A Comprehensive Guide to Dental Ceramics

A Comprehensive Guide to Dental Ceramics

By

Sushma R.

Cambridge Scholars Publishing

A Comprehensive Guide to Dental Ceramics

By Sushma R.

This book first published 2023

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-3205-4
ISBN (13): 978-1-5275-3205-2

I wish to dedicate this book to my daughter
Risha. D. Prasad

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF ABBREVIATIONS

1.	Alpha	α
2.	alumina	$A1_2O_3$
3.	Acidulated Phosphate Fluoride	APF
4.	Boron oxides	B_2O_3
5.	Computer-Aided Design and Computer-Aided Manufacturing	CAD-CAM
6.	Chairside Economical Restoration of Esthetic Ceramics	CEREC
7.	Coefficient of Thermal Expansion	CTE
8.	Hydrofluoric acid	HF
9.	Lime	CaO
10.	Leucite	$K_2O.\ Al_2O_{3.}4SiO_2$
11.	Low-temperature-degradation	LTD
12.	Porcelain-to-metal	PTM
13.	Porcelain-bonded-to-metal	PBM
14.	Porcelain-fused–to-metal	PFM
15.	Porcelain jacket crown	PJC
16.	Potassium aluminium silicate	$K2O\ Al_2O_3\ 6SiO_2$
17.	silicon-oxygen	Si-O
18.	soda	Na_2O
19.	Ultra Violet Radiation	UV radiation
20.	Vita Metal Keramik	VMK 95
21.	Y-TZP	Yttria Stabilized Zirconia
22.	zinc phosphate cement	ZP

PREFACE

Since time immemorial, man has had a quest for beauty. He has been constantly in search of materials and techniques that make human beings more aesthetic in terms of either transformation or replacement of body parts which closely mimic the nature. Ceramic is one such discovery by man from nature which has come a long way from earthen wear to the latest tooth look-alikes.

The purpose of this book is to create a book containing various aspects of ceramics, from its interesting history to how it has travelled through the centuries to become one of the most important parts of dentistry, as well as human lives.

ACKNOWLEDGEMENTS

It is my proud privilege and honour to express my deep sense of gratitude and heartfelt thanks to all my respected teachers and guides, for their valuable guidance, encouragement and constant support in my career.

I wish to thank my friends and colleagues for their cooperation and support.

I wish to acknowledge the encouragement and support of my family without which this work would not have been possible.

Dr. Sushma R.

INTRODUCTION

Ceramics are thought to be the first material ever made by man. They are among the earliest group of inorganic materials to be structurally modified by man. Although routine use of ceramics in restorative dentistry is a recent phenomenon, the desire for a durable and esthetic material is ancient. Dental ceramics are the most natural appearing replacement material for a missing tooth substance available in a range of shades and translucencies to achieve life-like results. However, the mechanical and physical properties and the manufacturing technique of so-called conventional dental ceramics have revealed certain clinical shortcomings i.e. excessive brittleness, crack propagation, low tensile strength, fracture of the restoration, wear of antagonists and sintering shrinkage. These shortcomings among other factors have limited the indications for dental ceramics.

Of the three basic materials – ceramics, metal and polymers – ceramics were the last to move into the high-technology phase of development. During the past decade, the demand for non-metallic highly biocompatible dental restorative material has, however, markedly increased. The aesthetic demands made on dental restorations have resulted in an increased use of dental ceramics. Aesthetically these materials are preferred alternatives to traditional materials; and ceramics are also regarded as bio-compatible and inert materials. Furthermore, the introduction of bonding procedures and new luting techniques has increased the general acceptance of these ceramic systems.

In an attempt to meet the requirements of dental materials and improve their strength and toughness, several new ceramic materials and techniques have been developed during the past decades. These recent developments have attempted to overcome the principal disadvantages of inherent brittleness and the potential to abrade the opposing dentition by either the use of increasingly complex technology or by the simplification of existing techniques and/or materials.

