ORIGINAL ARTICLE

BONDING OF ACRYLIC RESIN TEETH WITH DENTURE BASE RESIN

[1]ZIAULLAH CHOUDHRY
[2]SOFIA MALIK
[3]SHOAIB KHAN
[4]MUHAMMAD ADEEL AHMED

ABSTRACT

The debonding of acrylic resin teeth with the denture base resin has been related to several different factors of which contamination of the bonding surfaces with wax has been suggested as the major cause. The purpose of this study was to determine the efficient method of wax removal from denture teeth using hot water at different temperatures ranges.

Acrylic rods were used as tooth analogues and Raman spectroscopy was used to detect the presence of wax on the surfaces of the specimens. It was found that none of the techniques studied was able to remove all of the wax. Abraded ridge-lap surface showed least wax contamination when dewaxed at 100°C as compared to dewaxed at 85°C and 65°C respectively.

The spectrum for each specimen demonstrated peaks at different wavelengths and varying intensities, the spectra demonstrated traces of wax on abraded surfaces showed least wax when dewaxed at 100°C as compared abraded surfaces dewaxed at 65°C and 85° C temperatures respectively.

Key Words: *acrylic teeth, dewaxing, denture base.*

INTRODUCTION

Acrylic resin was introduced in 1937 as a denture base material. Due to the shortage of the raw material for vulcanite after World War II, acrylic resin became the material of choice for denture production.[1] Wax contamination of the bond surface of the tooth (ridge-lap area) has been consistently observed to be linked to a reduction in the tensile bond strength.[2,4] It is a universal finding that the wax contamination is the major cause of reduction in the strength of the bond between the tooth and denture base.[4,6]

Schoonover[2] studied the effects of different wax removal techniques and application of tinfoil substitute on the bond strength between teeth and denture base. The removal methods studied were boiling water, kerosene-ether mixture, and synthetic detergent. These showed that teeth which had no contact with wax made the highest bond strength with denture base compared with those which had been contaminated with wax and then cleaned. Of the latter group those treated with kerosene-ether mixture showed complete elimination of wax and the highest tensile strength compared with the other methods used for wax removal. It was observed that the conventional method (boiling water) cannot remove wax efficiently and that synthetic detergents should be used for effective wax removal.

Spratley[3] studied 11 different regimes for removing wax in a wax-eliminating machine. Acrylic and porcelain teeth were used. After testing in a compression cage in a mechanical tensile testing machine, porcelain samples exhibited a cohesive fracture (within the teeth) as well as the acrylic samples. Numbers of adhesive failures were higher in those samples treated by grinding the ridge lap area, without pre-heat-soaking of the wax or wax elimination at 70°C. It was observed that wax, and the temperature at which it was removed could be significant factors in reducing the bond strength.

The literature was reviewed by Cunningham[7] relating to the determination of the tensile bond strength of acrylic resin denture teeth to the denture base material. He reviewed 29 papers published over the previous 50

1 Dr Ziaullah Choudhry, Assistant Professor Prosthodontics Department, Section of Dentistry, Dow International Medical College, Dow University of Health Sciences
Correspondence: C-243, Block-14, Gulistan-e-Jouhar, Karachi
E-mail: choudhryziaullah@gmail.com Cell: 0300-8291131
2 Dr Sofia Malik, BDS, MSc. Dental Materials, Assistant Professor, Dental Materials Department, Section of Dentistry, Dow International Medical College, Dow University of Health Sciencs
Email: drsofiamalik@gmail.com Sciences Cell: 0324-2006201
3 Dr Shoaib Khan, Assistant Professor and Department of Science and Head of the Dept of Dental Materials, Ziauddin College of Dentistry, Ziauddin University
Contact:021-35862937 Ext: 484/481
4 Dr Muhammad Adeel Ahmed, BDS, MFDS, RCSEd (UK), FCPS, Operative Dentistry, Section of Dentistry, Dow International, Medical College, Dow University of Health
Email: dradeelahmed@hotmail.com Cell: 0322-3611437
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Fig 1: Introducing molten wax to the surface of the specimens in the silicone mould

