الجامعة السورية الخاصة SPU

كلية طب الأسنان –قسم التعويضات

مقرر مواد سنية 1

Dental Material-1

المحاضرة الخامسة

Dental metal alloys

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الفصل الأول

General classification of all Dental materials(According to composition)

All dental materials fall under 4 main groups:

Polymers.

Metals.

Ceramics.

Composites.

Introduction

Metals and alloys have many uses in dentistry. **Steel alloys are commonly used for the construction of instruments and of wires for orthodontics**. **Gold alloys and alloys containing chromium are used for making crowns**, **inlays and denture bases whilst dental amalgam, an alloy containing mercury, is the most widely used dental filling material.**

With the exception of mercury, metals are generally **hard** and **lustrous** at **ambient temperatures**, and have **crystalline structures in which the atoms are closely packed together**. Metals are **opaque, ductile** and are **good conductors of both heat and electricity.**

METAL

Definition

An element or alloy whose atoms readily lose electrons to form positively charged ions.

عنصر أو سبيكة تفقد ذراتها بسهولة الإلكترونات لتكوين أيونات موجبة الشحنة.

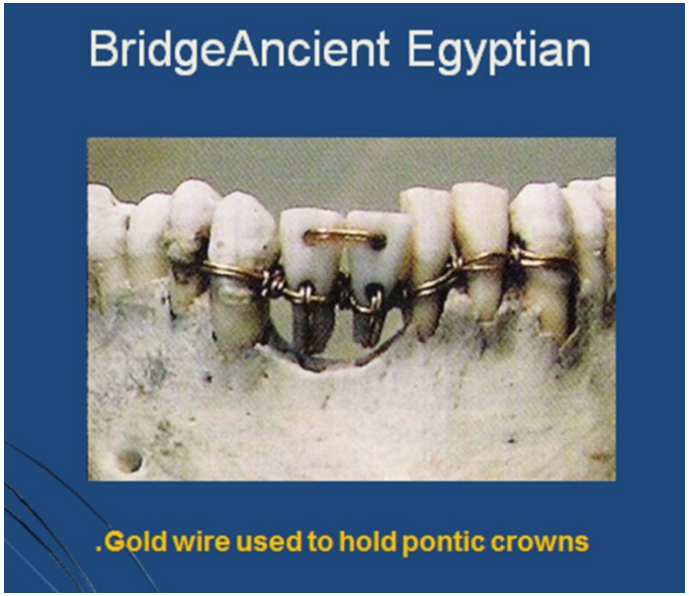
Alloy—A crystalline solid with metallic properties that is composed of two or more chemical elements at least one of which is a metal and all of which are mutually soluble in the molten state.

Alloy system—All possible alloyed combinations of two or more elements at least one of which is a metal. For example, the binary gold-silver system includes all possible alloys of gold and silver, varying from 100% gold and 0% silver to 100% silver and 0% gold

- السبائك - مادة صلبة بلورية لها خواص فلزية مكونة من عنصرين كيميائيين أو أكثر ، أحدهما على الأقل من المعدن وكلها قابلة للذوبان في الحالة المنصهرة.
- نظام السبائك — جميع المجموعات المخلوطة المحتملة المكونة من عنصرين أو أكثر أحدهما على الأقل من المعدن. على سبيل المثال ، يشتمل نظام الذهب والفضة الثنائي على جميع السبائك الممكنة للذهب والفضة ، والتي تتراوح من 100 ٪ من الذهب و 0 ٪ من الفضة إلى 100 ٪ من الفضة و 0 ٪ من الذهب

