How Well Do Fourth Year Wits Dental Students Place Resin Composite Restorations?

ABSTRACT

Objectives: To evaluate, by means of a scanning electron microscope (SEM) the quality of resin composite restorations, placed as a first attempt by fourth-year dental students.

Methods: Ten Class IV direct composite restorations, placed in plaster-mounted extracted incisor teeth as part of pre-clinical course requirements, were selected. Specimens were evaluated and graded on a two-point scale by a staff member according to departmental clinical evaluation criteria.

Results: Clinical assessment and SEM surface evaluation correlated favourably for all criteria, except contour, indicating that students were reasonably competent in finishing techniques. Ground samples revealed acceptable etched enamel layers and marginal adaptation. Bonding agent thickness varied between 0 and 200 μm casting doubt on procedural accuracy. Porosities and voids were apparent within the resin composite. Internal features were the main reason for unsatisfactory grades.

Conclusions: Students placed restorations satisfactorily. They would benefit if able to examine sectioned restorations to understand critical placement techniques which would contribute to resin composite restoration success. A research component can be introduced into the dental undergraduate curriculum by way of similar projects linked to didactic course-work.

INTRODUCTION

A comprehensive pre-clinical techniques course is an integral part of undergraduate restorative dental training. Up until 2001 this took place in the fourth year in the School of Oral Health Sciences at the University of the Witwatersrand, where students spend time in the techniques laboratory to develop the manual dexterity and technical knowledge required for amalgam and resin composite cavity design, preparation and restoration. This is achieved through a series of lectures, small group tutorials and demonstrations, between which students are given time to perform restorative exercises. The practical commences with students mounting extracted teeth adjacent to each other in plaster to simulate proximal contacts. Cavity preparations are performed, placement of bonding agent, composite adaptation, and overall consistency.

Five restored teeth were prepared for surface evaluation of marginal integrity, surface roughness and contour using SEM. The remaining specimens were embedded in resin and ground down transversely, parallel to the incisal edge until a dentine core was apparent. The ground surfaces were polished, prepared for SEM and assessed for etched layer, placement of bonding agent, composite adaptation and overall consistency.

Clinical assessment and SEM surface evaluation correlated favourably for all criteria, except contour, indicating that students were reasonably competent in finishing techniques. Ground samples revealed acceptable etched enamel layers and marginal adaptation. Bonding agent thickness varied between 0 and 200 μm casting doubt on procedural accuracy. Porosities and voids were apparent within the resin composite. Internal features were the main reason for unsatisfactory grades.

Conclusions: Students placed restorations satisfactorily. They would benefit if able to examine sectioned restorations to understand critical placement techniques which would contribute to resin composite restoration success. A research component can be introduced into the dental undergraduate curriculum by way of similar projects linked to didactic course-work.
Internal restoration features

The extent of the etched enamel layer influences bonding agent penetration and thus bond strength. Acid etching of the enamel creates a porous layer 5 to 50 µm thick into which the bonding agent flows. Subsequent polymerisation creates a micro-mechanical bond between the bonding agent and enamel. Furthermore, the etched layer must be continuous along the entire enamel margin to ensure an effective marginal seal.

Hand in hand with an adequate etched layer is the need for an acceptable bonding agent layer. This is not simple to define as there has yet to be consensus as to what the ideal thickness of bonding agent should be. If the bonding agent layer is greater than 500 µm, it results in a decreased shear bond strength while a thickness greater than 200 µm causes decreased tensile bond strength, crack propagation and microleakage. The bonding agent must be of adequate thickness to allow for a deeper polymerised layer for adhesion to dentine and be sufficiently thick to retain an unpolymerised surface layer for bonding to composite. Both Burke and Leinfell-Der suggest a bonding layer of less than 10 µm while others consider 50 to 100 µm to be optimal for marginal fit of ceramic restorations. Our criteria for satisfactory bonding agent placement (thickness of 50-100 µm visible around the entire cavity) is based on this latter suggestion. While this threshold could be regarded as arbitrary, we felt it imperative that the film thickness should be even along the entire resin composite-tooth interface to ensure consistent bonding and uniform stress distribution.