Recent material, technical and clinical innovation in restorative dentistry has increased the complexity of treatment planning and decision making. Many of these advances have not replaced, but have augmented a wide variety of existing materials or treatment protocols, as well as clinical techniques and skills.

Dentists today can choose from a variety of ceramic materials in dentistry; hence, should be familiar with the range of metal-ceramic and all-ceramic materials available for fabrication of ceramic restorations. This review outlines the developments in the evolution of dental ceramics over the last century and considers the state of the art in the several extended and innovative applications of dental ceramics.

TERMINOLOGIES

Alumina core – a ceramic containing sufficient crystalline alumina ($A1_2O_3$) to achieve adequate strength and opacity when used for the production of a core for ceramic jacket crowns.

Aluminous porcelain – A ceramic composed of a glass matrix phase and at least 35% Al_2O_3.

Body porcelain (also dentin or gingival porcelain) – A veneering ceramic for ceramic or metal-ceramic prosthesis.

Bisque – unglazed fired ceramic.

CAD-CAM ceramic – a machinable ceramic material formulated for the production of inlays and crowns through the use of a computer-aided design, computer-aided machining process.

Castable dental ceramic – a dental ceramic specially formulated to be cast using a lost-wax process.

Ceramic – a compound of metallic and non-metallic elements.

Ceramic, dental – a compound composed of metals (such as aluminium, calcium, lithium, magnesium, potassium, sodium, tin, titanium, and zirconium) and nonmetals (such as silicon, boron, fluoride, and oxygen) that may be used as a single structural component, such as when used in a CAD-CAM inlay, or as one of several layers that are used in the fabrication of a ceramic-based prosthesis. Dental ceramics are formulated to provide one or more of the following properties: castability, mouldability, injectability, color, opacity, translucency, machinability, abrasion resistance, strength, and toughness. *Note:* all porcelains and glass ceramics are ceramics, but not all ceramics are porcelains or glass-ceramics.

Copy-milling – a process of machining a structure using a device that traces the surface of a master metal, ceramic, or polymer pattern and transfers the traced spatial positions to a cutting station where a blank is cut or ground in a manner similar to a key-cutting procedure.

Core ceramic – a dental ceramic material that provides a mechanically strong base onto which a body ceramic (also called *dentine* or *gingival ceramic*) can be veneered.

Feldspathic porcelain – a ceramic composed of a glass matrix phase and one or more crystal phases. An important crystal phase is leucite (K_2O. $Al_2O_3.4SiO_2$), which is used to create a high-expansion porcelain that is thermally compatible with gold-based, palladium-based and nickel-based alloys. A more technically correct name for this class of dental ceramics is leucite porcelains, because feldspar is not present in the final processed porcelain nor is it necessary as a raw material to produce leucite crystals.

Glass – an inorganic nonmetallic compound that lacks a crystalline structure.

Glass-ceramic – a solid consisting of a glassy matrix and one or more crystal phases produced by the controlled nucleation and growth of crystals in the glass.

Glass-infiltrated dental ceramic – a minimally sintered Al_2O_3 or $MgAl_2O_4$ core with a void network that has been sealed by the capillary flow of molten glass. Examples include In-ceram (Al_2O_3) and In-ceram Spinell ($MgAl_2O_4$) core.

Glaze ceramic – a specially formulated ceramic powder that, when mixed with a liquid, applied to a ceramic surface, and heated to an appropriate temperature for a sufficient time, forms a smooth glassy layer on a dental ceramic surface.

Green state – a term reffering to an as-pressed condition before sintering.

Injection-moulded ceramic – a glass or other ceramic material that is used to form the ceramic core of an inlay, veneer, or crown by heating and compressing a heated ceramic into a mold under pressure. An example is **IPS Empress**.

Metal-ceramic restoration – a crown, fixed partial denture, or other prosthesis made with a metal substrate (usually cast) to which porcelain is bonded for aesthetic enhancement via an intermediate metal oxide layer. The terms *porcelain-fused–to-metal* (PFM), *porcelain-bonded-to-metal* (PBM), *porcelain-to-metal* (PTM), and ceramometal are also used to describe these restorations, but *metal-ceramic* is the preferred descriptor term for these restorations.