Metals

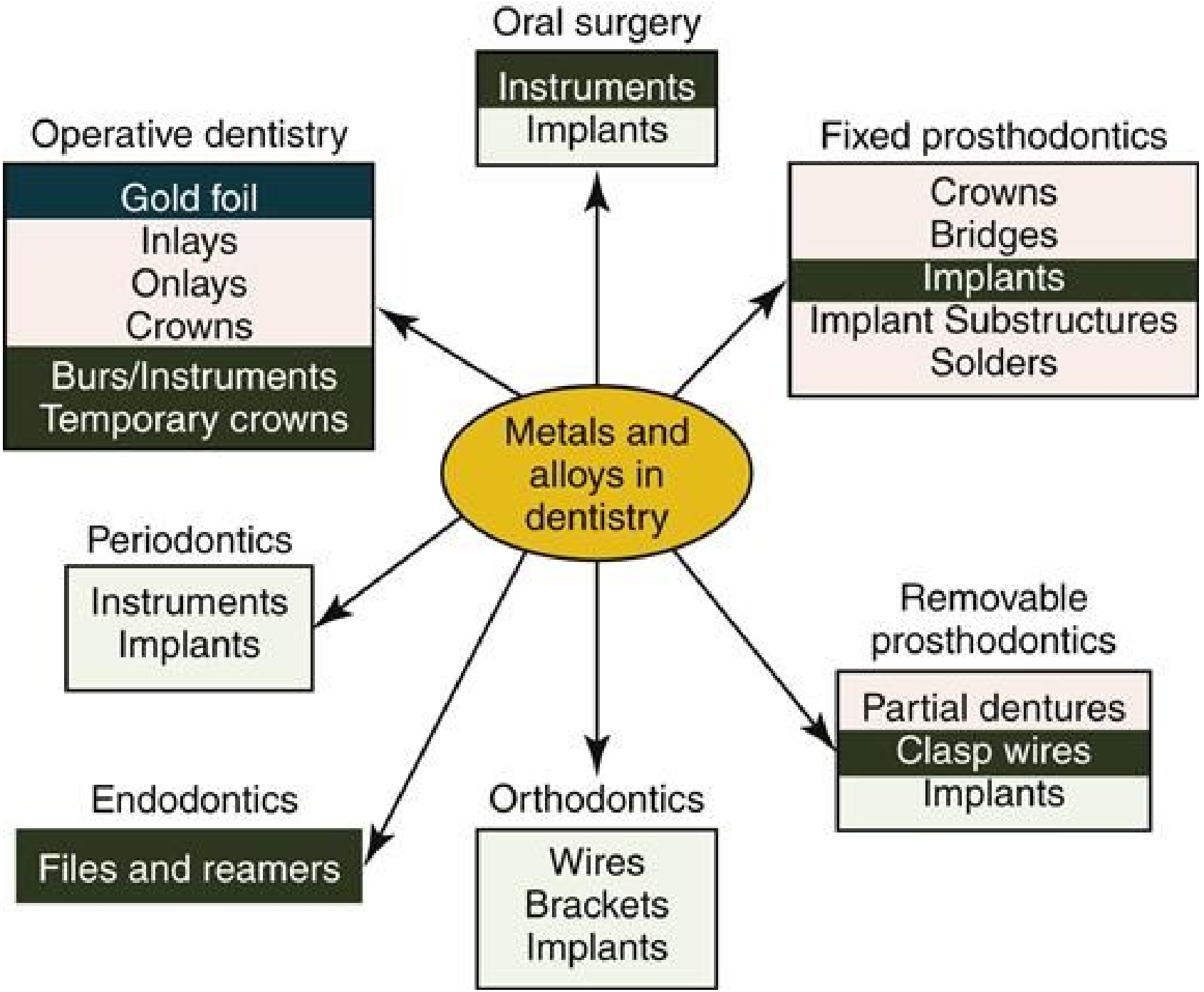
Ancient civilizations knew gold mineral, its importance and vital acceptance, and it was used by the Egyptians, Romans, Greeks and Arabs to link the sagging teeth in the form of strings, that is, as splints, and to link artificial teeth that replace the missing teeth with adjacent teeth.



In modern times, Fauchard mentioned a way to firing porcelain on gold as gold was used in the manufacture of wedges as the forefront of Richmond crowns. **Gold** has been used in the manufacture of crowns and bridges for a long period of time as it was used as an substructure in metal-porcelain prosthetic since the forties of the last century where it was used in the form of alloys of metals Precious.

Metals

Metal and metal alloys are still widely used in dentistry


Oral surgery
Instruments
Implants
Operative dentistry
Gold foil
Inlays
Onlays
Crowns
Burs/Instruments
Temporary crowns
Fixed prosthodontics
Crowns
Bridges
Implants
Implant Substructures
Solders
Metals and alloys in dentistry
Periodontics
Instruments
Implants
Removable prosthodontics
Partial dentures
Clasp wires
Implants
Endodontics
Files and reamers
Orthodontics
Wires
Brackets
Implants

These dental instruments require alloys that have good corrosion resistance, machinability, and edge retention.

Summary of the common uses of metals and alloys in dentistry.

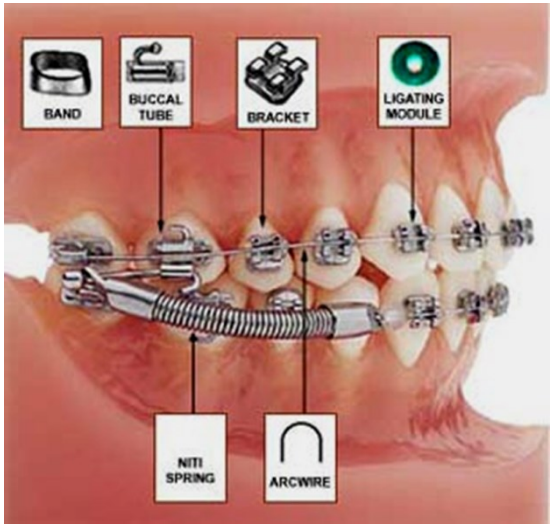
Pure metals have limited use in dental restorations but commonly are combined with other metals or nonmetals to form **alloys.**

