# An investigation into surface texture and *in-vitro* two-body wear of CAD/CAM dental materials antagonised by acrylic denture teeth

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Thesis submitted in partial fulfillment of the degree of

Doctor of Clinical Dentistry (Prosthodontics)

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**December 2015**

# Preface

This thesis reports on research completed during my Doctorate of Clinical Dentistry (Prosthodontics) at the University of Adelaide, from January 2012 to December 2014.

Two primary aims of the project were firstly, to investigate surface texture analysis technology use on dental materials, and secondly, to complete a two-body *in-vitro* wear study of modern dental restorative materials opposing a standardized artificial acrylic tooth.

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# Abstract

**Introduction:**

Wear of teeth and of dental materials is a normal chemical and biomechanical process and is one of the physical and behavioral characteristics of dental restorative materials that need to be understood when planning the incorporation of a dental restoration into the stomatognathic system. The aims for this investigation were to analyse and compare two-dimensional (*Ra*) and three-dimensional (*Sa*) methods for surface texture analysis and to apply these methods in a two-body *in-vitro* wear study using PMMA-acrylic denture teeth as antagonists and a range of commonly used dental restorative materials as test specimens. The material wear characteristics of the antagonist and sample materials were analysed both qualitatively and quantitatively in order to better improve the decisions made by clinicians

**Methods and Materials:**

The dental materials analysed are all commercially available CAD/CAM materials for clinical dentistry. They included three monolithic zirconia materials (BruxZir™, Lava Plus™, DenZir™), a lithium disilicate ceramic (eMax™), a nano-ceramic composite resin (Lava Ultimate™), and PMMA-acrylic denture teeth (Gnathostar™, Ivoclar Vivadent).

The first investigation involved SEM surface texture analysis of the materials using commonly applied 2-D (*Ra*) methodology and a novel 3-D (*Sa*) surface profile generation protocol (Me-X). Qualitative and quantitative information was considered to determine which method gave the most accurate and consistent results for dental material surface topography characterisation.

The second part of the investigation involved *in-vitro* two-body wear investigations using PMMA-acrylic denture teeth as an antagonist and samples from each of the test groups. A purpose-build wear simulator applied a load of 99.5N for 240,000 "chewing" cycles with distilled water lubrication. The total material volume loss for the test materials and PMMA-acrylic antagonist were analysed via 3-D surface profile methods. Qualitative analysis was undertaken via SEM.

**Results:**

*Ra* and *Sa* surface texture analysis and quantification indicated that the 3-D *Sa* method was more sensitive to surface topography variation in the materials than the 2-D *Ra* method. Both the *Ra* and *Sa* methods gave the same ranking of the materials in terms of which had more pronounced surface topography variation. The highest values were obtained for the PMMA-acrylic group, followed by Lava Plus™, DenZir™, Lava Ultimate™, eMax™, and BruxZir™ in descending *Ra* and *Sa* order. Post two-body wear testing analysis showed qualitative and quantitative changes in the materials. Obvious wear facets were noted for the acrylic antagonist and control groups and the Lava Ultimate™ test material. No wear facets were noted in the zirconia or eMax™ ceramic test samples.

The acrylic antagonist material showed the highest volume loss when opposing the nano-ceramic Lava Ultimate™ sample material, followed by the eMax™ group, then the acrylic control group. The Lava Plus™ group showed the least acrylic antagonist material volume loss. The highest overall test material volume loss occurred in the nano-ceramic composite resin (Lava Ultimate™), group followed closely by the acrylic-acrylic control group.

**Conclusions:**

The *Ra* and *Sa* surface texture analysis and quantification results indicated that either method could be used to analyse the surface roughness of dental materials. The *Ra* method was quicker and more cost effective than the *Sa* method. The highest values in descending *Ra* and *Sa* order were obtained for the PMMA-acrylic group, followed by Lava Plus™, DenZir™, Lava Ultimate™, eMax™, and BruxZir™. The monolithic zirconia material samples (BruxZir™, Lava Plus™, DenZir™) showed significant intergroup variation both qualitatively and quantitatively.

The two-body in-vitro wear analysis showed that the acrylic antagonist cusp had a clear wear facet for each test group. Results showed that the nano-ceramic composite resin material was more abrasive to the acrylic antagonist material than the other materials tested.

# Declaration

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Dated this 11th day of February 2015.

# Acknowledgements

I take this opportunity to express my thanks to many people who have provided their assistance in the production of this report and throughout my time at the School of Dentistry, The University of Adelaide.

I would like to sincerely thank my supervisors Professor Lindsay Richards and Dr Thomas Berekally for their continued advice and support. I greatly appreciate having the opportunity to benefit from their knowledge and experience in the field.

I would also like to thank the staff at Adelaide Microscopy and the research staff of the School of Dentistry, The University of Adelaide.

Finally, I would like to thank those close to me, without whom this would not have been possible. Thank-you to my wife Hayley and son Ari for your love and support. Thank-you to my father John, mother Suzanne, and sisters Jolene and Chanelle for your continued encouragement. To my grandmother Joan and my pop Joel, thank-you for your guidance over the years.