Fig 2: Waxed acrylic rods held in a stone mould for dewaxing

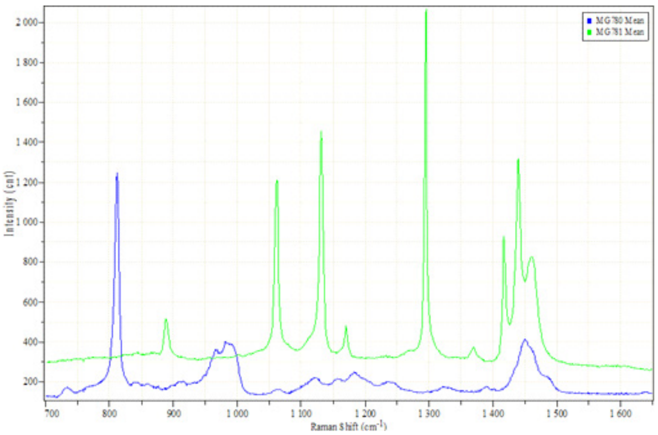

Fig 3:Control spectra for a clear acrylic rod (MG780) and an acrylic rod with wax contamination (MG781) showing peaks at 1400-1500 for the acrylic rod and at 1300 for the contaminated specimen

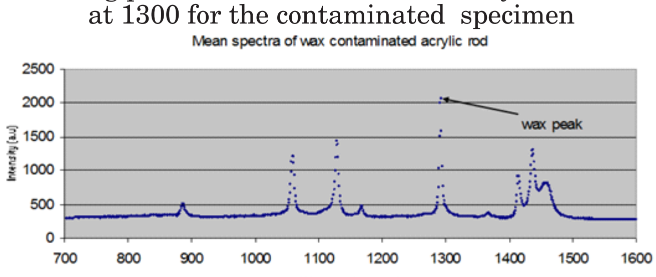

Fig 4: Mean spectra of wax contaminated acrylic rod

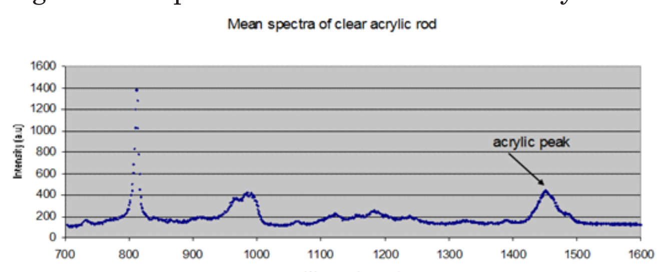

Fig 5: Mean spectra of clear Acrylic rod

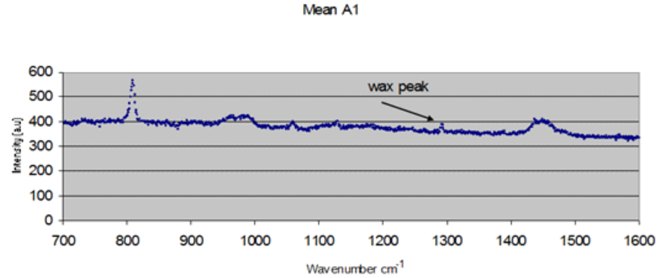

Fig 6: Mean spectra of ten acrylic rods with an abraded surface showing a peak at 1290.55cm-1 with an intensity of 390.3 a.u. (dewaxed at 65°C)

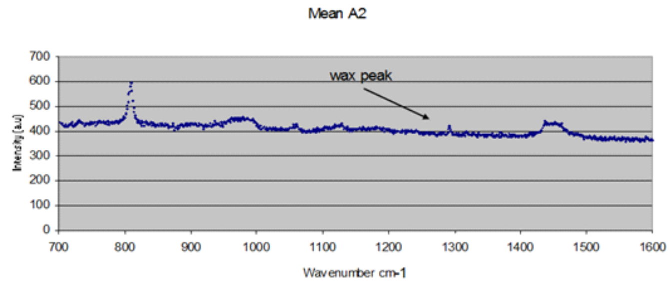

Fig 7: Mean spectra of ten acrylic rods with an abraded surface showing a peak at 1291.47cm-1 with an intensity of 420.7 a.u. (dewaxed at 85°C)

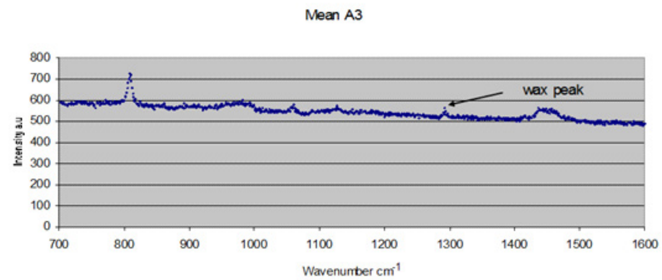

Fig 8: Mean spectra of ten acrylic rods with an abraded surface showing a peak at 1292.3cm-1 with an intensity of 563.9 a.u. (dewaxed at 100°C)

years and noted the plethora of different types of testing equipment used, thus making a standard technique difficult to formulate. There are, however, strong indications that highly cross-linked teeth do have reduced bond strength and that the use of high-impact resins significantly enhances tooth bonding. Contamination with wax was considered a major cause of bonding failure.