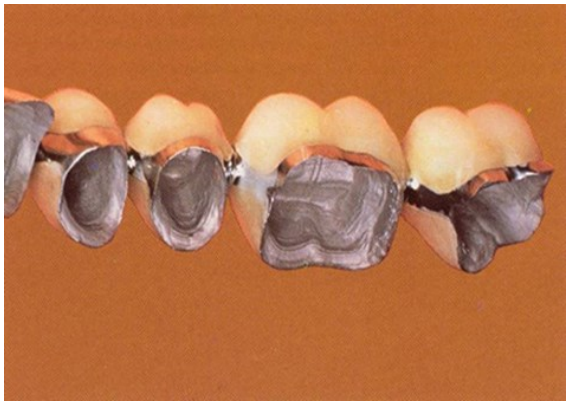
Alloys have diverse uses in nearly all dimensions of dentistry, including solders, wires, instruments, crowns, bridges, implants, and removable partial dentures. The alloy end product may be formed by mechanical force (wrought alloys) or by casting.

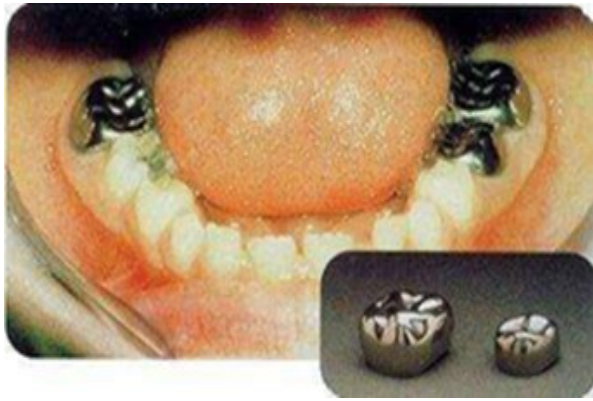
Alloys

Definition

A mixture of two or more metals or metalloids that are mutually soluble in the molten state; distinguished as binary, ternary, quaternary, etc., depending on the number of metals within the mixture. Alloying elements are added to alter the hardness, strength, and toughness of a metallic element, thus obtaining properties not found in a pure metal.


BAND
BUCCAL TUBE
BRACKET
LIGATING MODULE
NITI SPRING
ARCWIRE

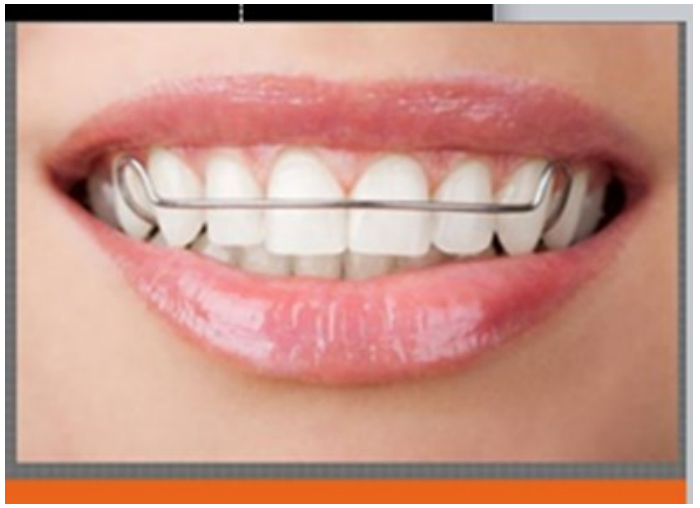




Wire is a wrought metal that may be soft and easily shaped or may resist bending.

Various degrees of resistance to bending can be created by annealing.

Orthodontic wires are used most commonly in dentistry.



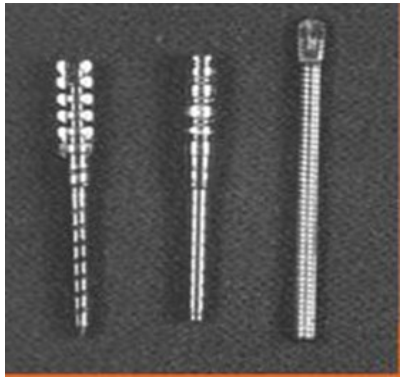
Posts are metal or nonmetal dowels or rods placed within the root canal space after a root canal treatment.

The purpose of a post is to retain the core buildup over which the final restoration (crown) is placed.

Posts can be classified as active or passive.

Active posts engage the root canal surface with threads; passive posts are simply cemented into the canal space without actively engaging the canal walls.

Posts can be custom made or preformed




WHY IS ALLOYING DONE??
To increase hardness and strength.
To increase fluidity of liquid metal
To make casting or working on the metal easy.
To increase resistance to tarnish and corrosion.
To lower or increase the melting point
To change the microscopic structure of the metal.
To change the color of the metal.
To provide special electrical and magnetic properties.

