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THE INFLUENCE OF CERAMIC VENEERING TECHNIQUE AND COPING-VENEER RATIO ON FRACTURE TOUGHNESS OF IMPLANT RETAINED ZIRCONIA AND METAL-CERAMIC CROWNS

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ABSTRACT

Zirconia (Zr) restorations are one of the exceptional innovations in modern dentistry. Although Zr demonstrates good stability as a framework material, veneer fracture and chipping has emerged as a common limitation for Zr ceramic crowns (ZCC) in function. The purpose of this study is to investigate the influence of veneering technique and veneer-coping (V/C) thickness and ratio on the fracture toughness of implant retained zirconia ceramic crowns (ZCC) and metal ceramic crowns (MCC). In study A, 40 zirconia and metal copings were divided into 2 groups of 0.5mm and 1mm coping thickness (n=20). Half of the 0.5mm and 1mm copings (ZCC & MCC) were veneered with an overall thickness of 3mm and 4mm respectively. Half of all copings (ZCC & MCC) were veneered using layering (LR) and the remaining half using hot press (HR) method (n=10). In study B, seventy copings each of metal and zirconia were fabricated using the CAD-CAM technique. Veneering ceramic was applied using hot-pressing technique for both MCC and ZCC specimens. The groups within each material (ZCC & MCC) were based on different coping thickness (0.5,0.7 & 1.0mm) and overall sample (2.0, 2.3 & 2.5mm) thickness. Specimens in each group were assessed for fracture toughness using micro-indenter. Crack lengths for specimens were evaluated to calculate KIC (fracture toughness). All specimens were cemented to titanium implant abutments and tested using micro indenter. Crack lengths for all specimens was measured which was then utilized to calculate fracture toughness. ANOVA was utilized to analyze the results. In study A, V/C thickness of 2.5/0.5 and 3.5/0.5 showed significantly better ($p=0.001$) fracture toughness as compared to V/C thickness of 2/1 and 3/1 for implant retained ZCC. MCC (V/C 2.5/0.5) showed significantly higher fracture toughness (3.18 ± 0.74 MPa, $p= 0.01$) as compared to ZCC of similar V/C thickness (2.77 ± 0.29 MPa). Fracture toughness (KIC) values for LR and HR veneered zirconia copings of similar V/C thickness were comparable ($p=0.409$). For study B, among MCC specimens, increasing V/C ratio showed higher KIC ($p=0.019$). Increasing veneer thickness from 1.3mm (2.71 ± 0.32 MPa) to 1.8mm (3.36± 0.58 MPa) improved ($p=0.006$) KIC, however KIC values were comparable ($p=0.086$) with different coping thickness for MCC specimens. For ZCC specimens, V/C ratio ($p=0.0444$), veneer thickness ($p=0.035$) and coping thickness ($p=0.032$), all showed significant influence on KIC. Veneer-coping ratio significantly influenced fracture toughness of veneered implant retained ZCC ($p<0.05$) and maximum KIC among ZCC was achieved for 3mm specimens with a V/C thickness of 2.5/0.5mm (2.91± 0.43) . Ceramic veneering technique did not influence fracture toughness of bilayered ZCC. Overall MCC showed higher KIC compared to ZCC specimens. Coping thickness, veneer thickness and V/C ratio showed significant influence on fracture toughness of bilayered ZCC specimens. Veneer thickness and V/C ratio showed significant influence on fracture toughness of bilayered MCC specimens..

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CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

All ceramic restorations have revolutionized esthetic dentistry. However until recently they were regarded to have limited clinical applications with little predictability due to compromised mechanical properties and fracture resistance. All ceramic zirconia based restorations have shown the potential to be used for both anterior and posterior, tooth and implant supported crowns and bridges due to their excellent mechanical properties (Gravie and Pascoe 1975). They comprise of an opaque zirconia coping veneered by layers of compatible glass ceramics.

Is has high stability as a framework material, however an unacceptable failure rate of YSZ restorations due to fracture and chipping of veneering ceramic has emerged (Sax et al., 2011, Beuer et al., 2009a, Sailer et al., 2007b, Sailer et al., 2006, Raigrodski et al., 2006). In a recent study by Rabel et al., (Rabel et al., 2018) failure rates for veneered all ceramic single crowns ranged up to 9% (chipping for a 5 years follow-up, however overall survival rates were as high as 94%. This mechanical failure either occurs at the core veneer interface or in the veneering ceramic itself. The veneering ceramics have lower fracture toughness as compared to zirconia cores. The conventionally used layering technique for veneering YSZ using inherently weaker glass ceramics potentially induce surface flaws and shrinkage. Consequently, micro cracks and porosities originating from the inner and outer surface of bilayered restorations result in damage and failure. Although not new, heat pressing of pre-sintered ingots is another technique for veneering metal and YSZ cores. As it minimizes the internal flaws of ceramic and processing shrinkage, it has the potential for replacing layering technique for veneering YSZ cores (Goldin et al., 2005a).

The design of metal ceramic crown (MCC) is well established and the support and design of metal copings has long provided predictability to these restorations (Warpeha and Godkind, 1976). One of the important factors influencing the fracture toughness of YSZ bilayered ceramics is thickness of materials (coping and veneer) and comparative ratio. Reports have recommended the use of MCC design to be implemented in