Natural glaze – a vitrified layer that forms on the surface of a dental ceramic containing a glass phase when the ceramic is heated to a lower temperature for a specified time.

Overglaze – the surface coating of glass formed by fusing a thin layer of glass powder that matures at a lower temperature than that associated with the ceramic substrate.

Porcelain jacket crown (PJC) – one of the first types of all-ceramic crown, made from a low-strength aluminous core porcelain and veneering porcelain (with matching thermal contraction coefficient) without the use of a supporting metal substrate except, in some instances, for a thin platinum foil (see ceramic jacket crown).

Pressable ceramic (hot-pressed ceramic) – a ceramic that can be heated to a specified temperature and forced under pressure to fill a cavity in a refractory mold.

Shade guide, ceramic – a series of ceramic tooth-shaped tabs mounted on metal or plastic strips that is designed for comparison of hue/ value, and chroma characteristics with those of natural teeth or existing ceramic restorations. The letter and number code on the metal strip allows the dentist to communicate the perceived appearance properties to a dental technologist who may not be able to observe the teeth to be restored.

Shoulder porcelain – porcelain that is formulated to be sintered at a lower temperature than that of opaque porcelain and higher than that of body porcelain to produce an esthetic porcelain margin as an alternative to a metal margin on a metal-ceramic crown.

Sintering – the process of heating closely packed particles to achieve interparticle bonding and sufficient diffusion to decrease the surface area or increase the density of the structure. For products such as In-Ceram and In-Ceram Spinell surface contact sintering and minimal density change are required.

Spinel or spinelle – a hard crystalline mineral ($MgAl_2O_4$) consisting of magnesium and aluminum; also, any of the group of mineral oxides of ferrous iron, magnesium, manganese or zinc.

Stain – a mixture of one or more pigmented metal oxides and usually a low-fusing glass that when dispersed in an aqueous slurry or monomer/medium, applied to the surface of porcelain or other specialized ceramic, dried or light cured, and fired will modify the shade of the ceramic-based restoration. One product is supplied in a light-curable binder. These stain products are also called 'surface colorants' or 'characterization porcelains'.

Thermal compatibility – a condition of low transient and residual tensile stress in ceramic adjacent to a metal or ceramic core that is associated with a small difference in the thermal contraction coefficients between the core material and the veneering ceramic.

HISTORICAL PERSPECTIVE OF PORCELAIN

Early History

As mentioned earlier, ceramics are thought to be the first materials ever made by man. Early fabrication of ceramic articles dates back to 23,000 B.C. The earliest glazing technique was a Sumerian invention made famous about 4000 B.C. as Egyptian Blue Fiance. This glaze was not like later ones; a melted pre-mix of glassforming materials, but was made by a type of cementation process.

Chinese Porcelain: In contrast to what was happening in Europe, stoneware had been produced in China by 100 B.C., and by the 10^{th} century A.D., ceramic technology in China had advanced to a highly sophisticated stage; in 1375, porcelain was copied in Florence, and rapidly became popular throughout Europe. So, strenuous efforts were made by the European pottery industry to imitate the Chinese porcelain; but it was found impossible to reproduce the translucency of Chinese porcelain.

This situation prevailed for some time until in 1717; a Jesuit missionary **Father d'Entrecolles** leaked the secret of Chinese porcelain, who passed it on to **M. de Reamer**, a scientist who was able to identify the components used by the Chinese as kaolin, silica and feldspar.

The ceramists were sometimes inadvertently using properties such as moisture derived from vitrification and devitrification, the nucleation of various crystalline phases and local variations of viscosity, surface tension and expansivity. Colours depended on various states of oxidation, abnormal ionic states and on structural imperfections in the crystals. The dental application of porcelain material finally came about in the 18th century in Europe.