- **Alloys are formed when metallic atoms are dissolved within the atoms and crystals of another metal.**

- Alloys have advantages over pure metals alone:
  - Stronger
  - Harder
  - Easier to fabricate
  - Less expensive

Pure metals have properties that can be markedly different when alloyed with other metals or nonmetals. For example, the element **iron** alloyed with relatively small amounts of **carbon** produces much stronger and harder metals called **steels**, which can be used for high-stress applications.

When **chromium** is alloyed with **iron** and **carbon**, the corrosion resistance of this alloy, called **stainless-steel**, is greatly enhanced because of the formation of an adherent oxide of chromium (Cr2-O3). Certain carbon steels are electroplated with chromium to produce corrosion-resistant instruments.

Desirable Properties of Dental Alloys

All casting alloys must first be biocompatible and then exhibit sufficient physical and mechanical properties to ensure adequate function and structural durability over long periods of time. Depending on the primary purpose of the prosthesis, such as to restore function, enhance aesthetics, or maintain occlusion, the choice of casting alloy or metal is made

Some of the clinically important properties and requirements of the alloys are

Biocompatibility

Biocompatibility is defined as the ability of a material to elicit an appropriate biological response in a given application in the body

Biocompatibility: The alloy should not react with the oral fluids and release any harmful products in oral environment

Resistance to tarnish

Tarnish—Superficial discoloration or dulling of a metal surface that is often caused by a reaction with oxygen or sulfur

Tarnish is a thin film of a surface deposit or an interaction layer that is adherent to the metal surface. Tarnish is usually on silver alloys and on gold alloys with higher silver content.

_Resistance to corrosion

Corrosion may lead to catastrophic failure; oxidized components may discolor natural teeth, porcelain veneers and soft tissues.

Corrosion also contribute to galvanic shock due to the electrons released during corrosion. Released metallic components may cause metallic taste in the mouth. The presence of noble metals in alloy increases resistance to corrosion.

Strength Requirements

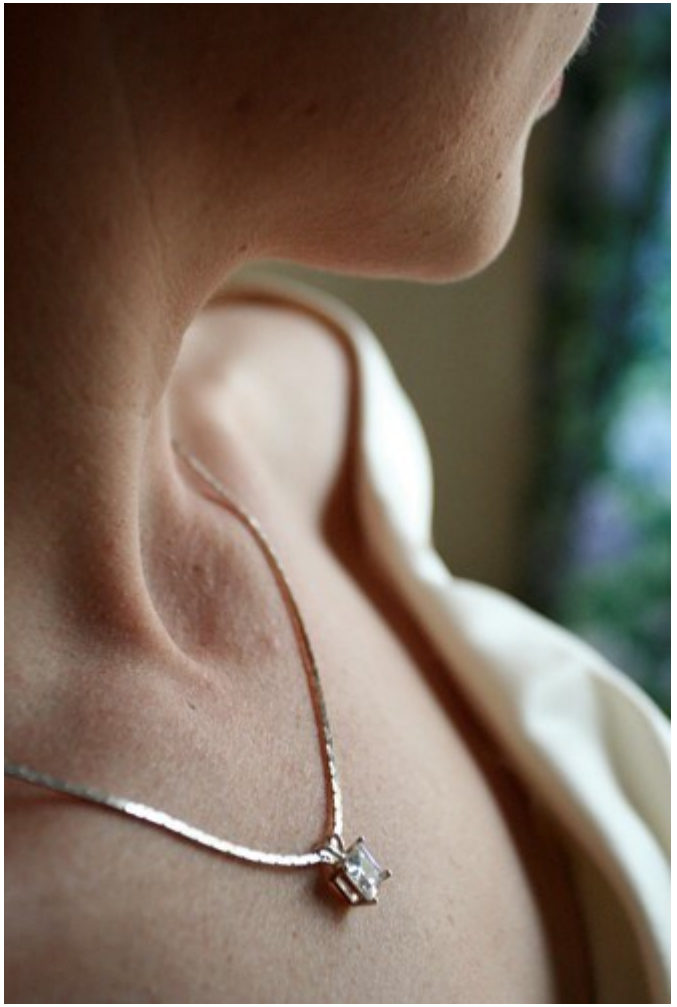
The alloy must have **sufficient strength** for the intended application.

Alloys for bridgework require higher strength than alloys for single crowns. **Alloys** for metal-ceramic prostheses are finished in thin sections and require sufficient stiffness to prevent excessive elastic deflection from functional forces, especially when they are used for long-span frameworks

Non allergenic

Although toxic materials are eliminated from the alloys. However, some individuals exhibits allergic reactions to some components. Since these allergic reactions are peculiar to the individual patient, the dentist should have a record of all the components of the alloy that is being used and should inform the patient accordingly.


