

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

**Influence of converging angles on the marginal  
adaptation and the fracture strength of CAD\CAM  
ceramic copings**

**A Thesis**

**Submitted to the Faculty of Oral and Dental Medicine, Cairo  
University for Partial Fulfillment of the Requirements For Master  
Degree**

**In**

**Fixed Prosthodontics**

**By**

**Aya Ahmed Mohammed**

**(B.D.S)**

**Ain-Shams University (٢٠٠٦)**

**Faculty of Oral and Dental Medicine**

**Cairo University**

**٢٠١١**

## ***ABSTRACT***

**Objective:** The aim of this study was to investigate the influence of converging angles on the marginal adaptation and the fracture strength of CAD/CAM ceramic copings.

**Materials and Methods:** Three stainless steel metal dies representing a prepared mandibular first molar were used with three different convergence angles ( $^{\circ}$ ,  $10^{\circ}$  and  $12^{\circ}$  respectively). All of the metal dies received a preparation of  $10$  mm cervical diameter,  $7$  mm height and  $1.0$  mm occlusal reduction. The finish line was rounded shoulder with  $1$  mm thickness. A total of  $10$  ceramic copings ( $^{\circ}$  for each convergence angle degree) were constructed on the stainless-steel dies using the milling machine. Vertical marginal gap measurements were recorded using a stereomicroscope; the mean of marginal accuracy in microns was calculated for each group of samples. The copings were subjected to fracture resistance testing using Universal Testing Machine and the mean in Newton was calculated for each group of samples. Data were collected, tabulated and statically analyzed.

**Results:** ANOVA test showed that there was a statistically significant difference between the three groups ( $P\text{-value} < 0.001$ ). Pair-wise comparisons between the three groups showed that there was no statistically significant difference between  $^{\circ}$  and  $10^{\circ}$  degrees ( $0.26 \pm 0.1 \mu\text{m}$ ,  $4.9 \pm 0.8 \mu\text{m}$  respectively); both showed the statistically significantly highest mean marginal gap distances,  $12^{\circ}$  degrees ( $3.2, 2 \pm 2.2 \mu\text{m}$ ) showed the statistically significantly lowest mean marginal gap distance. Pair-wise comparisons between the three groups showed that  $12^{\circ}$  degrees convergence ( $411.4 \pm 6.6$  N), recorded the statistically significantly highest mean fracture resistance; this was followed by  $10^{\circ}$  degrees ( $349 \pm 31.2$  N) and  $^{\circ}$  degrees ( $242.8 \pm 0.1$  N) group recorded the statistically significantly lowest mean fracture resistance.

**Conclusions:** It was found that increasing the axial convergence angle of the ceramic copings diminished their marginal gap distance and increased their fracture resistance values.

**KEYWORDS:** Cerec, CAD/CAM, Convergence angle, Fracture Strength, Marinal adaptation.

# **Supervisors**

**Dr. Hesham Katamesh**

**Professor, of Fixed Prosthodontics,  
Vice Dean, Faculty of Oral and Dental Medicine, Cairo  
University.**

**Dr. Omaira El-Mahallawi**

**Professor, of Fixed Prosthodontics,  
Faculty of Oral and Dental Medicine,  
Cairo University.**

# **Contents**

## **Page**

---

<b>List of Figures</b>	<b>i</b>
<b>List of Tables</b>	<b>IV</b>
<b>Introduction</b>	<b>١</b>
<b>Review of Literature</b>	<b>٤</b>
<b>Aim of the study</b>	<b>٢٤</b>
<b>Materials and Methods</b>	<b>٢٥</b>
<b>Results</b>	<b>٥٦</b>
<b>Discussion</b>	<b>٦٤</b>
<b>Summary and Conclusion</b>	<b>٧٦</b>
<b>References</b>	<b>٧٩</b>
<b>Arabic Summary</b>	<b>١</b>

## *Dedication*

*I will never be grateful enough to my family for standing beside me all over the way and for being the reason of each and every step forward in my life. My beloved Father (Dr. Ahmed Saad) who taught me everything in my life & for his extreme support and care, My Mother who supported me through the whole work and get worried till it came out to the light, My Husband (Dr. Kareem Ahmed Farid) for sharing with me all the effort and worries. And last but not least my dear brother and sister for being supportive throughout my life.*

## **Acknowledgement**

First of all, I feel thankful to *Allah* for giving me the guidance and internal support in all my life and in every step that I made until this study was completed.