Cunningham and Benington[4] studied different modifications of the ridge lap surfaces of the teeth. Surfaces contaminated with either sodium alginate or wax. Tensile testing was done in a universal machine at a cross head speed of 2.5 mm/min. No significant differences were found in the mean values for the tensile strengths of any of the surfaces investigated, except those which had wax contaminated ridge lap areas. Therefore, it was concluded that contamination by wax had a major role in decreasing the bond strength between acrylic teeth and denture base. Modification (mechanical) and application of sodium alginate did not have a significant effect in this study, which was in agreement with the findings of Hugget[8] et al and Geerts[9] et al but contrary to the findings of Fletcher[10] and Caswell.[11]

A postal survey on the methods of denture tooth preparation, prior to denture processing, was conducted amongst dental instructors in prosthodontic departments of dental schools in Great Britain and Ireland. Two groups of specimens were used (teeth with rough/smooth surfaces).Semi-molten fluorescent wax was introduced to the specimens for 20 seconds. Dewaxing was carried out by agitation for 30 seconds in water at temperatures ranging between 60 to 90ºC. One group of specimens was agitated in water for 20 seconds at 60ºC followed by the application of a wax eliminator for 20 seconds and then flushing with boiling water. Specimens were air dried for 30 seconds and then subjected to ultraviolet radiation and photographed. It was concluded that the roughened surface increased the area thus increasing wax retention. Dewaxing at 90º also showed the presence of wax on the surface. The use of wax eliminator showed significant removal of wax and this was recommended for efficient wax removal.[5]

To investigate the factors which might affect the bond between acrylic resin teeth and denture base resin further studies has been carried out and their results reconfirmed that wax contamination was a major cause of tooth bond failure.[6]

Debonding of acrylic denture teeth from the denture base resin is common problem encountered during treatment of the patient with dentures. The causes of this debonding were suggested to be contamination of the bonding surface with wax and the structure difference of the two components (acrylic teeth & denture base) due to different processing routes.[11]

Irrespective of the type of polymerization the denture teeth enhanced their shear bond strengths to the denture base resins by the airborne particle abrasion of the ridge lap area and monomer application.[12]

Mechanical modification of ridge lap area of denture teeth, chemical modification of ridge lap area of denture teeth, type of acrylic resin denture base used, type of acrylic teeth used and presence of any residues on the ridge lap surface are the factors which effect bond between acrylic teeth and denture base which should be avoided to prevent the disappointment to the patient which may result due to failure of denture.[13]

OBJECTIVES OF THE STUDY

1 Determine the efficient method of wax removal from denture teeth using hot water at different temperatures.
2 Study the effects of tooth surfaces on the efficiency of dewaxing using different techniques.

METHODOLOGY

In this study acrylic rod 13 mm long and 6 mm in diameter were used as tooth analogues. Nine experimental groups, each consisting of ten specimens were prepared. The surfaces of the specimens were contaminated with modelling wax, and then those in each group were subjected to agitation in hot water at one of the range of temperatures. The surfaces were then examined for traces of wax using Raman spectroscopy.

Raman spectroscopy is a spectroscopic technique used in condensed matter physics and chemistry to study vibrational, rotational and other low frequency modes in a system. It provide fingerprint by which molecules can identified.

PREPARATION OF THE TEST SURFACE OF THE RODS

A block of self-cured acrylic resin 8 cm long, 5 cm wide and 13 mm in depth was prepared and four holes (6 mm in diameter and 13 mm deep) were drilled through its longest surface using a drill. An acrylic rod was then prepared by rubbing them against the surface of wet and dry abrasive paper (medium P 320 and fine P 600) held on a flat glass sheet. This was lubricated with water. The procedure continued until a flat surface with an even texture visible with the naked eye. The rods were then divided into three groups of 10 and there were abraded with dry abrasive paper held on the flat glass sheet. Thirty specimens were prepared in this way.

The modelling wax was melted with a hot plate which is normally used in the dental laboratory during waxing-up of the teeth. The molten wax was introduced to the surface of the acrylic rods in the silicone mould and allowed to cool at room temperature for 24 hours.

For de-waxing, ten specimens are inserted in the dental stone mould and held with a pair of tongs while de-waxing by holding the specimens under a stream of hot water provided by boiling water unit at one of three different temperatures (65ºC, 85ºC, 100ºC) for two minutes. This process was repeated and 30 specimens with abraded surfaces were dewaxed at these temperatures with hot water (10 at 65ºC, 10 at 85ºC and 10 at 100ºC). After de-waxing all the specimens were air dried for 5 seconds.

