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Biomaterials for fabrication of dental crowns

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ABSTRACT: Biocompatible materials used for the fabrication of dental crowns were studied. Patients were treated with Gold, Porcelain and Zirconia crowns. Dental crowns were selected according to patient's clinical status and needs. We found that Gold crowns had low patient acceptance because of poor aesthetics and high cost. Gold crowns could not be used opposite to amalgam restorations for the fear of galvanic shock. Porcelain crowns were extremely aesthetic and did not cause galvanic shock. Porcelain crowns however could not be used in patients with habitual clenching of teeth condition called as Bruxism. Zirconia was found to be the most aesthetic and the most biocompatible with high mechanical strength.

Keywords: *Bruxism; Crown strength; CAD- CAM; Fracture toughness, Galvanic shock; Glass ionomer cement*

INTRODUCTION

The demand for biocompatible materials for dental restorations is growing by the day. Dental materials should not be toxic to the oral tissues in addition it should not contain any leachable or diffusible substance that can get absorbed in the circulatory system. Sometimes certain restorative materials are allergic to the soft tissues like gingiva, mucosa, and pulp and can cause excessive wear of teeth. Dental crowns used for dental restorations should therefore be made up of biocompatible materials. Dental crowns are often used to protect weak tooth, after root canal treatment, to hold dental bridges, dental implants, to cover discolored teeth etc. The currently used materials available for crown and bridge restorations include- gold, porcelain, zirconia, and porcelain fused to zirconia, porcelain fused to gold/other metal, dental composites etc. (Burke & Lucarotti, 2009). The aim of this paper is to review the pros and cons of these materials for the fabrication of dental crowns and to check their suitability for particular dental conditions.

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METHODOLOGY

Here we studied 30 patients treated with Gold, Porcelain and Zirconia crowns. Few patients reported the dental clinic with pain. Other patients wanted to replace their missing tooth with a suitable dental bridge. Crown preparation was done and impression for gold, porcelain and zirconia crowns respectively were taken.

1. 10 patients were given gold crowns
2. 10 patients were given zirconia crown
3. Other 10 patients were given porcelain crown

GOLD CROWNS

Gold alloys are used for gold crown preparation. Since pure Gold is extremely soft and practically unusable, it is mixed with other metals such as platinum, palladium, copper, silver etc. Gold is a noble metal and has the least reactivity of all the metals in the mouth. It is

relatively biocompatible, tolerates oral fluids well and does not harm the oral environment. These crowns are resistant to tarnish and corrosion. Gold has a high strength even when it is thin and allows more conservative tooth preparation and hence preserves healthier tooth structure. Patients who are bruxits and have a habitual clenching and grinding habits can make use of gold crowns. Gold bonds well with the commonly used glass ionomer cement for luting purpose. Although gold is the least reactive of all the metals used in dental restorations, some patients can still be sensitive to a gold crown because the gold crown is a gold alloy and contains other metals that the patient might be allergic to. Gold also cannot be used with other dissimilar metals in the same mouth because it can cause galvanic deterioration. For example, if a gold crown makes contact with an amalgam filling, current can flow between them because there is a difference in electrical potential between the gold in the gold crown and certain metals in the amalgam filling. Those metals are bathed in saliva with ions which acts as an ideal conductor of electricity (Knosp, *et al.*, 2003).

FULL PORCELAIN

These are extremely natural looking restorations available. They are very aesthetic and biocompatible because they are inert and have no reaction with oral tissues or fluids (Rehme, 2013). They are resistant to acid attack due to gastric acidity. Porcelain also does not conduct heat and cold like gold crowns. Porcelain does not have a very high strength and gets brittle and fractures easily where it is thin. Habitual bruxers (Della Bona & Kelly, 2008) were therefore not advised to go in for porcelain crowns. There is yet another type of porcelain crown that is the Porcelain-fused to metal (PFM), which is a hybrid construction type where porcelain encases the metal substructure. These crowns provide both good aesthetics and strength. Glass ionomer cement cannot be used for luting in these crowns. Porcelains are of two types- Feldspathic porcelain and Aluminous porcelain (Owall, *et al.*, 1996). Feldspars are a mixture of anhydrous alumina silicates of both potash feldspar – K_2O, Al_2O_3, SiO_2 and soda feldspar – Na_2O, Al_2O_3, Aluminous porcelain contains 40-50% alumina crystals in a low fusing glass matrix. They are further divided into High ceram and Inceram alumina.