History of porcelain use in dentistry: The history of porcelain used as a dental material goes back nearly 200 years. The use of porcelain in dentistry was first mentioned by **Pierre Fauchard**. The superior surface and colouring qualities were used by fusing the material to gold or silver. This involved the use of low fusing glazes, which had been known for some hundreds of years and had reached artistic eminence in the work of **Cellini**.

1728 – Pierre Fauchard, a French dentist first proposed the use of porcelain in dentistry. He suggested the use of jeweler's enamel to fabricate artificial teeth.

1760 – Fauchard, Bordet and other dentists constructed gum colour enamel and gum section teeth.

1774 – Alexis Duchateau, a French apothecary, with the assistance of a Parisian dentist **Nicholas Dubois de Chemant**, made the first recorded successful porcelain dentures at the Guerhard Porcelain Factory, replacing the stained and malodorous ivory prostheses of Duchateau. This was the first use of porcelain in its true form (a fused composition of the minerals Kaolin, Quartz and Feldspar), to form denture teeth.

1788 – Nicholas Dubois de Chemant continually improved porcelain formulations and first displayed a baked porcelain denture made in a single block. He published his book on artificial teeth.

1806 to 1808 – Giuseppangelo Fonzi an Italian dentist who worked in Paris introduced the first individually formed (single) porcelain teeth that contained embedded platinum pins. But they were never met with great approval because of their brittleness and opacity. He also used metalic oxides to produce 26 shades of colour in porcelain.

By 1820 – Porcelain denture teeth were introduced, which replaced ivory/natural denture teeth in the U.S.A.

By 1825 – Samuel Stockton began fabrication of fused porcelain teeth in Philadelphia. His initials were represented in the name of the S.S. White Company.

1838 – Elias Wildman formulated translucent porcelain.

1850 – Samuel Stockton of Philadelphia, his nephew **S. S. White** and **Claudia Ash**, placed the porcelain tooth on a successful commercial basis in England.

1887 – Dr C.H. Land of Detroit developed the first All-Porcelain jacket crown (PJC) using the Platinum Foil Matrix techniqe.

1889 – Dr. Charles H. Land patented the Plantinum Foil Matrix techniqe for PJC. (The traditional porcelain was obtained from a remarkably pure marble mined at an island in the Algean Sea named Paros. This Parisian China contaning feldspar as its principal constituent was extermely transluent and could be self-glazed.)

1898 – N.S. Jenkins of Dresden presented the first low-fusing porcelain for making inlays.

1900 – Brewster introduced porcelain inlays for clinical use.

1903 – E. B. Spaulding developed gingival shoulder porcelain for the PJC.

1910 – High fusing electric furnaces (fusion at 2000^0 F) were recommended to minimize the firing shrinkage and application of hydrofluoric acid to the fitting surface to produce a ‘honey-combe’ appearance to enhance retention by creating interlocks into which the cement would flow.

1930 – Frederick Gardner of the Steuben division of Corning Glass Works developed the ‘Lost–Wax’ or “cire-perdue” method (Taggart’s method of 1907) of forming three-dimensional glass articles.

1957 – S. D. Stookey of Corning Glass Works invented glass–ceramic accidentally which was document by **Anon**.

1962 – A major development occurred in ceramics; that is, the incorporation of a high proportion of leucite crystals into the feldspathic porcelain composition.

1962 – M. Weinstein, S. Katz & A. B. Weinstein were awarded the U.S. patent for gold alloy formulation and feldspathic porcelain designed for porcelain fused to metal restoration.

1963 to 1965 – The first viable technique for alumina-reinforced crowns was developed by **Mc Lean & Hughes** in England.

1968 – W.T. MacCulloch fabricated denture teeth from a glass-ceramic used to make cookware (Pyrosil). He recognized the other potential uses of glass-ceramics in dentistry and suggested the possibility of using glass-ceramics in inlays and crowns.

1976 – Mc Lean & Sced developed the stronger platinum bonded alumina crown. The attachment of aluminous porcelain to the platinum was achieved by surface coating of the metal with a thin layer of tin.

