be on metal-free esthetic dentistry, further reducing precious metal use in dentistry. In 2012, the National Association of Dental Laboratories estimated that 38% of dental restorations were being made offshore. Thus, outsourced precious metal work has shifted precious metal dental demand from the U.S. to elsewhere in the world.

### Impact on Dental Education

In order to focus on other areas, including the Digital Era, some dental schools no longer teach “the hands-on component” of the lost wax method for precious metal casting at the pre-doctoral level. Dr. Michael Madden of the University of Minnesota School of Dentistry indicated that the U stopped teaching the hands-

### Metal Based vs. Metal Free Restoration Production by Dental Labs



on portion of the cast metal lost wax method in about 2006. However, the theoretical component is taught, and a few students may actually venture to have a hands-on experience during dental school with the help of a faculty member or lab technician.

### Silver in the Mix

This article does not include platinum dental demand, as platinum demand is a small fraction of palladium demand, and in reality, platinum demand figures are not readily accessible from data available.

In a separate topic, dentistry today is also using less dental amalgam, and hence less silver, in general due to reliable composites. However, dental amalgam is still routinely used where patients seldom visit dental offices, at free or reduced-cost dental clinics, or events such as the MN Mission of Mercy. Silver demand in dentistry has been declining over the last decade as well.

### Precious Metals by Preference

On a positive note, precious metals are still the material of choice for 60%

of the dental professionals, as cited in a 2014 survey from the Esthetic Academy, when queried about full cast gold or PFM molars by Dr. Gordon J. Christensen.<sup>11</sup> On average, full cast gold restorations are proven, durable, corrosion resistant, biocompatible, and last longer than metal-free alternatives.

There is strong anecdotal evidence that full-cast gold crowns have an edge in longevity. On the January-February 2014 *Northwest Dentistry* cover, 106-year-old Agnes Richter is shown with her 60-year-old gold crown with Drs. Walter Warpeha, Sr. and Jr., father and son dentists, in the background. Neither a PFM nor a metal-free dental restoration can make the same claim about longevity.

Also per Dr. Gordon Christensen, about one third of the same dental Esthetic Academy professionals prefer a precious metal PFM for an anterior three-unit fixed prosthesis to metal-free restorations. Approximately 19% would prefer a precious metal PFM for a premolar, and 9% would prefer a PFM on a single anterior crown.<sup>12</sup>

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1978 – Global Dental Gold Usage Peaks at 2.8 Million troy ounces.

1980's – First Precious metal free PFM Alloys Developed

2005 – 3M introduces the Lava Milling Device utilizing CAD/CAM to produce metal free restorations

January 21, 1980 – Gold bull market peaks at \$850/troy ounce (\$2482 in 2016 dollars)

2005 – A second gold bull market begins

September 5, 2011 – Second gold bull market peaks at \$1895/troy ounce

## Summary

Gold prices are likely to remain high, and thus gold demand may continue to decrease. The gold price today of \$1,200 an ounce is about two-thirds of the 2011 peak of \$1,895 an ounce. Historically, the palladium price today is relatively high, at \$500 an ounce.

In general, improved oral hygiene from dental education, fluoridation, electric toothbrushes and the like have reduced cavities and the need for fillings and restorations.

The price of entering the digital realm to meet the respective needs of both the laboratory and the dental clinician can be quite high, often several tens of thousands to considerably more than a hundred thousand dollars for different systems, which is an impediment to wholesale acceptance of scanning and milling. But the dental community is embracing the Digital Era as prices drop and tolerances and materials for the restorations improve and become proven.

In closing, make no mistake about the increases and consequences of the Digital Era. The use of precious metals in dentistry is declining for the near future due to the digital revolution and high metal prices. In this sense, the Golden Age of Dentistry is over, as gold demand is unlikely ever to

recover. However, for the discriminating clinician or patient, full cast-gold crowns and palladium-based PFM restorations will be preferred by some in the dental community due to their superior performance, longevity, and reliability of those restorations for years to come. ■

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In 2012,  
the National  
Association  
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38% of dental  
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were being  
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