

Advancements in all-ceramics for dental restorations and their effect on the wear of opposing dentition

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ABSTRACT

Tooth wear is a process that is usually a result of tooth to tooth and/or tooth and restoration contact. The process of wear essentially becomes accelerated by the introduction of restorations inside the oral cavity, especially in case of opposing ceramic restorations. The newest materials have vastly contributed toward the interest in esthetic dental restorations and have been extensively studied in laboratories. However, despite the recent technological advancements, there has not been a valid *in vivo* method of evaluation involving clinical wear caused due to ceramics upon restored teeth and natural dentition. The aim of this paper is to review the latest advancements in all-ceramic materials, and their effect on the wear of opposing dentition. The descriptive review has been written after a thorough MEDLINE/PubMed search by the authors. It is imperative that clinicians are aware of recent advancements and that they should always consider the type of ceramic restorative materials used to maintain a stable occlusal relation. The ceramic restorations should be adequately finished and polished after the chair-side adjustment process of occlusal surfaces.

Key words: All-ceramic materials, all-ceramic restorations, surface roughness, tooth wear

INTRODUCTION

In many individuals, tooth wear is a natural unavoidable process that is usually a result of tooth to tooth and/or tooth and restoration contact. Contact usually occurs when sliding movements are taking place. The process of wear essentially becomes accelerated by the introduction of restorations inside the oral cavity,^[1,2] and the rate of tooth surface loss

is greater in case of opposing ceramic restorations.^[3] Wear of the entire dentition is possible without the presence of any restoration, and it should always be aimed for the hardness of restorative materials and their wear behavior remains similar to that of natural enamel; otherwise, tooth surface loss [Figure 1] may lead to a variety of clinical problems including

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damage to the opposing enamel structure, loss of occlusal vertical dimension, problems in mastication, temporomandibular joint problems, hypersensitivity, and esthetic impairment.^[4-6]

Based on the morphological and etiological factors, tooth wear can be classified into various types (erosion, attrition, abrasion, and abfraction).^[7,8] Shellis and Addy^[2] stated that tooth wear occurs due to interaction between erosion, attrition, and abrasion, whereas abfraction may potentiate the process. These mechanisms rarely act alone and always interact with each other, and this interface seems to be the major factor in occlusal and cervical wear.^[9-11]

For many decades, ceramics have been used for esthetic restorations because of their excellent esthetic qualities and superior biocompatibility.^[12]



Figure 1: Tooth surface loss in anterior maxilla

However, ceramics are brittle in nature, require careful polishing techniques and are abrasive to the opposite dentition.^[13-16] There have been suggestions by authors that placement of ceramics over the occlusal surfaces should be avoided so that opposing dentition wear could be minimized.^[17] For that reason, modified ceramics have been developed recently in an attempt to decrease their wear characteristics.

The newest materials have vastly contributed toward the interest in esthetic dental restorations.^[17] The effects of newly introduced dental ceramics have been extensively studied in laboratories. However, laboratory studies which test the abrasion resistance could produce results that are completely different for the same materials tested in clinical studies. Despite the recent technological advancements, there has not been a valid *in vivo* method of evaluation involving clinical wear caused due to ceramics upon restored teeth and natural dentition.

THE RECENT ADVANCEMENTS IN CERAMICS

All-ceramic materials have superior esthetic qualities, and their appearance is very similar to natural dentition. Their brittleness is a major drawback as they tend to fracture in conditions where there are high tensile stresses. Advancements have been made to re-enforce these materials with crystalline materials.^[18] The complete classification ceramics used in dentistry are outlined in Table 1.^[19] A brief description of these materials is described below.