Photo courtesy of Jere Mammino, DO



Inflammatory response adjacent to a crown (lower right) made from a metal coping. No definitive diagnosis can be made of a potential allergy to one of the component metals without testing the individual to a battery of dental patch test substances. Thorough dental and medical histories are also required for the evaluation of this condi- tion. (Courtesy of Dr. Hyun-Ju Chung.)

Photo of a patient's arm after she tested herself with metal discs made of a nickel–chromium (Ni-Cr) alloy. Note that the patient has noted the period during which the discs were taped to her arm prior to examination of the sites in a dental clinic. This type of test is not standardized, and the test results should not be used to confirm or reject the diagnosis of a suspected allergy to nickel or any of the other alloy components.

Large blue-colored areas, typically referred to as an amalgam tattoo, which is a benign area of discolored membrane in the mouth. These examples are not associated with allergic reactions to mercury or any other metallic elements in the amalgam fillings. The discoloration is caused by small amalgam granules that have fallen into open wounds created during the condensation and carving of amalgam fillings in prepared teeth **(A and B)** or retrograde fillings in root apices **(C)**. (Upper two photos courtesy of Dr. Hyun-Ju Chung.)

Aesthetics

The alloys must be in optimal balance among the properties of aesthetics, fit, abrasive potential and clinical survivability.

Thermal Properties

For metal-ceramic restorations, the alloys or metals must have closely matching thermal expansion to be compatible with a given porcelain, and they must tolerate high processing temperatures. The melting range of alloys must be low enough to form smooth surfaces with the mold walls of the investment.

Hardness

The hardness of an alloy should be sufficient enough to resist wear by the opposing tooth or restoration. At the same time, it should not be high enough to cause wear of the opposing enamel (VHN of enamel is 340 kg/mm^2). Hardness of an alloy should not be less than 125 kg/mm^2 or greater than 340 kg/mm^2

Ease of fabrication

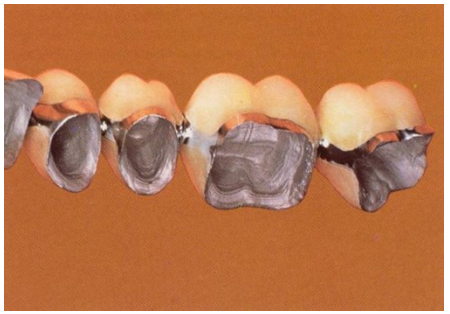
The material should be easily manipulated and the procedure for fabrication should not be too complicated and lengthy

Cast ability

To achieve accurate details in a cast framework or prosthesis, the molten metal must able to wet the investment mold material very well and flow into the most intricate regions of the mold without any appreciable interaction with the investment and without forming porosity within the surface or sub surface region.

Porcelain Bonding

The alloy used in metal- ceramic restorations should be able to form a thin, adherent layer of oxide on its surface to enable proper bonding with ceramic. The alloy must have a coefficient of thermal expansion/contraction closely matching to that of ceramic so as to create compressive stresses to enhance fracture resistance of the ceramic.



Finishing of cast metal

Some metals are harder, hence more difficult to finish and polish. Some noble metal alloys are more ductile and malleable, hence care should be taken during finishing of the casting. The hardness of an alloy is a good indicator of the difficulty in grinding and finishing of the alloy

Economic Considerations

For the dental laboratory owner who must guarantee the cost of prosthetic work for a certain period of time, the cost of fabricating prostheses must be adjusted periodically to reflect the fluctuating prices of casting metals, mostly those of high noble and noble metal alloys

Classification of dental alloys

1-Precious alloys(Nobel metal alloys)

2-Semi-precious alloys

3- Non precious alloys (Basic alloys)

