

The effect of different scanning techniques on the retention of monolithic zirconia crowns constructed with two convergence angles

A thesis submitted for the partial fulfillment of the
Doctor Degree in Fixed Prosthodontics, Faculty of
Dentistry, Ain Shams University

By

Omar Ahmed Fouad El Sergany

BDs , MD.Sc.
Faculty of dentistry,
Ain Shams University

2018

Supervisors

Prof. Dr. Tarek Salah El-Din Morsi

Professor and Head of Fixed Prosthodontics Department,
Faculty of Dentistry, Ain Shams University

Dr. Maged Mohamad Zohdy

Assistant Professor of Fixed Prosthodontics
Faculty of Dentistry, Ain Shams University

Dr. Ahmed Ezzat Sabet

Assistant Professor of Fixed Prosthodontics
Faculty of Dentistry, Ain Shams University

Dedication

This work is dedicated to

My Dear parents

Beloved wife and sisters

My brothers in law

My beloved son Selim

And our father Prof. Dr. Tarek
Abbass , and all my friends and
colleagues

Acknowledgement

At the beginning, I would like to thank **God** for this accomplishment

No words can express my deepest thanks and sincere gratitude to **Prof. Dr. Tarek Salah Morsi** Head of Fixed Prosthodontics Department, Faculty of Dentistry, Ain Shams University, for his generous support, valuable advices and devoted effort.

I am grateful for the endless guidance and advices provided by my mentors and elder brothers **Dr. Maged Zohdy** and **Dr. Ahmed Sabet** Ass. Professors at Fixed Prosthodontics Department, Faculty of Dentistry, Ain Shams University.

Last but not least, deepest thanks to my dear professors, colleagues and staff members at British University in Egypt and Ain Shams University for their great support and cooperation. Special thanks to my friend and brother Dr. Med Dent Ka mal Ebeid for his great help in this study.

List of Contents

Title	Page No.
• List of figures.....	II
• List of tables.....	V
• Introduction.....	1
• Review of Literature.....	3
• Aim of the Study.....	34
• Materials and Methods.....	35
• Results	67
• Discussion	79
• Summary and Conclusions.....	88
• References.....	92
• Arabic Summary	

List of figures

Figure 1: Stainless steel die with 12□ convergence	39
Figure 2: Stainless steel die with 20□ convergence	40
Figure 3: Acrylic base accommodating the dies	40
Figure 4: Epoxy die with 12□ convergence	42
Figure 5: Epoxy die with 20□ convergence.....	42
Figure 6: Impregum impression.....	43
Figure 7 : Impregum impression	44
Figure 8: Vaccum mixer	45
Figure 9: Gypsum model	46
Figure 10: Omnicam intraoral scanner	47
Figure 11: scanned die from group A2	47
Figure 12: Administration window for collab 2017	48
Figure 13: Selection of impression scanning mode	49
Figure 14: Scanning impression.....	49
Figure 15: Scanning model	50
Figure 16: scanned 3D model	51
Figure 17: Editing the preparation margin for group B1	52
Figure 18: Editing the preparation margin for group C1	52
Figure 19: Determining the insertion axis.....	53

Figure 20: The proposed crown design.....	54
Figure 21: Designing with fixed measurements and adding wings	54
Figure 22: Occlusal view with added wings.....	55
Figure 23: Nesting of crowns using DentalCam software	56
Figure 24: vhf 5-axis milling machine	56
Figure 25: Drying lamp	57
Figure 26: Nabertherm Sintering furnace.....	58
Figure 27: Arrangement of crowns in Sintering bowl	58
Figure 28: Sintering cycle chart.....	59
Figure 29: Hydraulic press seating device	60
Figure 30: Diagram showing measuring points for each replica	61
Figure 31: Replica cut in buccolingual direction.....	61
Figure 32: Light microscope used to measure internal fit	62
Figure 33: Replica of axial fit	62
Figure 34: Replica of occlusal fit.....	63
Figure 35: Cementation using a specially designed loading device.	64
Figure 36: Instron universal testing machine	65
Figure 37: Pulling off the crowns using specially designed loop	65
Figure 38: Bar chart showing mean internal misfit values in μm for all subgroups	70