Table 1: "Classification of All-Ceramic Material Types According to the Processing Technique"^[21]

Processing Technique	Ceramic Type	Crystallization stage	Manufacturer
Sintered Ceramics	Leucite re-enforced Feldspathic porcelain	Sanidine	Optec HSP, Jeneric INC
	Aluminous	Alumina	Hicram, Vident, CA
	Magnesia based core	Forsterite	Vident, CA
	Zirconia based porcelain	Mirage II	Myron International, CA
Castable Ceramics	Mica based porcelain	Tetrasilicic fluoromica	DICOR, Dentsply, York, PA
	Hydroxyapatite type porcelains	Oxyapatite	Cerapearl, Kyocera, CA
	Lithia based porcelain	Lithium disilicate	Vident, CA
Heat Pressed Ceramics	Leucite based porcelain	Leucite	IPS Empress, Ivoclar
	Lithium based porcelains	Lithium disilicate	IPS Empress, Eris, Ivoclar
	Cerestore	Spinel	Alceram, Innotek Dental, CA
Machinable Ceramics	Cerec System	Tetracilic flourmica	DICOR, Dentsply, York, PA
		Sanidine	Vitablocs, Mark II, Vident, CA
	Celay System	Sanidine	Vita-celay, Vident, CA
		Alumina	In-Ceram, Vident, CA
	Procera	Alumin	Procera, Nobel Biocare, USA
	CAD-CAM based	Leucite	IPS Empress, CAD, Ivoclar
		Lithium disilicate	IPS E.max, CAD, Ivoclar
	Lava CAD-CAM system	Y-TZP	Lava CAD/CAM, 3m St.Paul, USA

Sintered ceramics

Sintering is a process in which heat at very high temperatures is used to cause consolidation of the ceramic particles. Sintering causes a decrease in surface porosity and the bulk of ceramic during production, and the amount of porosities is directly influenced by the sintering time and temperature.^[20] Porosities on the surface cause an increase in surface roughness of a ceramics and could lead to increase wear of opposing dentition.^[14,20-23]

Porcelain can also be reinforced using alumina and magnesia,^[24] it can be re-enforced into dental ceramics by a mechanism termed as “dispersion strengthening.”^[25-28] Zirconia can be re-enforced into conventional feldspathic porcelain to achieve highest levels of strength. This mechanism of incorporating zirconia is termed as “transformation toughening.”^[29,30] Zirconia stabilized with yttria has high fracture toughness, strength, and thermal shock resistance. It has decreased translucency and low fusion temperature.^[31,32] Majority of zirconia re-enforced ceramics are radio-opaque, and copings are required to be veneered for better esthetic outcomes.

Glass ceramics

Restorations using glass ceramic materials are produced in a noncrystalline state which is converted into a crystalline phase by the process termed as devitrification.^[33] Fabrication of restorations using glass ceramics involves the use of wax patterns made using the phosphate-bonded investment material. The burn-out process is done, and a centrifugal machine is used to cast the molten ceramic into the pattern at 1380°C. After the sprue is removed, glass is invested yet again and heated at 1075°C for a period of 6 h which leads to crystallization of glass to form “tetra-silicic fluoromica crystals.” The procedure of crystal growth and nucleation is termed as ceramming.^[34,35] These crystals lead to increase in strength, abrasion resistance, fracture toughness, and chemical durability of the material.

Pressable ceramics

These ceramics involve the process of production at elevated temperatures in which sintering of the ceramic body occurs. The technique of fabrication prevents the formation of porosities and secondary crystallization which results in a restoration with superior mechanical properties.^[36-39]

Until recently, Ivoclar Vivadent developed two more ceramics named as IPS e.max-Press and IPS e.max. IPS e.max-Press is processed in the laboratory with pressing

equipment which provides very high accuracy of the restoration fit. The microstructure of this material can be distinguished as needle-like disilicate crystals which are embedded into a glass matrix. The flexure strength of IPS e.max-Press is more as compared to IPS Empress.^[40]

Machined ceramics

The development of computer-aided design and computer-aided machining method for the fabrication of inlays, onlays, crowns, and bridges has lead us to the development of next generation of machinable ceramic material.^[41-44] The crowns fabricated using these systems can be delivered to the patient in a single appointment since these are made chair-side. There are several drawbacks which include the expense of the equipment used, and also the process requires a high level of expertise.^[45] If a zirconia coping is to be used, the color difference between the core of zirconia and adjacent tooth must be matched using a specific layering technique for the veneering ceramic, and appropriate shade selection technique should be practiced.^[45-47]

