Introduction

For a long time we have been trying to provide our patients with the most strong, durable, good looking prosthesis that substitute the missing tooth part or an entirely missing tooth.

Though most dental materials that we use comes in short of quality to what God have already given us.

For decades ago all the concern was directed to fulfill the mechanical needs inside the oral cavity. Being an extreme environment where artificial material can serve its duty was our prime concern.

But the clock has turned its arrows and now esthetic need became much more pronounced than before. For statistics have shown a great increase in the patient's interest for an esthetical material that also would serve in the tough oral environment.

Not only had women but also men have become fans for a "good looking" restoration as they say.

And so dentists have using ever since the metal ceramic restorations having gold alloy as a metal substructure and veneering porcelain on top. It gave a very natural appearing look since gold is yellow mimicking the colour of dentine and feldspathic porcelain being translucent mimicking the quality of enamel.

With the price of gold shooting up the stars, other metal were suggested give properties equal results. Palladium based alloys (Pd Pt Ag, Pd Pt, Pd Cu) and finally base metal alloys.

In addition to the above mentioned metal alloys, a new trend came to light. All ceramic restoration was a dream every body wanted to happen because of its high compatibility and superior esthetics. The first attempts were not that successful due to inferior marginal fit in comparison to base metal and gold alloys and low mechanical strength.

Till this day manufactures and researchers are coming up with new materials and techniques to strengthen the all ceramic restoration, and progress is very rewarding but the porcelain fused to metal system seems to be proven better at all cases.

Base metal alloys became very popular these last decades because they gave very high mechanical values in very thin sections. They also showed quite a remarkable bond with the porcelain due to their high content of oxides that readily reacts with porcelain.

Titanium is also a type of base metal alloys but with a very distinctive feature. It quickly forms a passive oxide layer once exposed to air at room temperature due to its high affinity to reaction with gases. This passive oxide layer allows to react as an inert noble material giving it extreme biocompatibility.

So Titanium as a material has been used to screw up prosthesis to the human body getting use of its biocompatibility and ever lasting durability (no corrosion). It is but common sense to start and negotiate its use in the dental field.

Review of Literature

Historical review

Esthetics been defined in the 1936 by Plinkington[2] as" the science of copying or harmonizing our work with that of nature, making our art inconspicuous".

A growing trend towards youthful appearance has been noticed among patients and so dental treatment with recent materials could offer that changing one's smile and boosting up their self image and self esteem[1].

But not only is beauty and esthetics are those of prime importance but function and biocompatibility of the dental treatment is as important as esthetics as described by ***Gruel*** [2]. He stated that the true understanding of the esthetic and cosmetic dentistry is achieving the philosophical triad "health, function & beauty".

The full veneer metal crowns made up entirely of gold were used for a long time. Gaining the advantage that gold is an inert noble material that gives it high biocompatibility in the oral cavity. Since the 1970's gold have been used as a metal substructure under the porcelain giving into consideration that natural looking restoration were becoming of much more demand so Metal-ceramic crowns became the standard in dentistry and offered long-term structural performance. The method combines the esthetic qualities of porcelain with the strength, accuracy, and marginal adaptation of the metal.[5]

Hobo and Shillingburg [1] 1984 described the specific preparation techniques and the coping design. Much attention also has been paid to the strength of the bonding between gold and porcelain.

Several studies were made to investigate the efficiency of the porcelain-to-gold bonding. [1, 3- 6.]

But due to the financial and economical changes that had occurred since 1930's a shift to a much less expensive and more abundant material has to be made. In the early 1980's Ni – Cr was popular as a low cost alloy (2$ - 3$ per ounce) in comparison to gold (500$ per ounce). For gold was not easily agreed upon by patients with limited resources. And alloys with low gold content were used and a bit by bit the gold alloys were replaced by non noble and base metal alloys[10].

Base metal alloys

The discovery of base metal alloys was considered as a breakthrough. Due to its low cost, its high modulus of elasticity, its relative high mechanical properties, comparable clinical corrosion resistance, high hardness, its high melting temperature which made it easier to fire porcelain on top of it and in addition to the previous properties, it could be casted in very thin sections in compared to gold[10].