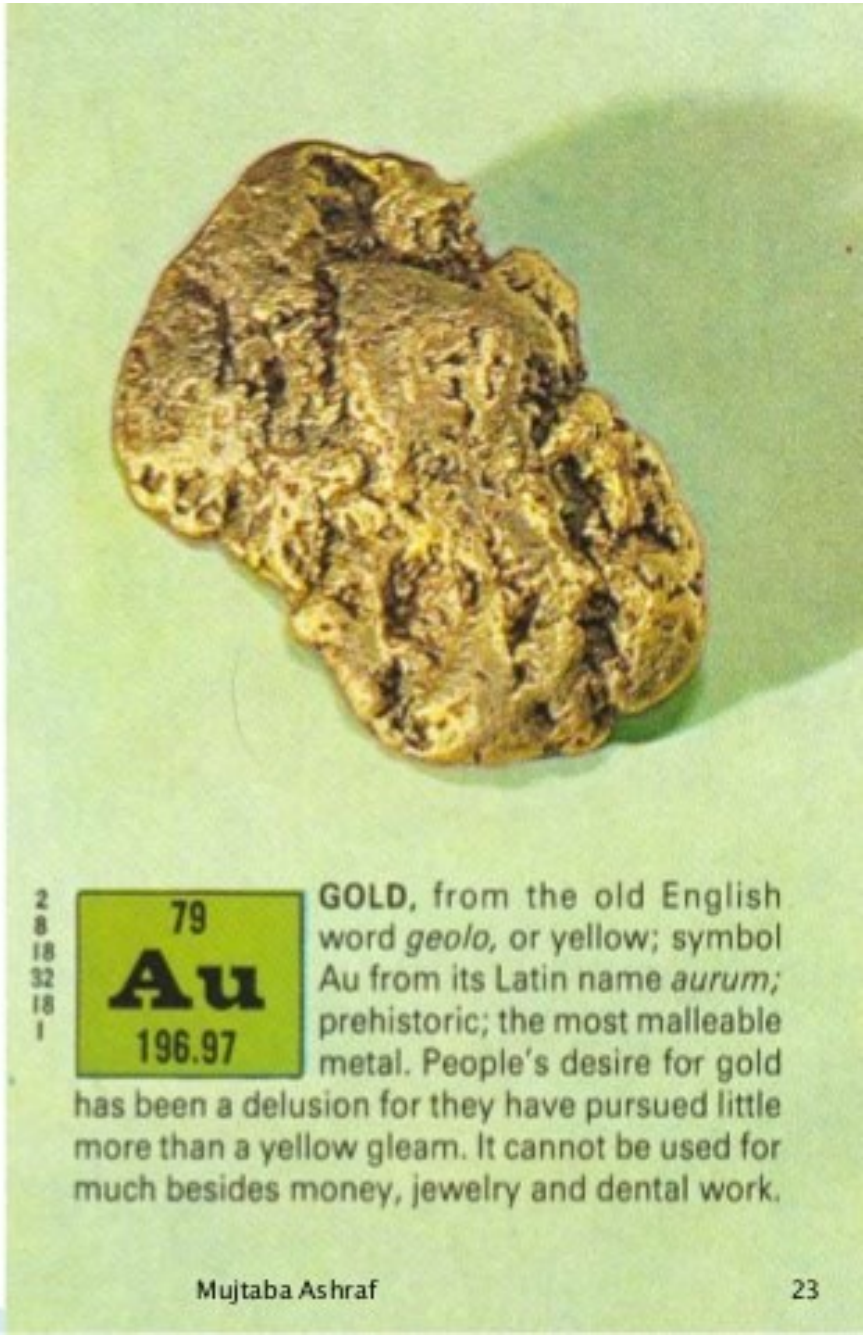
Precious alloys(Nobel metal alloys)

1- Gold - Platinum - Palladium Alloy:

It is the first alloy that was manufactured for use in metal- ceramic res**t**orations in 1958 under the name (Jelenko). Its composition is **78-87% gold** and **10-20% platinum and palladium** with a few additions of **tin**, **indium** and **iron**, it is an **antioxidant alloy**, **biocompatibility**, but it is **very expensive** and **weak Resistance to the Yield Strength**

GOLD

- Gold, a soft, yellow metal, is the most ductile and malleable of all metals but it has much lower strength.
- Density 19.3g/cm³
- Melting point 1063°C
- Resistance to corrosion
- High burnishability
- Low yield strength



PLATINUM

Platinum, a bluish-white metal is tough, ductile and malleable.

- Its hardness is similar to that of copper
- Density 21.37g/cm³
- Melting point 1755°C (highest)
- Elevates fusion temperature
- Elevates strength
- Whitens the alloy