Figure 39: : Bar chart showing mean internal misfit values in μm for different degrees of convergences	72
Figure 40: Bar chart showing mean internal misfit values in μm for different scanning techniques	73
Figure 41: Bar chart showing mean internal misfit values in μm for different surfaces	74
Figure 42: Bar chart showing mean retention values in newtons for all subgroups	76
Figure 43: Bar chart showing mean retention values in Newtons for different degrees of convergences	77
Figure 44: Bar chart showing mean retention values in N for different scanning techniques	78

List of tables:

Table 1: Materials used in the study	35
Table 2: Scanners used in the study.....	37
Table 3: Experimental Factorial Design	38
Table 4: Two-way ANOVA table showing significance of different variables and their interactions.....	69
Table 5: Means $\pm$ SD of internal fit in μm for all subgroups.....	70
Table 6: Mean $\pm$ SD for the internal fit (μm) for different degrees of convergence	71
Table 7: Mean $\pm$ SD for the internal fit (μm) for different impression techniques	73
Table 8: Mean $\pm$ SD of internal misfit related to axial and occlusal surfaces.	74
Table 9: Two-way ANOVA table showing significance of different variables and their interaction.	75
Table 10: Means $\pm$ SD of retention in Newtons for all subgroups.....	76
Table 11: Mean $\pm$ SD for retention values (N) for different degrees of convergences.....	77
Table 12: Mean $\pm$ SD for the retention (N) for different scanning techniques	78

Introduction

Full coverage crowns are one of the most common fixed prosthodontic treatments, and for many years elastomeric impression materials have been used in their fabrication with success. Recent technological advancements have introduced alternatives to conventional impression methods through the use of Computer Aided Design-Computer Assisted Manufacturing (CAD-CAM) and intra-oral digital scanners. These new technologies may offer similar or better results compared to conventional methods. Some benefits of CAD-CAM production may include a more standardized method of prosthesis fabrication and the use of highly homogenous materials. Additionally, the workflow associated with prosthesis fabrication by digital impression methods may offer benefits such as decreased length and number of appointments, and decreased material cost.

For intra-oral and extraoral scanning devices to be considered an acceptable alternative to conventional impressions methods, it is important that they yield crowns with similar or better clinical success. Of factors that can predict clinical success are internal fit and retention, which should be as maximum as possible.

The everyday improvement in the digital dentistry and the outstanding technologies present make it obligatory that one should follow and understand the benefits and limitations of such technologies.

Statement of problem:

Evolution of digital dentistry had lead to production of multiple scanning techniques. The effect of these scanning techniques on the accuracy of final restorations needs to be more closely assessed.

Review of literature

All the required steps during the fabrication of a crown necessitate precision and exactness in order to produce an accurately fitting restoration. Recent advances in technology have dramatically altered impression and crown fabrication procedures; specifically, digital impressions and computer-aided design/computer-aided manufacturing (CAD/CAM) systems have been introduced in dental clinical practice.

The impression of the hard and soft tissue of the oral cavity is one of the most crucial steps for a successful dental restoration. The dental impression can strongly affect the fit and accuracy of the indirect restoration. Over the past several decades, the impression materials have changed and today with proper selection and manipulation, excellent impressions can be obtained¹⁻⁶. In addition to the impression material, the choice of the impression technique is of great importance⁷. The combination of the proper material, the most reliable technique and adequate understanding and knowledge by the operator gives the most accurate result⁸. The introduction of dental digital impressions is a breakthrough in our specialty⁹⁻¹². Digital or virtual impression systems have the potential to produce accurate results while simplifying the entire prosthesis fabrication process, since several laboratory steps are eliminated¹³⁻¹⁶. Nevertheless, the recent introduction, the limited use and the very limited research with conflicting results do not allow for valid conclusions with regard to the accuracy and reliability of digital impression systems¹⁷.

Most digital impression systems are designed to be used in conjunction with all ceramic restorations. This has coincided with the growing demand for all-ceramic restorations that most closely mimic tooth

appearance and the development of all-ceramic materials with strength comparable to metal-ceramic restorations¹⁸⁻²¹.