With modulus of elasticity of 220 GPa and 205 GPa and yield strength of 540 MPa and 330 MPa and Vickers hardness of 280 HV10 180 HV10 for CoCr and NiCr alloys respectively it is clear that base metal alloys has higher mechanical properties than even a type IV gold alloy which holds the specifications of 110 GPa, 480 MPa, and 210 HV10 for modulus of elasticity, yield strength, and Vickers hardness respectively [10].

But on the other side these alloys have to operate in the oral cavity, which serves as a tough corrosive environment for any metal to function in. The oral cavity posses moisture, organic acids, oxygen, temperature fluctuations, chloride ions and proteins [10].

And these elements lie way below gold in the electrochemical series and supposable they will react more with these elements in the oral cavity leading to their corrosion and gradual dissolution in the oral cavity. But chromium possess a unique characteristic of forming a passive oxide layer so further corrosion becomes very slow only by diffusion through the oxide layer. This oxide layer protects the alloys from corrosion and allow it to some extent to act as a noble inert alloy

On a very rewarding study that compared bonding of porcelain to gold to bonding of porcelain to base metal alloys and most of the alloys proved to have a bonding strength above 25 MPa which is the ISO and the DIN specifications recommended for the metal fused to porcelain bond strength. The study compared the debonding strength of three different types of metal – ceramic systems with and without the opaque porcelain layer. And the results found were very promising proving that base metal alloys have good bond strength with porcelain and would survive equally in the oral cavity as gold alloys [6].

The majority of the base metal alloys used for crowns and fixed partial dentures are Ni – Cr and Cr – Co.

Though the base metal alloys seem to have solved all problems and took place as a permanent good successor to the highly cost gold alloys with supreme mechanical properties and good porcelain bond strength. But lately there seemed to be a concern with their biocompatibility property. As several individuals have been starting to show different types of reactions against the base metal alloys specifically the NiCr alloys.

A study have been conducted to test the influence of dental alloys and an all-ceramic material on cell viability and interleukin-1beta release in a three-dimensional cell culture model. In-Ceram, Pontostar and Ti-6Al-4V alloy did not influence cell viability. Copper (52-64%), and Remanium CS NiCr (17-20%) were found to be cytotoxic, compared to control cultures. In-Ceram, Pontostar and Ti-6Al-4V had no significant influence on IL-1b secretion. Remanium-CS NiCr increased IL-1b levels two fold compared to untreated control cultures. [7]

Another clinical report stated that Nickel was considered one of the most common causes of allergic dermatites and is responsible for more allergic reactions than all other metals combined. They also mentioned that Beryllium, which is present in many alternative alloys, is considered a potentially carcinogenic chemical element. A 33 year old woman showed intolerance to commercial alloys made with nickel-chromium, cobalt- chromium, and copper-aluminum. The reaction invariably consisted of intense pruritus and eczema-like eruptions. It was deemed necessary to also use a skin test for the gold alloy. No reaction was observed.[8]

And in another more detailed test that evaluated the effect of base metal alloys on the cytoskeletal filaments in the cultured human fibroblasts. Alloys tested were Ni-Cr (Wiron 99 Bego, Wirocer Bego, Duceranium U, Degussa) and CoCr (Wironit Bego , Wirocast Bego, Co-Cr Degussa) [9] The base-metal casting alloys tested did not grossly alter the morphology of in vitro–exposed cells. However, mild to moderate degradation of actin-based filaments, particularly in growing tips of the cells, indicated onset of a destructive mechanism that might result in the complete loss of cells if the culture period extends. The degradation of these intracellular fibers that are responsible for promoting cell movement, maintaining cell shape, and organizing intracellular organelles will eventually have an effect on cell function.[9]