CERAMICS AND TOOTH WEAR

Porcelain restorations, whether polished or not, have significant effects on opposing enamel or an opposing tooth with a restoration.^[48] This is mainly due to their hardness and due to this fact; ceramic restorations are not the material of choice for anterior and posterior teeth on many occasions.^[49] If the surface of a ceramic restoration is rough, there is a very high probability that it will cause excessive wear of the opposing restoration or the natural tooth.^[50] When a ceramic restoration is fabricated in the dental laboratory [Figure 2], it

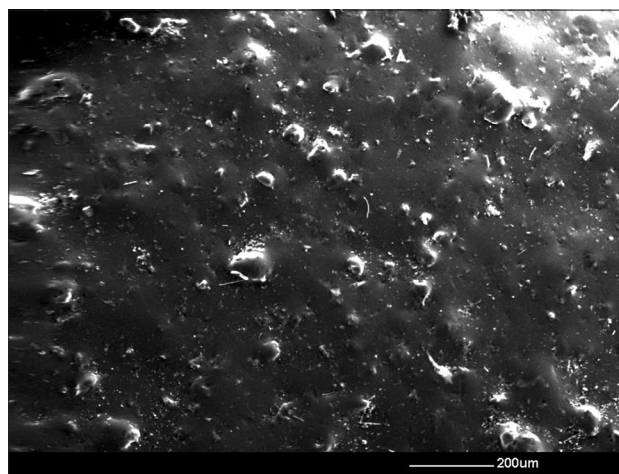


Figure 2: Scanning electron microscope image of an unglazed, unpolished ceramic surface

must be polished using a specific sequence as per manufacturer's recommendation so that its surface roughness can be reduced. The restorations after laboratory polishing are subjected to glazing which produces a final smooth, hygienic surface.^[20] If left unpolished and unglazed, there is a higher risk of plaque accumulation around the restoration and excessive wear of opposing dentition.^[14]

Jagger and Harrison^[51] tested enamel wear caused by different ceramic surfaces and they came to a conclusion that there was no difference in the rate of enamel wear produced by a glazed and an unglazed surface, and it was similar and stated that the phenomenon of wear occurs by a combination of different factors which include abrasion, corrosion, adhesion, and fatigue.^[1,52]

The notion that low-fusing porcelains produce lesser wear as compared to high-fusing porcelain is still debatable. Low-fusing porcelains offer a clinical advantage as their properties are much closer to that of human enamel.^[53] Metzler *et al.*^[54] investigated the effects of two low-fusing feldspathic ceramics and a traditional feldspathic ceramic on the loss of human enamel. Their results suggested that low-fusing feldspathic porcelains caused similar wear as compared to the traditional feldspathic porcelain, for all the measured periods.^[55]

Porosity formation and increased the surface roughness of a ceramic [Figure 3] lead to reduce strength, poor appearance, and increased plaque accumulation.^[56] The subsequent ceramic surface porosity may be exposed during wear process, and a sharp edge of the defect will be even more damaging for opposing dentition.^[57,58] Higher sintering time,

longer sintering temperature cycles, and particle size are three parameters which are associated with the porosity formation over ceramic surfaces.^[59-61] Piddock^[61] and Cheung and Darvell^[56] stated that by increasing the sintering time, air entrapment occurs, and this leads to increased surface and subsurface porosities, and during laboratory fabrication process of ceramic crowns, the influence of mechanical vibration during manipulation of porcelain in layers has limited or no effect on the formation of porosities.^[56,61]

Dental porcelain is not only wear resistant but also exceedingly hard and abrasive against opposing dentition.^[62] Porcelain is more abrasive than gold, amalgam, and composite restorative material and this is why some clinicians are reluctant to use porcelain restorations for anterior guidance.^[63] While the wear characteristics of other materials may be good, they do not satisfy patient's esthetic demands. The constituents of a ceramic material also have an effect on its wear characteristics.^[64] In addition, the higher the coefficient of friction between porcelain and the opposing material, the higher would be the fatigue and abrasive wear process of porcelain.^[65]

