CROWN AND BRIDGE

Lecture: 10 **Dr Farid**

Ceramics and metal-bonded ceramics

The word ceramic is derived from the Greek word keramikos, which literally means 'burnt stuff' but which has come to mean more specifically a material produced by burning or firing.

Composition of traditional dental porcelain:

The main ingredients are feldspar, silica, kaolin and pigments, only the purest ingredients are used in the manufacture of dental porcelain
The improved translucency of the modern dental ceramic materials was mainly achieved by the lowering of the kaolinites content or its complete removal from the composition.

1- Kaolin

Kaolin is a hydrated alumino-silicate. Only the purest clay or kaolin is used in porcelain. Kaolin gives porcelain its properties of opaqueness, when mixed with water, it becomes sticky and aids in forming a workable mass at the porcelain during molding.

2- *Silica*

Pure quartz crystals (SiO_2) are used in dental porcelain, silica remains unchanged at the temperature normally used in firing porcelain, and this contributes stability to the mass during heating by providing a framework for other ingredients.

3- Feldspar

Feldspar is the lowest fusing component and it is this which melts and flows during firing, uniting the other components in a solid mass.

Natural feldspars are mixtures of albite Na2AL3 Si_6O_{16} and orthoclase K2AL7Si6O16 with free crystalline quartz. These feldspars are never pure and the ratio of soda (Na_2O) to potash (K_2O) may vary quite considerably, for dental purposes, high potash content feldspar is generally selected because of its increased resistance to pyro-plastic flow.

Feldspar contains oxides of both potassium and sodium; these break down the Si-O network and thus are known as glass modifiers.

Two consequences result:

1. The softening temperature of the glass is reduced.
2. The coefficient of thermal expansion is increased and extensive breakdown of the Si-O network may occur, and devitrification results from crystallization of the glass. This occurs if porcelain is fired too often, and it is typically associated with loss of physical properties and appearance

4- Pigments

The coloring pigments added to the porcelain mixture are called “color frits”, they are prepared by grinding together metallic oxides with fine glass and feldspar, these frits are added in small quantities (less than 1%) to obtain the delicate shade necessary to imitate the natural teeth.

Types of porcelain

*According to the firing temperature porcelain is classified as:

A. High – fusing: 1290 to 1370C (2350 to 2500F).

B. Medium – fusing: 1090 to 1260C (2000 to 2300F).

C. Low – fusing: 870 to 1065C (1600 to 1950F).

D. Ultra – low fusing < 850C (1562F).

High–fusing porcelains are considered superior in strength, solubility, translucency, and maintenance of accuracy in form during repeated firing. Low firing temperatures are a definite assist in the fusion of porcelain to metal, since the differences in the coefficients of expansion of the porcelain and metal can be tolerated better at lower temperature ranges. The low–fusing and ultra–low–fusing porcelains are used for crown and bridge construction, some of the ultra–low–fusing porcelains are used for titanium and titanium alloys because of their low – expansion coefficients that closely match those of the metals and because the low firing temperature reduces the risk for growth of the metal oxide. One problem regarding low–fusing porcelains lies in their surface and color stability.

low–fusing porcelain was developed to offset the major disadvantages of traditional dental porcelains representing a major change in direction, one of the basic differences between this formulation and those that have been used for long periods of time is a significant reduction in the firing temperature being as 760C for a newer type (finease) versus around 940C for conventional type. It permits the clinician to generate a highly polished surface at chair side, thereby eliminating the need for reglazing after possible adjustments.

Another advantage regarding low–fusing porcelain reported was the less potential for abrading any materials against which it occludes.

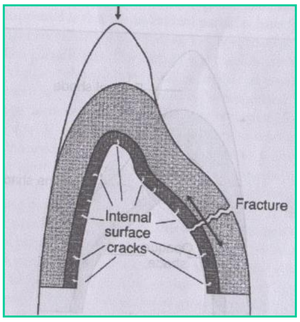
Properties of porcelain

- ✓ Dental porcelain provides excellent aesthetics that do not deteriorate with time. Unfortunately, its brittleness, low tensile and shear strengths render the porcelain restoration liable to fracture during mastication. Brittle dental ceramics are incapable of absorbing appreciable amounts of elastic strain energy before fracture.

- ✓ It is available in a range of shades and at various levels or translucency such that a most life-like appearance can be achieved.
- ✓ Although the compressive strength of dental porcelain is high, its tensile strength is very low, which is typical of a brittle solid. Porcelain (glasses) is extremely sensitive to the presence of surface microcracks. The superficial cracks which result due to thermal stresses are best avoided by slow cooling from the firing temperature.

Fracture can be initiated from the followings: -

- ❖ Small surface scratches in the outer surface caused by grinding and these should be eliminated by smoothing or by further fusing.



- ❖ Cracks in porcelain crowns invariably initiate from the inner, unglazed fitting surface and propagate outwards towards the exposed surface material.
- ❖ The brittleness of dental ceramics is compounded by their tendency to undergo ' static fatigue'. This is time-dependent decrease in strength, even in the absence of any applied load. The process is thought to occur through alkaline hydrolysis of Si-O groups within the porcelain structure. Alkalinity within the material results from a solubilization of Na20 and K20 which forms part of the feldspathic component of porcelain. Dynamic mechanical loading further accelerates the weakening and the whole process has been likened to stress corrosion cracking, which can occur with metals and alloys. Attempts to overcome some of these problems involved reducing the proportions of Na20 and K20 within the materials.

