



# **IN VIVO AND IN VITRO EVALUATION OF RESIN- BONDED PORCELAIN RESTORATIONS**

**S. ETEMADI**

Department of Dentistry  
The University of Adelaide

Submitted as a Partial Requirement for the  
Degree of Master of Dental Surgery  
in Conservative Dentistry

December 1996

## DECLARATION

This work contains no material which has been accepted for the award of any other degree in any university or other tertiary institution, and to the best of author's knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

This work will be available for loan and photocopying, when deposited in the University Library.

S. Etemadi

Candidate for the Degree of Master of Dental Surgery

December 1996

Signed \_

Dated 19,12,96

## ACKNOWLEDGEMENTS

Many people have contributed towards making this research report possible.

First of all I must thank my principal supervisor, Professor R.J. Smales, for his invaluable assistance and support during this research project. His dedication to the dental profession has been a constant source of inspiration. My sincere thanks for his unlimited guidance, patience and support. To my co-supervisor, Associate-Professor L.C. Richards, for his kind support and understanding when I needed it, my sincere thanks also. Many thanks to Mr. David A. Wester for his special expertise in data processing and for much of the statistical analysis, and to Mrs. Grace Y.T. Chan for typing the report.

I must thank Drs P.W. Drummond and J.R. Goodhart for being so helpful and understanding. I appreciated their assistance during the data collection, and their encouragement and sharing of knowledge. Many thanks also to their staff for being tolerant of my intrusion into their daily routines.

I would like to dedicate this report to my husband, Mohammad Reza, for his unlimited support and understanding. His expertise in computing and data analysis were an invaluable help to me during the completion of this project. His love and patience were the greatest encouragement for me, which kept me going despite many obstacles. He was always there for me when I needed him, while he was studying himself and had his own difficult times. I thank my daughter, Negar, for being so nice during this time. This report is also dedicated to my parents for their life-time encouragement and support.

## TABLE OF CONTENTS

SUMMARY .....	1
---------------	---

### **CHAPTER ONE INTRODUCTION**

1.1 INTRODUCTION .....	4
1.2 HISTORY OF RESTORATIVE MATERIALS .....	5
1.2.1 AMALGAM .....	5
1.2.2 GOLD .....	6
1.2.3 RESIN COMPOSITE .....	6
1.2.4 DENTAL PORCELAIN .....	7

### **CHAPTER TWO LITERATURE REVIEW**

2.1 LITERATURE REVIEW .....	13
2.1.1 MARGINAL ADAPTATION .....	13
2.1.2 BOND STRENGTH .....	17
2.1.3 PREPARATION DESIGN .....	24
2.1.4 PORCELAIN STRENGTH .....	28
2.1.5 BIOCOMPATIBILITY .....	39
2.1.6 CLINICAL BEHAVIOUR .....	41

### **CHAPTER THREE RESEARCH OBJECTIVES**

3.1 RESEARCH OBJECTIVES .....	53
-------------------------------	----

### **CHAPTER FOUR METHODS AND MATERIALS**

4.1 INTRODUCTION .....	55
4.2 DEFINITION OF RESTORATIONS .....	55
4.3 SAMPLE SELECTION .....	57
4.4 PART ONE: RESTORATION DESIGNS AND DIMENSIONS .....	57
4.4.1 PATIENT DETAILS .....	58
4.4.2 RESTORATION DETAILS .....	58

4.4.3	MEASUREMENTS.....	58
4.4.3.1	<i>Intercuspal Width</i> .....	59
4.4.3.2	<i>Isthmus Width</i> .....	59
4.4.3.3	<i>Proximal Width</i> .....	59
4.4.3.4	<i>Height of axial wall</i> .....	59
4.4.3.5	<i>Depth of Occlusal Floor from the Central Fissure</i> .....	60
4.4.3.6	<i>Cusp Reduction</i> .....	60
4.4.4	PREPARATION CHARACTERISTICS: .....	60
<b>4.5</b>	<b>PART TWO: RESTORATION FAILURES AND SURVIVALS.....</b>	<b>63</b>
4.5.1	BASELINE DATA.....	63
4.5.2	GENERAL ORAL FEATURES .....	63
4.5.3	RESTORATION INFORMATION .....	64
4.5.4	BASIC PROBLEMS WITH THE PREPARED TOOTH .....	65
4.5.5	REASONS FOR RESTORATION PLACEMENT .....	65
4.5.6	RECORDED DATES AND RESTORATION IDENTIFICATION .....	66
4.5.7	FAILURE DATA: .....	67