1977 – Kasloff used a combination of vacuum and air pressure casting techniques to produce transparent castings.

1977 – Peter Adair of Biocor Inc, suggested that Corning's machinable glass-ceramic might provide a superior restoration because of their ease in adjustment and overall similarity in properties to natural enamel.

1983 – First dental CAD/CAM prototype was presented at the Garanciere Conference (in France).

1983 – Sozio & Riley first described shrink-free ceramics (marketed as Cerestore), which was followed by development of another injection-moulded castable glass-ceramic by the University of Zurich (marketed as IPS Empress).

1984-1985 – Magnesium oxide, a high-expansion material was developed as an alternative to metallic core**. O' Brien** described magnesia core ceramics.

1985 – First CAD/CAM crown was publicly milled and installed in the mouth.

1985 – Hobo & Kyocera (Biocream group) developed a castable glass-ceramic which melts at 1460^0C and flows like molten glass.

1986 – The first generation CEREC 1 (Siemens) CAD/CAM system was introduced.

1988 – Michael Sadoun first introduced In-ceram, glass-infiltrated aluminous porcelain.

1989 – Duceram LFC, a low fusing Hydrothermal ceramic was introduced.

1992 – The Celay copy-milling system (Mikrona AG), became commercially available.

1993 – The Procera CAD/CAM system was developed by **Andersson M. & Oden** by a co- operative effort between Nobel Biocare AB and Sandvik Hard Materials AB.

1994 – The second generation CEREC 2 (Siemens/Sirona) CAD/CAM System was presented.

Late 1990's – IPS Empress 2, a second-generation pressable ceramic made from lithium-disilicate frame work with an apatite layered ceramic was introduced.

1997 – IPS Empress® Cosmo Ingot (Ivoclar), a glass-ceramic material that can be heat pressed directly onto Zirconia posts (eg; Cosmopost) was introduced.

1999 – IPS SIGN (Ivoclar AG), a feldspar-free fluorapatite glass ceramic system for use in metal-ceramics was presented.

REVIEW OF LITERATURE

Ralph B Sozio and Edwin J. Riley (1985) conducted a study on Shrink-free alumina ceramic as its substrate. They concluded that core renders the restoration exceptional fit and strength. A ceramic layering technique employed with the aluminous porcelain veneers offers the capability of constructing a full crown restoration incorporating the optical properties present in a natural tooth.

Peter Schaerer, Tomohiko Sato and Arnold Wohlwend (1988) conducted an invitro study on three crown systems and concluded that the Cerestore crown system produced an impressive marginal fit without technique sensitivity. However, irregularities on the crown margin due to the porosities of the fired core were noted. 2. The Dicor castable ceramic crown system in this study produced rounded marginal openings because of the shrinkage during ceramming, the treatment of the surface texture after ceramming, and damage from air abrasives. 3. The Ceplatec crown system produced a suitable marginal fit when the distortion of the foil coping during porcelain firing was controlled. The quality of the margin was ultimately determined by the skill of the technician.

Harald O. Heyman, Stefhen C. Bayne, John R. Sturdevant, Aldridge D. Wilder and Theodore M. Roberson (1996) conducted a long-term clinical study of 50 CEREC (Siemens AG) CAD-CAM inlay restorations in 28 patients. After four years, they found the inlays to rate very highly in color matching, interfacial staining, secondary caries, anatomic contour, marginal adaptation, surface texture and postoperative sensitivity. They monitored cement loss along the occlusal margins and found it to be relatively low, with an unusual decrease in measured cement wear from the third to the fourth year. They concluded that the favorable results of this long-term clinical study of these CAD-CAM restorations portend significant success for this restorative approach.

Sven Rinke and A. Huls (1996) investigated the new copy-milled technique for various technical properties and concluded that the advantages of this new technique are shortening of processing time and reduction in defects during processing through the use of an industrially prefabricated material.