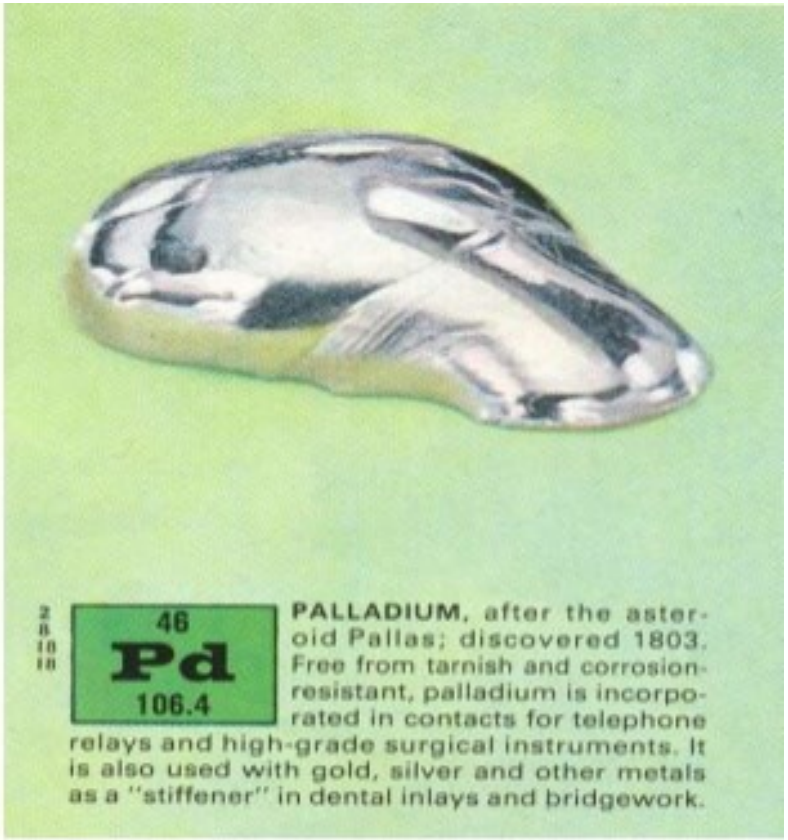
2
8
18
32
17
1

78
Pt
195.09

PLATINUM, from *platina*, or little silver; discovered in the 16th Century. Found in nuggets which weigh up to 21 pounds (9.5 kg), this metal is utilized not only in weights and measures, laboratory utensils and dental alloys, delicate instruments and electrical equipment, but also in jewelry.

PALLADIUM

- Palladium, a white metal
- It whitens the alloy, any gold alloy containing more than 6% palladium will be white.
- Density 11.4g/cm3
- Melting point 1555°C
- Enhance mechanical properties such as hardness and tensile strength



Disadvantage: At elevated temperature, it has a great affinity for hydrogen gas. Consequently high Pd content castings may causes internal porosity by absorbing large amount gas, if not cast under ideal conditions.

2- Gold- palladium - Silver Alloy:

It was put on the market in 1970, its composition **55% gold, 20-30%, palladium, 10-15% silver**, and a small percentage of tin - cadmium - indium.

It has the advantage of being resistant to oxidation and is Biocompatibility, and one of its disadvantages is that it causes coloration of porcelain because it contains silver.

3- Gold- Palladium alloy.

1975 Olympin 50% Gold / 40% Palladium Good oxidation resistance - its hardness is higher than previous ones.

Semi-precious alloys

1-Palladium- **Silver Alloy:**

First use in 1970 Will ceram **50-60% palladium / 30-40% silver + tin-cadmium-zinc elements**. The color of this alloy is white. Its **resistance to oxidation is high**. One of its **disadvantages is the color problem** because it contains silver.

2-Palladium-copper alloy:

It was produced in 1982 under the name of optiom **color white gray 75-80% palladium 5-10% copper 5-15% tin indium 5% gallium 2-10%**

3-Palladium-Cobalt Alloy:

It was introduced in 1985-88% Palladium 4-5% Cobalt and other elements

(Basic alloys) Nonprecious alloys

1-Nickel-Chrome alloy(Ni-Cr)

It is one of the most used in metal- ceramic

Its composition is **60-82% nickel** / **12-26% chrome** / **0-10% molybden** / **0-3% silicium** with **few additives** from aluminum, titanium and gallium.

This Alloy is characterized by **high physical and mechanical properties, melting point 1300 C under porcelain firing degree / high hardness** 200-400 WH allowed to be used to build long bridges - strong bond with porcelain **-inexpensive - an acceptable thermal conductivity**, but labors find it difficult to deal with it because it has a yield strength of 800 m / pa and **high hardness**

This Alloy has a complex microscopic structure that can be changed by exposing it to temperatures higher than its melting temperature during its casting process or when castig multiple times. This affects the physical and mechanical properties of the alloy. **Therefore, the alloy must be casted with the lowest degree possible and with the shortest time and not casting several times in order to avoid deformation in Casting process**

Ni-Cr

Gold-palladium

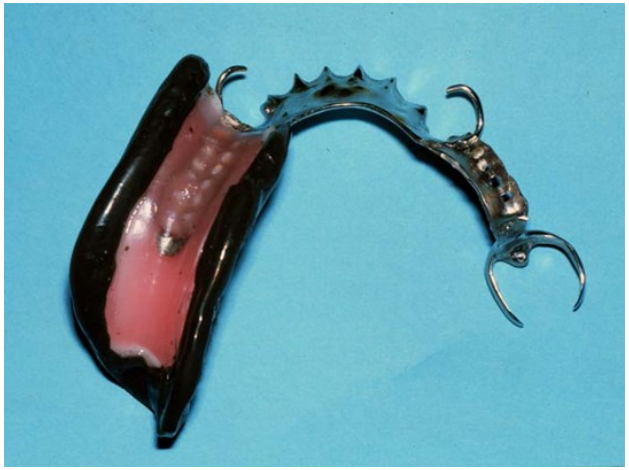
2-Nickel-chrome-beryllium Alloy:

Beryllium is added by 0.5-2% to reduce the melting point of the mixture and improve its liquidity, thereby increasing its susceptibility to casting.