I would like to express my deep appreciation to Dr. Hesham Katamesh Professor, of Fixed Prosthodontics, Faculty of Oral and Dental Medicine, Cairo University, for his extreme support, valuable ideas, stimulating discussion, enlightening guidance, and his keen supervision throughout the research program, which was instrumental in achieving the completion of this study.

I would like to express my heartfelt thanks and deep gratitude to Dr. Omaima El Mahallawi Professor, of Fixed Prosthodontics, Faculty of Oral and Dental Medicine, Cairo University, for her unforgettable help, advice, wise guidance, and fruitful assistance during the course of this research.

I would like to thank Dr. Hesham Amr Lecturer, of Fixed Prosthodontics, MSA University, for his valuable help in the preparation of my samples and getting this study into light.

**Last but not least, I would like to thank all my colleges who showed and gave all the valuable support throughout the research program.**



## **List of Figures**

	<b>Page</b>
<b>Figure ١:</b> IPS e.max CAD premilled ceramic blocks.	٢٥
<b>Figure ٢:</b> Stainless steel die.	٢٧
<b>Figure ٣:</b> Three different convergence angles.	٢٧
<b>Figure ٤:</b> Die prepared to be conical in shape.	٢٨
<b>Figure ٥:</b> An antirational groove.	٢٨
<b>Figure ٦:</b> The start up menu of the program.	٣١
<b>Figure ٧:</b> New restoration type selection.	٣١
<b>Figure ٨:</b> Tooth selection (no. ٤٦).	٣٢
<b>Figure ٩:</b> Select material.	٣٢
<b>Figure ١٠:</b> VITA Cerec propellant powder.	٣٣
<b>Figure ١١:</b> Impression screen.	٣٣
<b>Figure ١٢:</b> Die Sprayed with cerec propellant powder.	٣٤
<b>Figure ١٣:</b> inEos scanner.	٣٤
<b>Figure ١٤:</b> Die secured on the specific tray of the inEos scanner using specific clay.	٣٥

<b>Figure ١٥:</b> Digital photo of the die.	٣٧
<b>Figure ١٦:</b> A ٣D model of the die.	٣٧
<b>Figure ١٧:</b> Tracing of the preparation margins.	٣٨
<b>Figure ١٨:</b> Adjustment of insertion axis	٣٨
<b>Figure ١٩:</b> Selection of material.	٣٩
<b>Figure ٢٠:</b> Buccal view of the coping.	٣٩
<b>Figure ٢١:</b> Occlusal view of the coping.	٤٠
<b>Figure ٢٢:</b> Internal view of the crown coping.	٤٠
<b>Figure ٢٣:</b> Milling screen.	٤١
<b>Figure ٢٤:</b> Mill icon.	٤١
<b>Figure ٢٥:</b> IPS e.max CAD blocks (C١٤).	٤٢
<b>Figure ٢٦:</b> IPS e.max CAD block in its place in the milling machine.	٤٣
<b>Figure ٢٧:</b> Closure of the milling machine door.	٤٣
<b>Figure ٢٨:</b> Scanning of the block dimension.	٤٤
<b>Figure ٢٩:</b> IPS e.max CAD block milling.	٤٤
<b>Figure ٣٠:</b> IPS e.max CAD block after milling displaying a bluish color.	٤٦

<b>Figure ٣١:</b> Checking of coping on its corresponding metal die.	٤٦
<b>Figure ٣٢:</b> IPS Object-fix material.	٤٧
<b>Figure ٣٣:</b> Crystallization furnace.	٤٧
<b>Figure ٣٤:</b> IPS e.max CAD coping after crystallization displaying a whitish color.	٤٨
<b>Figure ٣٥:</b> Stereomicroscope.	٥٠
<b>Figure ٣٦:</b> Specially designed holding device.	٥٠
<b>Figure ٣٧:</b> Photo shot of marginal gap.	٥١
<b>Figure ٣٨:</b> Lloyd universal testing machine.	٥٣
<b>Figure ٣٩:</b> Stainless steel dies secured to the machine.	٥٤
<b>Figure ٤٠:</b> Fracture of the coping.	٥٤
<b>Figure ٤١:</b> Bar chart for mean marginal gap for the copings of the three groups.	٥٨
<b>Figure ٤٢:</b> Bar chart for mean fracture resistance for the copings of the three groups.	٦١
<b>Figure ٤٣:</b> Scatter diagram showing negative (inverse) correlation between fracture resistance and marginal gap distance.	٦٣