Karl F. Leinfelder (1997) studied the various restorative systems to demonstrate the most possible technology to maintain esthetics. In most cases, resins have exhibited insufficient wear resistance, whereas the ceramic materials have had a history of excessively abrading whatever opposes them occlusally. Based on recent clinical information, they conclude that it appears that major successes have been achieved in reaching the goal. As the author discusses these advances and proposes a possible replacement for amalgam, based on new technology.

N. Hochman and M. Zalkind (1999) – The increasing demand for highly esthetic, biocompatible posts and cores has led to the development of metal-free, post-and-core systems. The authors in this article describe and evaluate an indirect method for the fabrication of an all-ceramic post and core.

P. A. Brunton, P Smith, J. F. McCord and N. H. F. Wilson (1999) – In this article the investigators offer suggestions for case selection, preparation design, and luting procedures, and in addition illustrate these with a number of completed cases. They also report on possible solution quest for sufficiently strong, metal-free, all-ceramic restorations to function in all areas of the mouth through the use of computer-aided design/computer-aided milling (CAD/CAM) technology coupled with a novel, densely sintered, ceramic material.

Koutayas S. O. and Kern M. (1999) describe the fabrication of all-ceramic posts and cores, using high-toughness ceramic materials such as alumina or zirconia ceramics, through 4 different techniques: the slip-casting technique; the copy-milling technique; the 2-piece technique, which involves a prefabricated zirconia ceramic post and a copy-milled alumina or zirconia ceramic core; and the heat-press technique. Indications, contraindications, advantages, and disadvantages of the different techniques are compared.

Guazzato M., Albakry M., Swain M. V., Ironside J. (2002) – This study compared the mechanical properties of In-Ceram Zirconia and In-Ceram Alumina. Mean biaxial flexure strengths, mean fracture toughness measured according to indentation strength and mean fracture toughnesses were measured according to indentation fracture respectively. They concluded that no statistically significant difference was found in strength. In-Ceram Zirconia was tougher ($P < .01$) than In-Ceram Alumina when tested according to indentation strength.

Borges G.A., Sophr A.M., de Goes M.F., Sobrinho L.C., Chan D.C. (2003) conducted this study to assess the surface topography of 6 different ceramics after treatment with either hydrofluoric acid etching or airborne aluminum oxide particle abrasion. IPS Empress, IPS Empress 2 (0.8 mm thick), Cergogold (0.7 mm thick), In-Ceram Alumina, In-Ceram Zirconia, and Procera (0.8 mm thick) were used in the study. Hydrofluoric acid etching and airborne particle abrasion with 50-microm aluminum oxide was done. They conclude that increased the irregularities on the surface of IPS Empress, IPS Empress 2, and Cergogold ceramics. Similar treatment of In-Ceram Alumina, In-Ceram Zirconia, and Procera did not change their morphologic microstructure.

Albakry M., Guazzato M., Swain M. V. (2004) – This invitro study was conducted to evaluate the effect of sandblasting, grinding, polishing and glazing on the flexural strength of two pressable all-ceramic dental materials they concluded that no significant difference in the mean strength values was found between untreated, sandblasted and ground groups for each material ($p>0.05$). Heat treatment had no effect on roughness or strength values of all treated groups of both materials. Surface roughness may not be the only feature that determines strength.

Rizkalla A.S., Jones D.W. (2004) – The study evaluated and compared the flexural strength, dynamic elastic moduli and true hardness (H(o)) values of commercial Vita In-Ceram Alumina core and Vita In-Ceram matrix glass with the standard aluminous porcelain (Hi-Ceram and Vitadur), Vitadur N and Dicor glass and glass-ceramic. In their conclusions they found that Vita In-Ceram Alumina and IPS Empress 2 exhibited significantly higher flexural strength than aluminous porcelains and IPS Empress at p=0.05. The dynamic elastic moduli and true hardness of Vita In-Ceram alumina core were significantly higher than the rest of the commercial ceramic core materials.