Dental impressions

The dental impression is of great importance in dentistry in general, and in fixed prosthodontics in particular. The materials and techniques have gone through major evolution throughout the years. At the beginning, rigid materials including zinc oxide eugenol paste, wax, modeling compound and impression plaster were used. Because of the obvious rigidity, distortion and breakage that occurred, their use was significantly reduced during the later years. In the 20th century, elastomeric materials were introduced.

They are classified as aqueous and non-aqueous elastomers. The first category consists of the reversible hydrocolloid (agar) and the irreversible hydrocolloid (alginate). Agar is dimensionally unstable thus casts must be poured immediately. Alginate is the most commonly used material for diagnostic impressions, mainly because it is inexpensive. However, it is also dimensionally unstable and it must be poured within 10 minutes to get better results¹.

The second category, non-aqueous, consists of polysulfides (1950), condensation silicones (1955), polyethers (1965) and addition silicones (1975). Polysulfides were also called “rubber base”; they reproduced details with excellent results, were not rigid and captured subgingival margins but they were dimensionally unstable, did not have good elastic recovery and had long setting time. For the condensation silicones, the release of ethyl alcohol during polymerization that causes shrinkage was the main disadvantage.

However, it was shown that this shrinkage was greater in the low viscosity than in the putty-like viscosity. Polyethers are hydrophilic (contact angle 49 degrees); thus they have superior detail reproduction in the presence of moisture. They are, also dimensionally stable and they provide an excellent reproduction of detail. However, strict disinfection guidelines should be respected in order to prevent expansion. Also, their rigidity makes them more difficult to remove than addition silicones and more likely to fracture delicate gypsum dies.

Addition silicones, Polyvinyl siloxanes (PVS), have become the most widely used impression material in dentistry³. They have the best detail reproduction and elastic recovery of all available materials, and their dimensional stability allows multiple pours; thus, PVS materials are the materials of choice in fixed prosthodontics^{3,4}. They are moderately rigid, have good tear strength, relatively short setting time and can be used with most disinfection protocols. Their disadvantages include susceptibility to contamination as a result of sulfur and sulfur compound and hydrophobic behavior (contact angle 98 degrees) caused by hydrophobic aliphatic hydrocarbon groups around the siloxane bond. Today, in order to overcome this, nonionic surfactants (nonylphenoxypolyethanol homologues) have been incorporated and the new PVS materials, have improved wettability (contact angle 53 degrees); however they are still clinically acceptable only in dry conditions².

According to the ANSI/ADA Specification No. 19 (ISO 4823) regarding detail reproduction, all elastomeric materials, except from very high-viscosity products, should reproduce a V-shape groove and a 0.02mm wide line². **Walker et al.** evaluated the detail reproduction of polyether and PVS material by observing the continuous replication of at least two out of

three horizontal lines²². The impressions were made under dry and moist conditions. They found that under dry conditions all materials produced satisfactory detail reproduction 100% of the time; however under moisture only 29% of PVS materials produced satisfactory detail while 100% of polyether met the detail criteria.

Dimensional stability over time allows the operator to pour the impression at any time. *Thongthammachat et al.* evaluated the influence on dimensional accuracy of dental casts made with different types of trays and impression materials when they were poured at different and multiple times⁸. The researchers concluded that an impression made from polyether should be poured only once within one day after impression making because of the distortion of the material that occurs over time. Addition silicone impression materials had clearly better dimensional stability than polyether up to 720 hours which is in agreement with previous studies²³. In the study, addition silicone also showed deviations increasing over time, but these were relatively small. The possibility of imbibition should be considered- especially with polyether impression materials due to the fact that polyether absorbs water from the gypsum and swells with each successive pour.

Elastic recovery allows the material to return to its original dimensions when the impression is removed from the mouth. No contemporary material has 100% elastic recovery. PVS materials have the best elastic recovery at over 99% with a specific test undercut²⁴.

In addition to the material, the impression technique is a factor that has been studied with relation to the influence on the success of the impression. *Hung et al.* reported that the accuracy of addition silicone was affected more by the type of materials than by the technique²⁵, while *Johnson and Craig* stated that accuracy could be better controlled with