CHAPTER I
INTRODUCTION

1.1 Background and rationale

Dental ceramic has been widely used in the last decade to fabricate restorations in esthetic dentistry as it provides highly desirable esthetic properties such as translucency, light transmission and extreme biocompatibility. Thermal conductivity and coefficient of thermal expansion (CTE) of dental ceramic are similar to those of enamel and dentine, hence it gives a good marginal seal. Bonding to metal makes it stronger to bear the masticatory load. The restoration is known as a porcelain fused to metal (PFM) crown, or as a fixed partial dentures (FPDs) or a bridge in case of replacing a tooth or teeth or in term “metal ceramic restoration”. With higher demand of esthetics, all ceramic restorations have become more popular [1]. The popularity of all-ceramic dental restorations has been increasing in recent years due to their superior esthetic appearance and metal-free structure [2]. It is the combination of strength of core ceramic and superior esthetics of a weaker veneering ceramic that result in a reliable and biocompatible restoration [3, 4]. The dental profession seeks an ideal all-ceramic restoration with excellent physical properties, strength, marginal fit, and esthetics necessary for anterior, as well as posterior, restorations [5].

Since, dental ceramics are brittle materials in nature, it is not appropriate to use in the posterior region that severe high loading especially long-span fixed partial dentures (FPDs) or a bridge. The development of advanced dental material technologies has recently led to the application of zirconium dioxide or zirconia in dentistry. The most representative zirconia-based dental ceramics are yttria- stabilized tetragonal zirconia [6]. In the early 1990s yttrium oxide partially stabilized tetragonal zirconia polycrystal (Y-TZP) was introduced to dentistry as a core material for all-ceramic restorations and has been made available through the Computer assisted design/ Computer Aided Manufacturing(CAD/CAM)technique. The transformation toughened Zirconia has unique properties such as high fracture toughness and strength. Zirconium is a polycrystalline ceramic without any glass component. It is a polymorph that occurs in three forms, monoclinic (M), cubic (C) and tetragonal (T). Pure Zirconia at room temperature is monoclinic and stable till 1170 °C. Above this temperature it transforms itself into tetragonal and then further into cubic phase at 2370 °C. During cooling, a T-M transformation takes place at the temperature range of about 100 °C below 1070 °C. The phase transformation, which takes place during cooling, is associated with volume expansion of approximately 3–4%. This means that components made of pure zirconium oxide would burst due to volume increase of grains and tension [7]. Due to a transformation toughening mechanism, Y-TZP has been shown to have superior mechanical properties compared to other all ceramic systems. In vitro studies demonstrated a flexural strength of 900–1200MPa, and a fracture toughness of 9–10MPam$^{1/2}$ [8].

Long-term clinical results for zirconia all-ceramic restorations are not available at the present time. In short and medium-term studies the Y-TZP core ceramic exhibited a high stability as a framework material [9-11]. No fractures of the zirconia framework have been reported. However, the long-term success of veneered zirconia restorations seems to be determined by the weak performance of the veneering ceramics and its limited bond to the zirconia substrate. Delaminations with exposure of the zirconia core ceramic and minor chip-off fractures of the veneering ceramic were described as the most frequent reason for failures of zirconia FPDs (9, 10)]. Chip-off fracture rates at 15% after 24 months 25% after 31 months and 8% and 13% after 36 and 38 months, respectively were observed [9, 10].

The failure rate of core-veneered all-ceramic restorations revealed that delamination of the veneering porcelain from the core structure is a common failure mode and that restoring such fractures with porcelain repair systems puts high demands on the bonding quality[12]. The strength of a non-homogenous (layered) all-ceramic structure is determined by its weakest component. Usually this will be the core-veneer bond strength or the veneering material itself, which has to be strong enough to withstand the stresses of mastication to prevent delamination and fracture of the veneering material. Many variables may affect the core-veneer bond strength.