Guazzato M, Albakry M, Ringer SP, Swain MV.(2004) The examiners divided the present study, into two parts, one to compare the strength, fracture toughness and microstructure of a range of all-ceramic materials. In part I, three hot-pressed glass-ceramics (IPS-Empress, Empress 2 and a new experimental ceramic) and alumina glass-infiltrated ceramics (In-Ceram Alumina), processed by both slip casting and dry pressing, were compared. In their conclusions microscopy revealed the relationship between the glass matrix and the crystalline phase and the characteristics of the latter were correlated to the strengthening and toughening mechanisms of these glass-ceramics.

Attia A., Kern M.. (2004) – This study was conducted to evaluate the influence of cyclic loading and luting agents on the fracture load of two all-ceramic crown systems under wet conditions on the fracture load of CAD-CAM and pressable all-ceramic crowns. Three luting agents (Panavia F, Superbond C&B and ProTec CEM) were used for cementation (n = 16). However, they concluded that cyclic loading did not decrease the median fracture load of crowns luted using Panavia F, Empress 2 (P =.431) and ProCAD (P =.128: Cyclic loading reduced the fracture load of ProCAD crowns luted with Superbond C&B and ProTec CEM and of Empress 2 crowns luted with ProTec CEM.

Guazzato M., Quach L., Albakry M., Swain M.V. (2005) – The study was conducted to investigate the influence of surface and heat treatments on the flexural strength of Y-TZP dental ceramic. They concluded that sandblasting and grinding may be recommended to increase the strength of dental Y-TZP, provided they are not followed by heat treatment. Fine polishing may remove the layer of compressive stresses and therefore, lower the mean flexural strength.

Goldin E. B., Boyd N. W. 3rd, Goldstein G. R., Hittelman E. L., Thompson V. P. (2005) – The in vitro study to compare the marginal adaptation of a pressable ceramic system when used with both all-ceramic and metal-ceramic crowns, with a traditional metal-ceramic restoration. They concluded that no significant differences between groups were found.

Luo X. P., Watts D. C., Wilson N. H., Silsons N., Cheng Y.Q. (2005) – This study was conducted to investigate the microstructure and mechanical properties of a new IPS-Empress 2 dental glass-ceramic. AFM, SEM and XRD were used to analyze the microstructure and crystal phase of IPS-Empress 2 glass-ceramic. IPS-Empress 2 glass-ceramic. They documented that the high strength and fracture toughness of IPS-Empress 2 glass ceramic are attributed to the fine lithium disilicate crystalline, interlocking microstructure and crack deflection.

Balkaya M. C., Cinar A., Pamuk S. (2005) – This study was conducted to examine the effect of porcelain and glaze firing cycles on the fit of 3 types of all-ceramic crowns. Conventional In-Ceram, copy-milled In-Ceram, and copy-milled feldspathic crowns within the limitations of this study, it was concluded that the 3 all-ceramic crown systems demonstrated a comparable and acceptable marginal fit. The porcelain firing cycle affected the marginal fit of the all-ceramic crowns. However, the glaze firing cycle had no significant effect on fit. The conventional and copy-milled In-Ceram crowns demonstrated medial deformations at the labial and palatal surfaces that might result in occlusal displacement of the crown.

Herrguth M., Wichmann M., Reich S. (2005) – The investigators evaluated the aesthetics of all-ceramic veneered and monolithic CAD/CAM crowns. Within the limits of this study it was documented, that the mean values for the layering technique and for the machined restorations did not differ significantly and that machinable blocks could attain aesthetically satisfying results.