3-Chrome-Cobalt alloy:

Its composition is 50-70% Cobalt 20-32% Chrome 6% Molybden in addition to titanium-silicium, tungsten.

The most frequently used in the manufacture of RPD, but can be used as a substitute for a nickel-chromium mixture in some cases of fixed Prosthodontics ceramic-metal, especially in patients who complain of cases of sensitivity to nickel



Titanium

Titanium is considered a promising material in the field of dentistry due to its biological and mechanical properties:

Excellent Biocompatibility.

Low thermal conductivity.

High ductility.

Radio opacity.

Non corrosive.

Light specific Weight

It is used in either its **pure commercial** form (C.P.Ti).

Or as a **titanium-aluminum-vanadium** Ti-6nl-4V **alloy**

Titanium- Implant

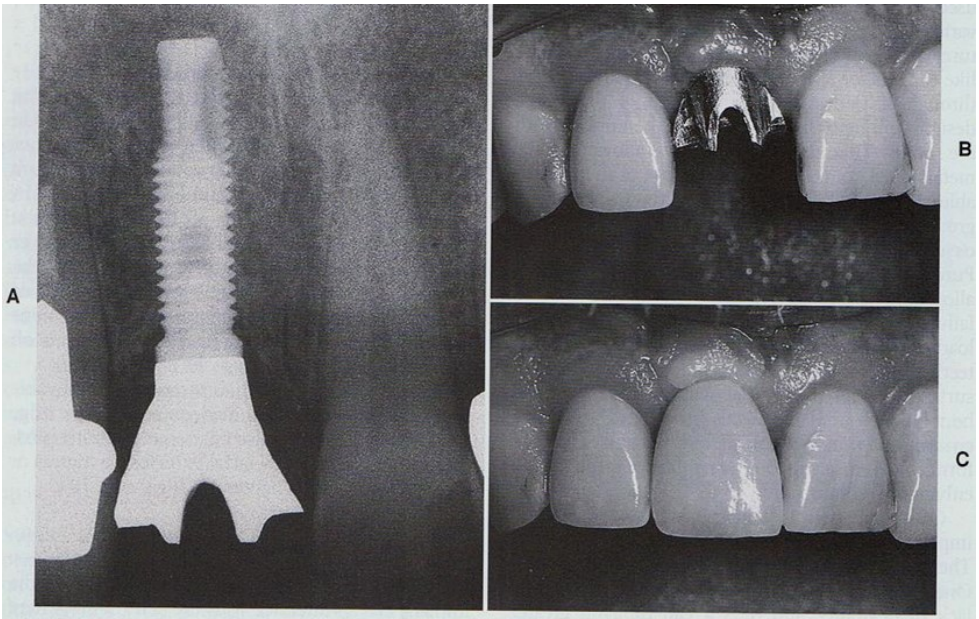


FIGURE 8-8 ■ Single-tooth implant. **A**, Radiograph of implant fixture in bone. **B**, Abutment member to which the crown is attached. **C**, Crown attached to implant.

The role of the mineral elements added to the Alloys

We have noticed that the basic composition of each Alloy depends on two or more elements, as these minerals constitute a large percentage. In addition to each Alloy , simple proportions of additional elements are added, which play a role in improving the properties and specifications of each Alloy.

Carbon C:

The addition of carbon to the **cobalt chromium alloys** contributes to the **hardness** of this Alloy.

Aluminum AL:

Adding aluminum to a **nickel-chromium** Alloys **increases the Yield Strength** values of this alloy as a result of forming a Ni, AL compound.

Mo Molybdenum: Nbium Nb:

Increase the strength of the Alloy and its **corrosiom resistance** by forming nickel complexes.

Mo **molybdenum** also contributes to increasing the **coefficients of thermal expansion C.T.E**.

Fe & SM:

The addition of these two elements to the precious Alloys contributes to the formation of an **oxidative layer on the restoration surface** as a **necessary layer** to secure the **metal - ceramic Chemical bond.**

Zinc- Zn :

Adding it to the Alloy contributes to **absorbing oxygen** from the surrounding air while casting the metal and **decreases the surface tension**, which prevents the formation of air bubbles and defects in the casting.

Mn & Si :

These two elements contribute to **increasing the liquidity of the Alloy** and thus improving its cast ability.

Beryllium – Be

Adding it **reduces the melting point** of the alloy and thus improving its **susceptibility to casting**, in addition to increasing the resistance of the ceramic-metal bonding. Several studies have reported a **carcinogenic role** for beryllium which made the use of mixtures containing it subject to strict conditions and instructions.

PROF.DR. ELIAN ABU SAMRA

THE END