## CHAPTER FIVE RESULTS AND DISCUSSIONS

INTRODUCTION .....	69
<b>5.1 SECTION ONE - PREPARATION DIMENSIONS AND DESIGN.....</b>	<b>69</b>
5.1.1 GENERAL DATA .....	69
5.1.2 MEASUREMENTS.....	71
5.1.2.1 <i>Intercuspal Width</i> .....	71
5.1.2.2 <i>Isthmus Width</i> .....	72
5.1.2.3 <i>Proximal Width</i> .....	73
5.1.2.4 <i>Height of Axial Wall</i> .....	74
5.1.2.5 <i>Depth of Occlusal Floor from Central Fissure</i> .....	75
5.1.2.6 <i>Cusp Reduction</i> .....	77
5.1.3 PREPARATION CHARACTERISTICS .....	78
5.1.3.1 <i>Gingival Margin in Dentine or Enamel</i> .....	78
5.1.3.2 <i>Margins Bevelled Occlusally or Gingivally</i> .....	79
5.1.3.3 <i>Opposing Tooth Contact at Restoration Margins</i> .....	79
5.1.3.4 <i>Angular Cavosurface Margins</i> .....	79
5.1.3.5 <i>Sharp Internal Line or Point Angles</i> .....	80
5.1.3.6 <i>Retention Boxes</i> .....	80
5.1.3.7 <i>Metal Reinforcement</i> .....	80
5.1.3.8 <i>Preparation Taper</i> .....	81
5.1.4 EXAMINER RELIABILITY .....	81
5.1.5 LIMITATIONS OF THE STUDY .....	81
5.1.6 <b>DISCUSSION</b> .....	83
5.1.7 <b>CONCLUSIONS AND RECOMMENDATIONS</b> .....	87
<b>5.2 SECTION TWO: RESTORATION FAILURES .....</b>	<b>89</b>

5.2.1	INTRODUCTION .....	89
5.2.2	SAMPLE POPULATION .....	89
5.2.2a	<i>Gender</i> .....	89
5.2.2b	<i>Age Range</i> .....	89
5.2.2c	<i>Distribution of Restorations</i> .....	90
5.2.2c1	<i>Restoration Distribution in Male and Female Patients</i> .....	90
5.2.2c2	<i>Restoration Distribution in Maxilla and Mandible</i> .....	90
5.2.2c3	<i>Restoration Distribution With and Without Metal Reinforcement</i> .....	91
5.2.2c4	<i>Restoration Distribution by Operators</i> .....	92
5.2.2d	<i>Reasons for Restoration Placement</i> .....	92
5.2.2d1	<i>Tooth-Related Reasons</i> .....	92
5.2.2d2	<i>Previous Restoration-Related Reasons</i> .....	93
5.2.3	RESTORATION FAILURES .....	94
5.2.3.a	<i>Failure Types for Different Restorations</i> .....	95
5.2.3b	<i>Failure Types for Different Age Groups</i> .....	98
5.2.3c	<i>Failure Types for Operators</i> .....	98
5.2.3d	<i>Failure Types for Bruxer and Non-bruxer Patients</i> .....	99
5.2.3e	<i>Failure Types with Different Liners/Bases</i> .....	100
5.2.3f	<i>Failure Types with Different Resin Composite Luting Agents</i> .....	101
5.2.3g	<i>Failure Reasons and Treatments after Failures</i> .....	102
5.2.3g1	<i>Debonding</i> .....	103
5.2.3g2	<i>Bulk Fracture</i> .....	103
5.2.3g3	<i>Chip Fracture</i> .....	104
5.2.3g4	<i>Microfracture</i> .....	104
5.2.3g5	<i>Colour Mismatch</i> .....	105
5.2.3g6	<i>Pulpitis</i> .....	105
5.2.3g7	<i>Apparent Failure</i> .....	106
5.2.4	EXAMINER RELIABILITY .....	106
5.2.5	LIMITATIONS OF THE STUDY .....	106
<b>5.3</b>	<b>SECTION THREE: RESTORATION SURVIVALS .....</b>	<b>107</b>
5.3.1:	INTRODUCTION .....	107
5.3.2	RESTORATION SURVIVALS .....	108
5.3.2.1	<i>Survival of All Restoration Types</i> .....	108
5.3.2.2	<i>Veneers With and Without Incisal Coverage</i> .....	109
5.3.2.3	<i>Onlays With and Without Metal Reinforcement</i> .....	110
5.3.2.4	<i>Shell Crowns With and Without Metal Reinforcement</i> .....	110
5.3.2.5	<i>Cantilever and Fixed-Fixed Bridges</i> .....	111
5.3.2.6	<i>Restorations Luted with Different Resin Composite Cements</i> .....	112
5.3.2.7	<i>Restorations in Patients with Parafunctional Habits</i> .....	112
5.3.2.8	<i>Restorations in Patients from Different Age Groups</i> .....	113
5.3.2.9	<i>Restorations in Male and Female Patients</i> .....	113
5.3.2.10	<i>Restorations by Arch Distribution</i> .....	114
5.3.2.11	<i>Restorations Placed by Different Operators</i> .....	115
5.3.3	DISCUSSION.....	116
5.3.3.1	<i>Introduction</i> .....	116
5.3.3.2	<i>Bulk Fracture</i> .....	116
5.3.3.3	<i>Post-Operative Sensitivity</i> .....	122