Ahmad R., Morgano S. M., Wu B. M., Giordano R.A. (2005) – This invitro study was conducted to evaluate the effects of handpiece speed, abrasive characteristics, and polishing load on the flexural strength of polished ceramics by using a custom-made machine that applied standardized loads and speeds that coincided with the mean loads and speeds used by experienced prosthodontists. Specimens were untreated, polished with different polishing systems, polished at different speeds, ground and autoglazed, polished and autoglazed, autoglazed and polished, polished with loose (paste) and bonded abrasives, or overglazed under a clinical load of 0.6 N for a coarse polishing wheel, 1.0 N for a medium polishing wheel, and 1.3 N for a fine polishing wheel, a linear speed of 499 mm/min, and a rotational velocity of 10,000 rpm, they conclude that the use of Autoglazing treatment of the diamond-polished specimens did not reverse the strength degradation (P=.125). Conversely, diamond polishing of the autoglazed specimens resulted in significant flexural strength reduction (P=.029). Fine-diamond-bonded abrasive significantly reduced flexural strength (P=.025)

Attia A., Abdelaziz K. M., Freitag S., Kern M. (2006) – This study investigated the effect of cyclic loading fatigue and different luting agents under wet conditions on the fracture load of CAD/CAM machined composite resin and all-ceramic crowns (Vita Mark II) and Composite resin crowns (MZ100 Block) were fabricated using a CAD/CAM system (Cerec 3). Three luting agents-RelyX ARC (RX), GC Fuji CEM (FC), and zinc phosphate cement (ZP) were used for cementation cyclic loading fatigue, significantly reducing the fracture loads of composite resin and all-ceramic crowns and concluded that adhesive cementation significantly increased the fracture loads.

Amaral R., Ozcan M., Bottino M. A., Valandro L.F. (2006) – The study evaluated the effect of three surface conditioning methods on the microtensile bond strength of resin cement to a glass-infiltrated zirconia-reinforced alumina-based core ceramic. They documented that Silica coating with silanization either using 110 microm SiO(x) or 30 microm SiO(x) particles increased the bond strength of the resin cement to the zirconia-based ceramic significantly compared to that of airborne particle abrasion with 110-microm Al(2)O(3).

Sarac D., Sarac Y. S., Yuzbasiooglu E., Bal S. (2006) – The in vitro study compared the effect of different porcelain polishing methods on the color and surface texture of a feldspathic ceramic. A medium-grit diamond rotary cutting instrument was used to remove the glaze layer, and then the surface was polished using 1 of the 4 following polishing systems or a combination thereof: polishing paste (Ultra II), polishing stick (Diamond Stick), polishing wheel (CeraMaster), or an adjustment kit (Porcelain Adjustment Kit). Color measurements were made using a colorimeter (Minolta CR-321 ChromaMeter). Polishing techniques significantly affected the color of the feldspathic ceramic. No significant differences were found withie adjustment kit groups or within the polishing wheel groups. All specimens polished with the various techniques showed significantly different surface roughness values than the control specimens ($P<.001$), except for the groups polished using the adjustment kit. The evaluation of the polishing techniques showed that the use of an adjustment kit alone or preceding polishing paste or polishing stick application created surfaces as smooth as glazed specimens. The use of polishing paste alone did not improve the smoothness of the porcelain surface. The color differences of all groups were found to be at the acceptable level.

Papanagiotou H. P., Morgano S. M., Giordano R. A., Pober R. (2006) – This study was carried out by the investigators to find out the influence of low-temperature-degradation (LTD) treatment, airborne-particle abrasion, and polishing on the flexural strength and structural stability of a Y-TZP ceramic material. It was documented that aging or "finishing" treatments had no significant negative effects on flexural strengths.

Zhang Y. X., Zhang W. H., Lu Z. Y., Wang K. L. (2006) – This study was conducted by the authors to compare the fracture strength of endodontically treated teeth which were thereafter given different types of posts and cores and crowns restoration, respectively. The evaluated post-and-core systems are: custom-fabricated Celay all-ceramic post-core, custom cast metal post-core, and prefabricated stainless steel post (Parapost) with and without 2.0 mm dentine ferrule. They concluded that Celay ceramic post-cores restored teeth with 2.0 mm dentine ferrule and cast metal post-cores restored teeth with 2.0 mm dentine ferrule had significantly greater mean fracture strength than the other three groups in which no significant difference was observed. The 2.0 mm dentine ferrule could cause significant fracture resistance alteration of Celay post-core restored teeth.