## **List of Tables**

	<b>Page</b>
<b>Table ١:</b> Samples Grouping.	٢٩
<b>Table ٢:</b> Crystallization cycle of IPS e.max CAD copings.	٤٥
<b>Table ٣:</b> Mean and standard deviation (SD) of marginal gap distance values measured in $\mu\text{m}$ for copings fabricated with different convergence angles using CAD/CAM technique.	٥٧
<b>Table ٤:</b> Mean and standard deviation (SD) of fracture resistance values measured in N for the copings fabricated with different convergence angles using CAD/CAM technique.	٦٠
<b>Table ٥:</b> Results of Pearson's correlation coefficient for the correlation between fracture resistance and marginal gap distance.	٦٢

## **Introduction**

Material selection is one of the most important factors for the success of crowns and other extra-coronal restorations. Material properties, such as the strength of the restoration, how well it fits, its aesthetics, also wear resistance and biocompatibility dictates the long-term efficiency of fixed restorations.

The use of all-ceramic materials for fixed restorations has become a key topic in aesthetically oriented dentistry. Recently, all-ceramic crowns have come into wide use in the posterior region as well as the anterior region because of their natural look and excellent biocompatibility.

Ceramics are basically brittle materials, having low tensile strength, and fracture toughness; therefore all-ceramic crowns have always come with some risk of fracture. To prevent crown fractures, it is not only necessary to use as strong material as possible, but also to fabricate the crowns with the best fit possible, providing good structural durability.

Poor marginal fit can lead to secondary caries, periodontal disease, and endodontic inflammation due to microleakage from the oral cavity, and clinical failures of the fixed restoration. Misfit in all-ceramic crowns can also affect their fracture strength and thus reduce longevity.

Adequate marginal adaptation is therefore an important criterion to consider when evaluating the success of all-ceramic restorations. The current clinically acceptable marginal opening is between 0.0 and 0.2 mm.

Many factors influence the fracture resistance and marginal adaptation of crowns, including the type of cement, cementation technique, use of die spacer, and tooth preparation geometry.

Degree of convergence angle can affect both the mechanical and the biological considerations; which will consequently affect the fractural resistance and the maximum marginal adaptation of the ceramic copings.

Yet there has been relatively few studies and no clear understanding on the influence of the abutment taper on the marginal fit and fractural resistance of all-ceramic copings.

Computer-aided design/computer assisted manufacture (CAD/CAM) systems are rapidly gaining importance in dental practice as some of their products aim to combine aesthetics with strength and facilitated the development of superior dental ceramics.

Using this system, procedures may be performed without intermediate appointments, thereby decreasing cost, time and the chance of contamination during the provisional phase. However, many investigators have criticized the marginal accuracy of these restorations.

As patients are primarily concerned with improved aesthetics, and dentists are interested in the longevity of restorations in term of strength and fitness, so studying the marginal adaptation and fracture resistance was the goal of this study.

## **Review of literature**

The traditional metal ceramic system allows maximal strength but at the same time there is growing concern among clinicians over the safety implications of using base metal restorations intra-orally and the light transmission properties which are completely different from those of the natural teeth. Patient esthetic expectations and need for biologically compatible materials lead to an increase in demand for ceramic restorations. <sup>1-2</sup>

Dental ceramic materials provide essential advantages over metal-ceramic and gold restorations. Not only do they offer superior aesthetic properties but also increased biocompatibility with tissues of the periodontium and pulp as well as radio-opacity which is similar to that of the natural tooth structure. <sup>3</sup>

Dental ceramics have a composite structure consisting of a crystalline phase or phases within a glassy matrix. Clinical experience with all ceramic restorations breaking under occlusal load confirms that these materials are generally susceptible to stress corrosion and slow crack growth. <sup>4</sup>

There are now a number of porcelain systems in the market and research is continuing to develop materials which are strong, aesthetic and suitable for multiple applications, including crowns, bridges, inlays and onlays. Some materials rely on the production of an opaque, heavily reinforced core over which weaker but more aesthetic layers of porcelain are built eg In-Ceram and AllCeram.