In 1989 a research has been conducted to study the effects of dental alloys containing the elements of nickel, beryllium, and chromium on the human host. It was basically designed to characterize the acute and chronic toxicities of base alloys to organ systems. The risks involved where those to the dentist, patient, and the dental technician. [10, 11] Nickel accumulates in the skin, central nervous system, lungs, and kidneys. The metal is a potent skin sensitizer. Patients have been described with nickel eczema after having been orally rehabilitated with prostheses containing Ni alloys. What actually makes it difficult for us to correlate the presence of Ni in the different dental restoration to any allergic reaction, is that there are fundamental environmental differences between the skin and the oral cavity that may contribute to the lack of reported mucosal reactions to nickel. One difference is the rapid and complete formation of salivary glycoprotein films on exposed oral surfaces, which act as diffusion barriers.[11]

In 1982, ***Moffa et el*** [12] reported that, for patients between ages of 24 and 44 who possessed Ni alloy prostheses, 9.7% of the females and 0.8% of the males experienced positive reaction to 2.5% nickel sulfate.

The first report of delayed beryllium poisoning was made in 1946. In humans, beryllium affects the skin, eyes, lungs, and nasal passages in either acute or chronic form. Acute problems include acute dermatitis, conjunctivitis, and bronchitis. Chronic beryllium disease may not express itself for a number of years after exposure. [10, 11]

The main risk for beryllium is its vapor form. Exposure to beryllium vapor is greatest among the dental technicians during melting of the alloy, especially in the absence of an adequate ventilation system. Although the beryllium content in the base metal alloys do not exceed the 2% by weight, the amount of beryllium vapor released in the breathing space during the melting of the alloy may be significant over an extended period of time. [10]

Craig and Hanks [13] did a very interesting study. They determined the cytotoxicity of a series of 29 experimental alloys and 6 pure metals using cell culture techniques and succinic dehydrogenase histochemistry.. By using very specific tests pure metals, Au, Pd, and Ti were the least cytotoxic, followed by Ag, then Ni, and finally, Cu.

A more recent study made by ***Girmaudo*** [14] presented a comparative evaluation of the biocompatibility of nickel-chromium, nickel-chromium-beryllium, and cobalt-chromium alloys. It concluded that although true allergic hypersensitivity to dental materials is rare, certain products have definite allergenic properties.

With the base metal alloys proven to be a direct or an indirect cause of several allergic reactions, whether it is the nickel or beryllium to blame, many researchers have taken the approach for the all ceramic systems.

Taskonak et al [17] were caught by the problem that Ceramic systems have limited long-term fracture resistance, especially when they are used in posterior areas or for fixed partial dentures. The objective of their study was to determine the site of crack initiation and the causes of fracture of clinically failed ceramic fixed partial dentures. Six Empress II lithia-disilicate ($Li_2O{\cdot}2SiO_2$) -based veneered bridges and seven experimental lithia-disilicate- based non-veneered ceramic bridges were retrieved and analyzed. Fractography and fracture mechanics methods were used to estimate the stresses at failure in 6 bridges (50%) whose fracture initiated from the occlusal surface of the connectors. Fracture of 1 non-veneered bridge (8%) initiated within the gingival surface of the connector. Three veneered bridges fractured within the veneer layers. They concluded that fracture initiation sites are controlled primarily by contact damage.

Bulpakdi et al [23] have conducted a study that tested the hypothesis that fracture toughness of the veneers in clinically failed zirconia-based fixed partial dentures (FPDs) is not significantly different from that of the in vitro group and to determine the potential reasons for their failures. Fracture toughness values of the veneer layers in clinically failed zirconia core/glass veneer FPDs (n = 4) and laboratory prepared glass veneer bar specimens (n = 6) were determined using fractal analysis Significance. Fractal analysis is shown to be an alternative analytic tool for clinically failed ceramic restorations, especially for those with fracture origins chipped off during mastication and hence could not be analyzed using other techniques, such as fractography.

The use of all ceramic crowns requires some changes in the preparation design as well as the finish line type [15, 20, 21].