- ✓ Porcelain is compatible with soft tissue and it possesses high wear resistance
- ✓ Porcelains are poor conductors and therefore are excellent insulators for the abutment teeth against thermal and electrical shock. This fact is of

importance when gross amounts of enamel and dentine are to be replaced and the residual layer of dentine may be of minimal thickness.

- ✓ Correctly formulated porcelain is very resistant to chemical attack, being unaffected by the wide variations of pH which may be encountered in the mouth.
- ✓ The relatively poor mechanical properties of porcelain can be improved using alumina, or metal supporting structures: -

A. Alumina inserts and aluminous porcelain:

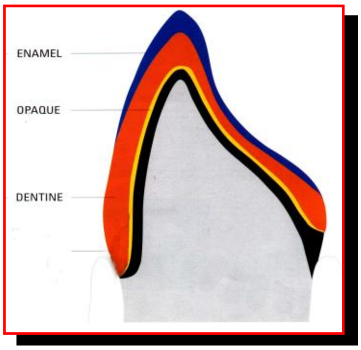
The major disadvantage of porcelain is brittleness and this is the factor, which most limits its use. Several methods are available which are aimed at preventing the formation or propagation of cracks on the inner surface of porcelain restorations.

- One approach is to use a core of pure alumina on which the porcelain crown is constructed. Alumina particles is a very hard (stronger than the glass), opaque material which is less susceptible to crack propagation (crack stoppers) than porcelain.
- Powdered alumina may be added to porcelain in order to achieve a significant strengthening. The mechanism of strengthening is that the alumina particles act as 'crack stoppers' preventing the propagation of a crack throughout the body of the porcelain.

B. Metal bonded porcelain

It involves a marrying of the good mechanical properties of casting dental alloys with the excellent aesthetic properties of porcelain.

Types of porcelain:



1- **Opaque porcelain**: It is applied as a first ceramic layer and performs two major functions: it masks the color of the alloy, and it is responsible for the metal ceramic bond.

2- **Body porcelain**: this is fired onto the opaque layer, usually in conjunction with the incisal porcelain. It provides some translucency and contains oxides that aid in shade matching. Body porcelains are available in a wide selection of shades, to match adjacent natural teeth.

3- **Incisal porcelain**: this is rather translucent; as a result, the perceived color of the restoration is significantly influenced by the color of the underlying body porcelain.

The Alloy-Porcelain Bond Mechanism

A proper bond between the porcelain and the alloy is one that is stronger than the porcelain itself; therefore, the porcelain rather than the bond will fail cohesively.

An understanding of the bonding mechanisms is essential for successful metal–ceramic restoration.

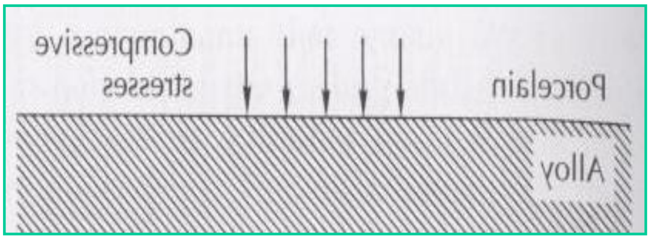
Mechanisms have been described to explain the bond between the ceramic veneer and the metal substructure: -

A. Mechanical entrapment

By interlocking the ceramic with microabrasions in the surface of metal coping, takes place by penetration of the porcelain within the roughness of the casting surface which is produced by finishing the metal with non contaminating stone or disc and air abrasion.

B. Compressive forces (Physical Bonding)

This bond is developed by a properly designed and a slightly higher coefficient of thermal expansion for the metal coping than for porcelain veneered over it. This will cause porcelain to “draw” toward the metal coping when the restoration cools after firing, so the porcelain will be firmly bounded to the metal .



C. Chemical bonding

Metal and porcelain react chemically in an oxidizing atmosphere at approximately 1000°C to bond together. It is indicated by the formation of an oxide layer on the metal.

It is the ability of the fused porcelain to absorb ions from the metal that produces a chemical bond between a metal and porcelain (migration of indium or tin to the alloy surface to form an oxide that combines with the porcelain during its firing). The alloy must contain at least one component that will be soluble in the fused porcelain without losing its contact with the basic chemical structure of the metal.

Requirements of the alloys:

1- The alloy, having been previously cast into the desired shape, should be capable of withstanding porcelain firing without melting or suffering creep. Hence the alloy must have a high fusion temperature.

2- The alloy should be sufficiently rigid to support a very brittle porcelain veneer otherwise a fracture of the veneer is inevitable.

3- The alloy should be capable of forming a bond with the porcelain veneer in order that the latter does not become detached.

4- The alloy should have a value of coefficient of thermal expansion similar to that for the porcelain to which it is bonded.

Reference: Contemporary Fixed Prosthodontics