CHAPTER V
DISCUSSION AND CONCLUSION

5.1 Discussion

For traditional metal ceramic restorations, the CTE is one of the important factors for metal-ceramic compatibility. If the CTE of ceramics is much lower than that of the metal, tangential cracks will form upon cooling as a result of tensile stresses oriented perpendicular to the external surface. Similarly, it the CTE of the metal, cracking will occur in a radial fashion upon cooling. The stresses that cause such cracking are directly proportional to the difference in thermal expansion between the two materials[16]. In this study, used Vickers indentation cracks to determine the residual stress further more can probe the behavior of cracks intersecting interfaces in all-ceramic bilayers, porcelain bonded to Y-TZP core. The result shown the pattern of crack same as the study of Kim JW et al. (2006) that for indentations in the veneering ceramic the lead corner crack will slow down as it approaches the interface and ultimately arrest there.

Taskonak et al. found that core-veneered specimens were stronger compared to mono-layered specimens. Additionally, there was a difference in the longitudinal and horizontal crack dimensions on the surface of the veneering ceramic after indentation. Such findings were attributed to compressive pre-stresses at the surface of the veneering ceramic which are also accompanied by tensile pre-stresses at the zirconia veneer interface. The latter was considered to be responsible for chipping and de-lamination failures of the veneering ceramic during loading which is in agreement with the present finding [4].

The results of this study demonstrated that the core-veneer bond strength is also affected by the CTE of veneering ceramics, the higher bond strength that mean the minimal fracture or de-bonding of all ceramic restorations. For Cercon®core, has CTE 10.5 μm/m•K, the Cercon®ceramkiss and VITAVM®9 which are closely of CTE have the highest SBS (Table17). On the other hand, the IPSdSIGN® which CTE greatest mismatch with Cercon®core has the lowest SBS (2.96±0.83MPa) as the CTE of

IPSdSIGN® has suitable manufactured for metal that has CTE 13.5 μm/m•K, while the metal-ceramic SBS in previous study was 30.16±5.88MPa [5] this results can similarly explain by the reason follow Steiner PJ, 1997.

The shear bond strength of VITAVM®7 and VITADur®alpha were 19.74 and 22.55 respectively, lower than Cercon®ceramkiss and VITAVM®9, because of that the application is aimed specifically at veneering alumina ceramic frameworks that have CTE in range of 7.2-7.9 μm/m•K such as In-Ceram alumina, In-Ceram spinell and In-Ceram zirconia [40, 41].

In this present study, confirming the finding of previous studies, the SBS values of veneering ceramics to their core ceramics in all ceramic restorations ranged between 23-41MPa [12, 42] and 22-28MPa[5], while the other study were 9.4-12.5MPa [8] that may be the different of sample prepared conditions and testing method.

The interpretation of these shear bond strength data requires consideration of the effect of CTE mismatch on core-veneered bonding which has been frequently discussed in the dental literature. The bond strength can be compromised by residual stresses from veneer and core CTE mismatch [12]. To generate acceptable levels of residual stress within a multilayer all-ceramic composite, efforts have been made by dental manufacturers to develop ceramic cores and low fusing veneering ceramics with similar CTE[8]. In the present study the CTE difference varied from 0.77 to 2.97 μm/m•K for the five all-ceramic systems (Table 2), but the measured SBS showed no difference in four pairs except the pair of IPS emax®ceram and VITAVM®9. However, these CTE difference can provided the core-veneer bond in all groups except IPS dSIGN®, while other studies suggest that CTE different should to varied from 0.5 to 1.0 μm/m•K [16].

The influence of CTE on reliability of the shear bond strength has been discussed in terms of Weibull analysis parameter as show in table 20. As expected, the scatter in strength values in all type of veneering ceramics except IPS dSIGN® (suitable for metal-ceramic restorations) are small. Regarding, only the Cercon®ceramkiss and VITAVM®9 have the Weibull modulus (m) greater than five that showed the lower variability of strength and greater homogeneity of the material.

Conversely, the other VITADur®alpha, VITAVM®7 and IPSe.max®ceram have the lower Weibull modulus indicated the lower reliability of strength.

However, in the present study very low correlation between shear bond strength and CTE difference could be found indicating that further parameters affecting the shear bond strength need to be considered similar to the study of Fischer J, 2009. The authors acknowledge that depending on the technical skills, particularly required for the sophisticated layering technique production of all-ceramic bilayers, porosities and micro-gap formations at the interface could be small observed in the present study and may be another factor that provided the low value of Weibull modulus (m) of shear bond strength.