The surface analyses of the specimens were performed using Raman Spectroscopy to detect any traces of wax on the surfaces of the specimens. The area of the surface to be scanned was selected randomly for each specimen and was 20/20 µm. Nine different locations in this selected area were scanned, and spectra generated for subsequent comparison with the control spectra. These were generated for a clear acrylic rod and a waxed acrylic rod by scanning two acrylic rods, of which one had been contaminated with wax and other prepared. These were used as controls.

The spectra of the experimental group were transferred to an Excel spread sheet for the preparation of graphs to facilitate a study of the intensity and wavelength of the light rays passing through the specimens resulting in peaks of spectrum. The specimens which had peaks approximately identical to the clear acrylic spectra, showed that there was no wax present on that surface. Spectra similar to that of the waxed acrylic rods indicating the presence of wax on that surface.

RESULTS

A total of 30 rods was examined. These were divided into three sub- groups of 10. Three sub-groups were de-waxed using hot water only, at a temperature of 65ºC, 85ºC or 100º, these were then examined for evidence of wax contamination using Raman spectroscopy. The spectrum for each specimen demonstrated peaks at different wavelengths and of varying intensities, which were related to the nature of the surface contamination. The system differentiated between the acrylic group (C5O2H8) and wax which has a CH (C25H52) group.

The spectra are presented as a series of graphs, one for each test group. They represent the mean of nine recordings for each of the rods, and thus a mean of 90 recordings for that group. The X axis shows the wavenumber (cm-1), and the Y axis is the intensity has an arbitrary unit (a.u). For control samples a single rod was used, with nine discrete areas being sampled.

DISCUSSION

The present study investigates the efficiency of wax removal from the rough acrylic surfaces using hot water at three different temperatures, 65ºC, 85ºC and 100ºC. The specimens dewaxed at 100ºC showed slight evidence of the presence of wax, with the abraded surfaces, as compared to dewaxing done at 65ºC and 85ºC. Dewaxing with hot water at 65ºC and 85ºC resulted in more wax contamination, with the rough surfaces (abraded) being widely contaminated. These findings are in agreement with a previous study Cunningham et al. which showed that dewaxing with hot water at 60ºC showed more wax retention and as the dewaxing temperature (70ºC, 80ºC, 90ºC) was increased, the efficiency of wax removal was increased, although it was not completely removed.[5] Another study by the same worker showed that dewaxing with hot water at 70ºC did not result in efficient wax removal and decreased the bond strength between the tooth and the denture base.[6] Spratelysuggested that teeth showed adhesive failures in which dewaxing was performed with hot water at 70ºC resulting in difficulty in efficient wax removal from the rough surfaces.[3]

CAST ACRYLIC RODS IN COMPARISON WITH ACRYLIC TEETH

The cast acrylic rods used as tooth analogues in the study were made from polymethyl methacrylate. The polymethyl methacrylate resins used in the fabrication of prosthetic teeth are very similar to the poly methyl methacrylate used to fabricate cast acrylic rods (Perspex). The cast acrylic rods were used in this study to standardized the experiment so that every specimen had same diameter and length and its end surface was perpendicular to the long axis of the rod.

EFFICIENCY OF THE SYSTEM USED TO DETECT TRACES OF WAX ON THE SURFACE OF THE SPECIMENS

Raman spectroscopy is an analytic, non-destructive technique that provides the molecular structure of the investigated samples.[14] When incident light falls on the sample, it excites the molecules in the sample, which subsequently scatter the light. This inelastically scattered light is known as Raman scatter, resulting from the interaction between the incident light and the molecular motion or vibration of the molecules present in the sample. It is commonly used in chemistry to identify chemical compounds. In this study spectra were produced for control groups in order to identify the peak which was produced by certain chemical groups in the sample, and the spectra were used as a key when comparing the spectra of the experimental group with that of the controls. The aim of the study was to detect any traces of wax on the surface of the specimens and not to quantify the amount of wax present on the surface which can be done by calculating the ratio of wax peak height to the acrylic peak which is related to the amount of wax present on the sample.

CONCLUSION

- There is no efficient method of dewaxing found for complete removal of wax residues during denture construction
- The rough surfaces (abraded) showed more wax retention. These surfaces are usually prepared by the dental technician in a belief that modifying the ridge-lap area of the teeth will increase the bond strength between the teeth and the denture base.
- Wax residues can still remain on the tooth surface even after dewaxing it at 100ºC.

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CONTRIBUTION BY AUTHORS

1 Ziaullah Choudhry:	Topic selection, Acquisition of data, performing procedures, Drafting of manuscript, Drafting of abstract
2 Sofia Malik:	Study conception and design, Analysis and interpretation of data, Discussion write up, Critical revision.
3 Shoaib Khan:	Literature review.
4 Muhammad Adeel Ahmed:	Input of references into Endnote.