Shinya et al [21] studied the stress distribution at the marginal edge of metal free crowns (All Ceramic and Hybrid composite) with different finish line designs (Knife edge, chamfer, deep chamfer, rounded shoulder). The study has revealed that rounded shoulder (1.5mm) provided more even stress distribution at the margin than the other finish line designs.

And generally the all marginal preparation designs for hybrid composite showed lower compressive and tensile stress at the margin than the all ceramic crowns.

Celik et al [22] conducted a study that aimed to determine the color changes of an all-ceramic restoration with two different veneering porcelain shades after repeated firings. They came out with the conclusion that the color of the all-ceramic specimens with different veneering porcelain shades is influenced by repeated firings. The results of this in vitro study suggest that the shade of veneering porcelain and repeated firings of the zirconia-based all-ceramic material affect the color of the final restoration (another problem of all ceramic restorations), and should be considered during shade selection and fabrication.

But on the other hand the long life durability of the all ceramic crowns and bridges is not yet fully documented in comparison to the metal fused to porcelain system which is very well established to serve for a period of 12 – 15 years [15].

As proved by many researchers [16, 17, 18, 23], all ceramic had a relatively satisfactory low fracture rate but most of these studies had a limited observation period of 2 to 5 years only. And for exception of Procera Zirconium most of all ceramic systems have a low survival rate when it comes to a three unit posterior bridge.

Since the all ceramic bridges and crowns are yet still under study and development to withstand the masticatory forces in the oral cavity, scientist have shifted again to the old metal ceramic technique.

The popularity of the base metal alloys increased intensively over the past few decades as a result of their mechanical properties and relatively cheap price. But being a potential biohazard and difficult handling are their main disadvantage.[10, 24]

Titanium as an alternative

So a more biocompatible, inert, and cheap alternative to gold alloys had to be found to fabricate cast restorations. The biocompatibility of Titanium was first discovered in the 1950's at the Cambridge University in England, when Titanium chambers were implanted in rabbits' ears and it was shown that the ear bones would bond to the metal. It wasn't until the 1970's that Titanium were used to produce metal ceramic restoration. Titanium has proven to be inert in many other studies. Researchers used it on dogs to close a palatal defect and yet no signs of resorption occurred. Again Small disks of Titanium were imbedded in dogs under surgical asepsis, the metal were allowed to remain undisturbed in situ for a period of 7 months. [25, 26, 34]

According to the American Society for testing and Materials (ASTM), there are five unalloyed grades of Commercially pure Titanium Commercially pure Titanium (grades 1-4, grade 7) based on the concentration of oxygen. Grade 1 Commercially pure Titanium is the softest and purest form. It has a moderately high tensile strength (240 MPa), moderately high stiffness (elastic modulus 117 GPa), low density (4.51 g/cm^3), and low thermal coefficient of expansion and contraction (9.4 x 10^{-6}). The elastic modulus is comparable to that of the tooth enamel and Nobel metals but rather lower than that of base metal alloys. Commercially pure Titanium is highly resistant to tarnish and corrosion. The corrosion protection is derived from the thin (10 nm) passivating oxide layer that forms spontaneously. Though it has a high melting temperature (1668^{o}c), its oxidation rate increases markedly above 900^{o}c. [10]

Historically, Titanium has been used extensively in aerospace, aeronautical and marine applications because of its high strength and rigidity, its low density and corresponding low weight, its ability to withstand high temperatures and its resistance to corrosion. Titanium is a highly reactive metal that readily passivates to form a protective oxide layer, which accounts for its high corrosion resistance. The low density of Titanium provides for high-strength, lightweight prostheses. Additionally, dental porcelain can be fused and bonded to Titanium to produce an esthetic restoration. The strength and rigidity of Titanium are comparable to those of other noble or high noble alloys commonly used in dentistry. [27, 28, 30, 35, 37, 39.]

A review performed in 2009 by ***Roberts et al*** [96] investigated all metal ceramic systems available. It concluded that a number of alloys and metals are available for metal-ceramic use in dentistry. Each has its advantages and disadvantages, primarily