For the view of residual stress, a positive mismatch in the CTE (CTE of veneering ceramic is lower than that core ceramic) between the underlying framework and veneering porcelain which brings the veneer into compression is generally considered to be one of the basic requirements for success of all ceramic restoration. Taskonak et al. used a four step approach to analyze the stresses in bi-layered all-ceramic specimens and found that these specimens were stronger compared to mono-layered. Additionally, there was a difference in the specimens longitudinal and horizontal crack dimensions on the surface of the veneering ceramic after indentation. Such findings were attributed to compressive prestresses at the surface of the veneering ceramic which are also accompanied by tensile prestresses at the zirconia veneer interface. The latter was considered to be responsible for chipping and delamination failures of the veneering ceramic during loading which is in agreement with the present findings [43].

It is important to understand how the stress distribution in dental ceramics can be used to predict failure mechanisms. Stress development mechanisms become more complex especially when bilayer composite ceramics are used for dental restorations. Potential crack formation is typically predicted by the manufacturers using thermal expansion mismatch data of the components in multilayer ceramic composites. Bilayer dental ceramics can exhibit a significant amount of residual stress [44]. Global residual compressive stress in the veneer layer significantly increases the flexural strength of bilayer materials. However, global residual stresses may also be the main cause of chipping or spalling fracture in bilayer all ceramic prostheses when contact damaged in present [45]. Global residual stress refers to uniform stresses distributed within all surfaces. The global stresses usually change in magnitude and sign toward the interior of the specimen and it was depend on the CTE different (ΔCTE) and Tg of each material. Considerable research has been conducted to estimate and measure residual stress in ceramic cause by a mismatch between the coefficients of linear thermal expansion. This study, localized residual stress in veneering side of bilayer ranged between 1.30-3.35 Mpa, found that CTE different affected only at near the interface of veneering side on core-veneer specimen which have the residual stress ranged 1.79-3.35 Mpa while the dilatometric analysis results suggest that the maximum CTE different between veneering ceramic and core materials was 0.77-2.97 μm/m•K.

Bilayer specimens exhibited longer longitudinal cracks than transverse cracks. However, there was no statistically significant difference between the mean indentation-induced transverse and longitudinal cracks of monolithic glass veneer layers. The difference in mean crack lengths was the first indication of residual stress in bilayer specimens [32]. In this study, the crack line which originated in the veneering porcelain could not penetrate into the Y-TZP core, similar to the study of Kim J, 2006 [46].

The X-ray diffraction confirmed that the Y-TZP core ceramic had phase transformation, transformation toughening, cause by stress and temperature. This present study, there was no significant change was observed in nature of X-ray diffraction pattern of the ceramic core, showed m and t in table 27. However there was different in relative amount of tetragonal and monoclinic phases in all of testing groups upon the difference CTE of core and veneering ceramics compared to Y-TZP core specimen. An explanation for this apparent contradiction may be the limitation of the X-ray diffraction technique, the possibility that different toughening mechanisms had resulted in similar values, and the effect of the glass. The errors resulting from using the XRD analysis to measure the amount of the monoclinic phase in the surfaces of the specimens are high, as the transformed zone depth is much smaller than the x-ray penetration [6].

The clinical implication of this study was that the CTE of Y-TZP core ceramic should be higher than veneering ceramic range from 0.77 to 2.97 µm/m•K can provide the acceptable shear bond strength for all ceramic restorations. However, this present study can prove that the Cercon®ceramkiss and VITAVM®9 provided the highest shear bond strength and easy to handle in baking technique.

5.2 Conclusion

This investigation described the role of CTE on residual stresses and bond strength of ceramic veneered to Y-TZP core ceramic restorations. There was a significant different of bond strength in veneering ceramic which has CTE closed to core material. The CTE different 0.77 to 2.97 µm/m•K can provided the core-veneer bond strength which low variability and high homogeneity of Y-TZP all ceramic restorations. However, there were significant different only in localized residual stresses of veneering ceramic in core-veneered ceramics at near the interface (300 µm from interface). There was the phase transformation of Cercon®core due to temperature in firing and stresses from veneering procedure in all groups. Thus, proper selection of veneering ceramic, optimal CTE for yttrium-stabilized zirconia core ceramic restorations is extreme importance to assure that all ceramic (Y-TZP veneered) restorations will fulfill according to their expected functional demands.

5.3 Suggestion

This study evaluated the influence of CTE mismatch of core and veneering ceramics upon residual stresses and shear bond strength of core-veneer ceramic bilayer of Cercon®. However upon clinical situation, the core-veneer bilayer must be the tooth shaped and faced other conditions in the mouth. Thus, further studies on the influence of CTE mismatch of core and veneering ceramics to yttrium-stabilized zirconia core ceramic restorations, simulating closer to the clinical situation would perhaps provide scientific evidences for clinical practice.