All ceramic bilayer restorations were fabricated to be based on the principle of metal-ceramic restorations. The success of metal-ceramic restorations depends upon the firmness of bond between metal and ceramic [13]. The mechanisms of bonding between metal and ceramic are result of the: mechanical, chemical, dendritical, transition phase, and van der Waal's forces [14]. The effect of thermal expansion has been discussed as one of the factors determining the strength of metal-ceramics. The compressive force factor in bond strength contributes from 26–68 %, and results from difference in coefficient of thermal expansion (CTE) between ceramic and metal. On the other hand, crazing and cracking appear unexpectedly and often during laboratory procedures such as firing, cooling, grinding and post soldering. The fundamental cause of cracking is the difference in thermal expansion, except when it is caused by deformation of metal structure

Matching of core-veneer ceramic on behalf of CTE compatibility becomes of practical interest both economic and esthetic reasons. Economically, establishing compatibility between systems might help dental laboratories moderate some expense by combining systems rather than having to stock special veneer porcelains. For the esthetic concern, the range of color, translucency, and opalescence represented in nature is usually not completely encompassed by any one system [15, 16].

Many commercial all-ceramic systems have been introduced into the market have the veneering ceramic which has the CTE value almost similar to the core ceramic materials because the manufacturers are assured that the matched CTE value of core and veneering ceramic provide the best core-veneer bond strength. However, the limited difference of CTE between core ceramic and veneering ceramics is an interesting phenomenon that may affect the core-veneer bond strength. The optimal difference of CTE of the core-veneer ceramic that provide the highest core-veneer bond strength has not been reported.

1.2 Objective of the research

The purpose of this study was to evaluate the role of coefficient of thermal expansion on residual stresses and bond strength of ceramic veneered to yttrium-partially stabilized tetragonal zirconia polycrystal (Y-TZP) ceramic restorations.

1.3 Statistical hypothesis

1.3.1 Residual stresses

H_0 : There is no significant difference in the residual stress among treatment groups of yttrium partially stabilized tetragonal zirconia polycrystal (Y-TZP) ceramic restorations.

H_A : There is significant difference at least for one pair of treatment intervention in the residual stress among treatment groups of yttrium partially stabilized tetragonal zirconia polycrystal (Y-TZP) ceramic restorations.

1.3.2 Shear bond strength

H_0 : There is no significant difference in the mean bond strength among treatment groups of yttrium partially stabilized tetragonal zirconia polycrystal (Y-TZP) ceramic restorations.

H_A : There is significant difference at least for one pair of treatment intervention in the mean bond strength among treatment groups of yttrium partially stabilized tetragonal zirconia polycrystal (Y-TZP) ceramic restorations.

1.3.3 Relation between bond strength and residual stresses

H_0 : There is no relationship between bond strength and residual stresses.

H_A : There is a relationship between bond strength and residual stresses.

1.3.4 Relation between bond strength and and CTE difference

H_0 : There is no relationship between bond strength and CTE difference.

H_A : There is a relationship between bond strength and CTE difference.

1.4 Limitations of the study

It is the intention of this study in an attempt to determine the effect of different CTE on bond strength and residual stress of ceramic veneered to Y-TZP core (Cercon®) ceramic restorations as the treatments faced to clinicians in clinical situations that might be questioned whether there is any alteration of the bond strength and residual stress of the restorations as the effect of CTE mismatches. The bond strength and residual stress of ceramic are the commonly faced to the clinicians in clinical situations. Even though they may not explain all of the properties clinically, the results still provide a benefit information in proper selection of veneering ceramics for Y-TZP core (Cercon®) ceramic restorations that dental clinicians need to aware to attain the all ceramic (Y-TZP veneered) restoration treatments successfully.

1.5 Anticipated outcomes

1.5.1 To provide the data for mean bond strength and residual strength and probability of failure of Cercon® (Degudent GmbH, Hanau-Wolfgang, Germany) all ceramic restorations among various CTE of veneering ceramics.

1.5.2 To initiate clinical performance of the dentists to be aware, knowledgeable and able to select the appropriate veneering ceramic for Cercon®core all ceramic restorations in prosthodontic treatment.

1.5.3 To enhance the capability of the dentists to be capable of choosing the appropriate veneering ceramic for Cercon®core all ceramic restorations.