ZIRCONIA

A promising solution for a dental crown is an all ceramic- zirconia crown preparation which is extensively biocompatible and has remarkable aesthetic properties. The most popular dental ceramic systems are silica-, leucite-, lithium disilicate-, alumina-, and zirconia-based materials. Zirconia (ZrO_2), also called as "ceramic steel" has recently received attention widely in dental clinics owing to its superior aesthetic property and biocompatibility. Furthermore, Zirconia is said to have high strength, fracture toughness and hardness (Kelly, *et al.*, 1996, Hisbergues, *et al.*, 2009, Chevalier, 2006). Porcelain fused to zirconia is less likely to fracture than porcelain fused to gold. Zirconia is frequently being used in Prosthodontics for the preparation of crowns, bridges and implants. It is also used as a dental implant mostly because it does not inhibit the bone forming cells (osteoblasts), which are essential for osseointegration (Subbarao, 1998). But since zirconia is quite radiopaque, it cannot be used for preparation of veneers (Kobayashi, *et al.*, 1995). Zirconia is produced by CAD CAM (Computer-aided design and Computer-aided manufacturing) (Baldissara, *et al.*, 2010) assisted milling machine. These techniques not only produce crowns with excellent fit, but the prostheses are also very aesthetic as each layer of the crown can be easily customized to match with the patient's natural dentition. Different ZrO_2 polymorphs, i.e., the monoclinic (m), tetragonal (T) and cubic (c) structures can be formed depending on the temperature. Pure ZrO_2 undergoes low temperature degradation (sometimes even at room temperature) and tends to fracture. The zirconia tetragonal-to-monoclinic phase transformation is known to be a martensitic transformation. During this zirconia phase transformation, the unit cell of monoclinic configuration occupies about 4% more volume change than the tetragonal configuration, which is a relatively large volume change. This could result in the formation of ceramic cracks if no stabilizing oxides were used. These include-

1. Zirconia toughened ceramics such as ZrO_2-Al_2O_3 (ZTA)
2. Tetragonal zirconia polycrystals such as Y_2O_3-ZrO_2 (Y-TZP)
3. Partial stabilized zirconia such as Mg-ZrO_2 (Mg-PSZ) (Dell Bona, 2009, Belli, 2013, Silva, *et al.*, 2010, Cain, 1990, Jin & Jiao, 2007).

To enhance mechanical properties of zirconia and improve its fracture toughness, zirconia based composites and stabilizing oxides are used that controls its phase transformation. Ceria (CeO_2), yttria (Y_2O_3), alumina (Al_2O_3), magnesia (MgO) and calcia (CaO) have been used as stabilizing oxides. Dopants/ stabilizers are also used for stabilization of cubic/tetragonal structures (Dell Bona, 2009). Zirconia is increasingly becoming the preferred crown and bridge material among the dentists nowadays.

RESULTS AND DISCUSSION

On examination, we found that Gold crowns are -
1. Less aesthetic and cannot be used for anterior front teeth.
2. Conducts hot and cold temperatures quickly resulting in initial sensitivity for sometime after placement.
3. Sometimes leaves microgaps at margins which get vulnerable to decay.
4. 3 patients were found allergic to gold crowns.
5. Could not be used for patients having amalgam restoration in opposite arch for the fear of galvanic shock.

It was found that Porcelain crowns are –
1. Porcelain crown on molars were not the best choice in patients who had the habit of clenching of teeth (Bruxism).
2. Porcelain affected the opposite natural teeth.
3. Produced an exact life like cosmetic result.
4. Did not carry the risk of galvanic shock.

It was found that Zirconia crowns are -
1. Zirconia has a very high strength and does not break or chip off even in patients who are bruxits.
2. Zirconia is extremely aesthetic and can be used for anterior and posterior teeth alike according to the shade of other teeth.
3. Zirconia had a considerable patient acceptability because of its biocompatibility.
4. Because of its high cost, not every patient could afford a zirconia crown.

CONCLUSIONS

The new era of biomaterials and biomaterial engineering including regenerative medicine and applications are numerous in the modern dentistry. All the materials used for dental restorations and dental crowns should be extremely biocompatible and selected according to patients needs. All types of dental crowns have the potential to ultimately develop decay overtime due to food lodgement or may need to be re-cemented from time to time as the teeth flex with use. The use of fixed prostheses prepared from gold based alloys has been reduced markedly over a few years. Gold crowns had a low acceptability as more patients wanted tooth colored restoration. Gold crowns also mean a high cost and use of these for dental restoration will ultimately come to an end. Porcelain and porcelain fused to metal (PFM) although have high strength, get easily chipped off. Their durability is still being questioned. All ceramic and porcelain fused to metal (PFM) crowns are

Table 1. Different types of crowns and their properties for particular dental conditions.

PROPERTIES	GOLD CROWN	PORCELAIN CROWN	ZIRCONIA CROWN
Aesthetics	Poor	Acceptable	High
Strength	High	Lesser than Gold & Zirconia	High
Heat conductivity	Conducts heat	Does not conduct	Does not conduct
Galvanic shock	Yes	No	No
Cost	High Cost	Cost Effective	High Cost

commonly used crown and bridge material but now, most dental clinics are switching from the conventional PFM and all-ceramic crowns towards the use of zirconia for fabricating fixed dental prostheses. There are different types of crowns to suit different needs and each type of crown has its own unique set of advantages and disadvantages, each of which must be evaluated according to a patient's specific need. Not one kind universally makes the best choice for every situation. Zirconia however continues to grow in use as high strength and better aesthetics are provided by it.

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