The surface treatment of all-ceramic crowns may be responsible for the change in the rate of enamel wear. The adjustment, finishing, and contouring process for ceramic restorations play an important role in achieving function and optimal esthetics [Figure 4]. It is therefore important to consider various ceramic finishing and polishing systems to recreate the lost smoothness of the abraded ceramic surface to obtain maximum biocompatibility.^[65-67] It is a well-recognized fact that improved esthetic results are achieved by polishing, and the ultimate goal of finishing and

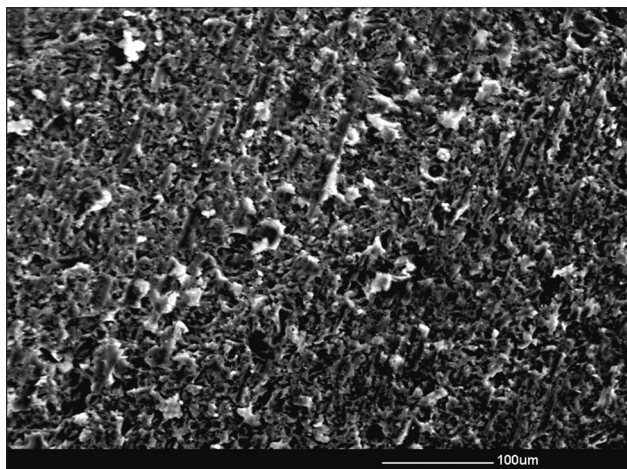


Figure 3: Scanning electron microscope image of an abraded/adjusted ceramic surface

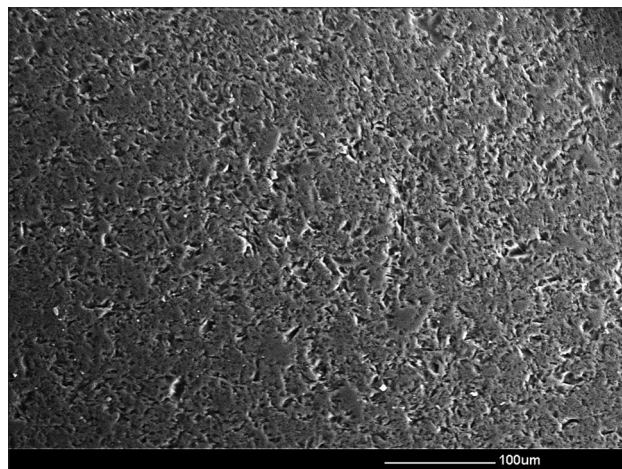


Figure 4: Scanning electron microscope image of an adjusted, polished surface of a ceramic

polishing ceramics is to obtain a surface that can serve as a substitute of a glazed porcelain so that wear of the opposing dentition and restoration could be reduced.^[68-70] However, it is important to differentiate between surface integrity and a quantitative measure of surface smoothness.^[71] Porcelain surface which is devoid of glaze will be virtually identical to a glazed surface in the view of surface smoothness, yet it will differ in terms of other characteristics, i.e. the wear, abrasion resistance, and stain absorption. Reglazing of a ceramic restoration may be done before its cementation in the mouth, but reglazing may not always be possible, especially once the restoration has been cemented and therefore, polishing becomes the best alternative.^[72]

CONCLUSION

Technological advancements in dental ceramics are a fast and growing area in dental research and development. The esthetic appearance of ceramic restorations is attributable to surface texture of the restoration, which is determined by the surface finish. It is very important that clinicians are aware of recent advancements and that they should always consider the type of ceramic restorative materials used to maintain a stable occlusal relation. Further, the ceramic restorations should be adequately finished and polished after chair-side adjustment process of occlusal surfaces. Modifications of ceramic materials are recommended to produce more durable ceramic in terms of wear resistance and to minimize the undesired effects.

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Conflicts of interest

There are no conflicts of interest.

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