5.3.3.4	<i>Debonding</i> .....	124
5.3.3.5	<i>Parafunctional Habits</i> .....	125
5.3.3.6	<i>Age Distribution</i> .....	126
5.3.3.7	<i>Arch Distribution</i> .....	127
5.3.3.8	<i>Operators</i> .....	127
5.3.4	<b>CONCLUSIONS AND RECOMMENDATIONS</b> .....	128

<b>REFERENCES</b> .....	<b>130</b>
-------------------------	------------

**APPENDICES**

I.	Materials Details .....	i
II.	Proformas .....	ii
III.	Preparation Dimensions .....	v
IV.	Restoration Failures .....	xxii
V.	Life Tables Estimates.....	xxx vii
VI.	Examiner Reliability .....	li

## Summary

During the last decade, the demand by patients for tooth-coloured restorations has increased. Common problems associated with large resin composite restorations in general dental practice include wear, fracture, and secondary caries. Such problems have restricted their wide-spread use, especially in posterior teeth. Ceramometal restorations, on the other hand, require excessive tooth reduction and may also have aesthetic problems. These limitations resulted in the development of resin-bonded porcelain restorations. Porcelains are well-known as aesthetic and biocompatible materials, and can be a valuable alternative restorative material when appropriate case selection and indications for their clinical use are applied. Many in vivo and in vitro investigations of resin-bonded porcelain restorations have been reported in the literature. The aim of the present study was to investigate whether or not these investigations are relevant to private dental practice. For this purpose, the study was divided into three sections to:

- 1) Investigate the preparation designs used in a specialist private practice, and to compare the dimensions of the dies of fractured posterior single restorations (shell or full veneer crowns, and onlays) with those of similar intact restorations,
- 2) Determine the usual failure modes of resin-bonded porcelain restorations, and
- 3) Evaluate the survival rates of different types of such restorations in a comparative manner.

A total of 536 resin-bonded porcelain restorations were selected from a private practice in which two prosthodontists worked. The restorations comprised shell (full veneer) crowns (229), onlays (97), inlays (9), labial veneers without incisal coverage (64), labial veneers with incisal coverage (46), chip porcelain veneers (15), cantilever bridges (49),



and fixed-fixed bridges (27). Of these restorations, 103 posterior single shell crowns and onlays were selected to investigate preparation dimensions and designs. Measurements of different aspects of the preparations were taken from stone dies of the prepared teeth, for both intact and subsequently fractured restorations, and for restorations with and without metal reinforcement. Measurements were taken of the intercuspal width, isthmus width, height of axial wall, proximal width, depth of occlusal floor from central fissure, and working cusp reduction. Preparation characteristics such as preparation taper, retention grooves, margins finished in dentine or enamel, and type of finishing lines were also assessed.

The results of this study showed that the average porcelain thicknesses were often within the range of those generally recommended in the literature (1.5-2.0 mm). However, thicknesses less than 1.0 mm, and more than 4.0 mm, at the central fissures and over the working-side cusps, were also found following the removal of previous amalgam restorations, and extension of preparations into the access cavities of root canal filled teeth. Preparation dimensions tended to be slightly larger in the fractured restorations. No significant differences were found between the dimensions for shell crowns or onlays fabricated with and without metal reinforcement, although the dimensions of those restorations with metal reinforcement tended to be slightly larger. Preparation tapers were mostly between 21-40° for the intact restorations, and 10-20° for the fractured restorations. Large preparation convergences were more frequently observed after removal of amalgam restorations, but this did not compromise the retention of the restorations.

Of the 536 restorations, 123 (23%) failed. Bulk fracture comprised the highest number of failures recorded in this study (10.4%). Other restoration failures included debonding

(2.8%), pulpitis (2.8%), chip fracture (2.6%), microfracture (1.1%), colour mismatch (1%) and connector-fracture for bridges (0.6%). No recurrent caries was reported. Fixed-fixed bridges showed the highest failure rate (70%) followed by onlays (without and with metal reinforcement), chip porcelain veneers, shell crowns (without metal reinforcement), cantilever bridges, and then veneers without and with incisal coverage. Restorations survivals were analysed using life table methods. The period covered by the study records was from 1988 to mid-1995. The overall survival of all of the restorations at the 75% quartile was  $58.9 \pm 6.2$  months. The results of the survival analyses showed that labial porcelain veneers with incisal coverage showed a better survival than did veneers without incisal coverage. Shell crown restorations demonstrated a better survival than did onlays, but the difference was not statistically significant. Comparison of shell crowns and onlays fabricated with and without metal reinforcement showed that those with a metal substructure survived for slightly longer than did those without a metal substructure. Shell crowns and onlays placed in the maxillary arch had better survivals than those placed in the mandibular arch. Cantilever bridges showed significantly better survivals than did fixed-fixed bridges. The results showed that porcelain restoration thickness was not the most significant factor determining the longevity of resin-bonded porcelain restorations, since many very thin and very thick restorations survived during the period of this study. However, bulk fracture, as expected from the physical characteristics of porcelain materials, was an important failure reason. The use of metal reinforcement of the porcelain in selected cases increased the clinical survivals of the posterior restorations.