The presence of voids, bubbles, inclusions and discrepancies can indicate poor handling of the material and errors in placement technique. Both the adaptation of the resin composite restorative material to the bonding agent and the uniformity of the restorative material itself require an absence of such disparities. Inconsistencies within the restoration would create potential sites of weakness and result in decreased bond strength if sited at the tooth restoration interface as well as a decreased abrasion resistance.

Using the assessment criteria as selected and the SEM, this study examined and evaluated the surface and internal features of ten Class IV resin composite restorations, which were completed by students in their first attempt at manipulating this material. The aims were to:

- determine whether students performed work of adequate quality
- decide whether the method of assessment is effective and objective
- compare the demonstrator evaluation with SEM surface evaluation to detect any placement errors missed by the techniques examination.

Materials and methods

Twenty-five Class IV resin composite restorations prepared by the students were available for this study of which ten specimens of approximately the same dimensions were selected and processed according to a study design (Figure 1). The original clinical assessment grades were not used and all restored teeth were presented to a single demonstrator to be re-evaluated. Surface finish, margin integrity, facial-lingual contour and proximal contour were assessed on a five-point scale to determine whether the feature was to be graded as satisfactory or unsatisfactory (Table 1).

If any one feature was found to be unsatisfactory, the restoration as a whole was considered unsatisfactory. Thereafter, each restored tooth specimen was carefully removed from the plaster, randomly assigned a code number from 1 to 10 to prevent examiner bias and divided into two equal groups of five specimens: one for surface restoration qualities, the other for internal restoration properties.

Surface evaluation

The five teeth for surface evaluation were mounted on SEM stubs with double-sided adhesive tape and DAG 580 colloidal graphite in denatured alcohol ensuring that the entire restoration margin could be seen. After sputter coating with a 15 nm layer of gold palladium the specimens were viewed in a JSM-840 SEM at 5 to 10 kV and suitable tilt and magnifications to emphasise surface profile.

Surface evaluation of a restoration was regarded as unsatisfactory if:

- any defect 80 µm or greater was present be it a groove, pit or marginal defect.
- over- or under-contouring was present or any disharmony with existing tooth form.

The surface was regarded as satisfactory if the:

- surface of the composite was smooth and free of defects.
- irregularities and/or voids on the restoration surface were smaller than 80 µm in diameter.
- tooth restoration marginal gap was consistently less than 80 µm.
- contour was continuous with existing tooth form.

<table>
<thead>
<tr>
<th>Resin composite restorations prepared by 4th year students</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Class IV restored teeth selected</td>
</tr>
<tr>
<td>Clinical evaluation by demonstrator as per departmental criteria</td>
</tr>
</tbody>
</table>

5 restored teeth
Prepared for SEM surface evaluation of restoration
Evaluation of 4 surface features of restoration
Correlation with clinical evaluation

Figure 1 Flowchart of experimental method.
<table>
<thead>
<tr>
<th>Rating</th>
<th>Surface (finish)</th>
<th>Margin integrity</th>
<th>Axial contour</th>
<th>Proximal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfactory</td>
<td>Surface of composite smooth, absence of voids</td>
<td>No evidence of a crevice along the margin detectable with explorer.</td>
<td>Marginal ridge, lingual and/or facial contours continuous with existing tooth form. Functional occlusal contact restored.</td>
<td>Axial contour continuous with existing tooth form. Proximal embrasure, and proximal contact restored.</td>
</tr>
<tr>
<td></td>
<td>Surface of composite, deeply grooved.</td>
<td>Margin open; explorer can penetrate to dentine or base</td>
<td>Traumatic occlusion. Enamel reduced during finishing.</td>
<td>Proximal contact open. Gross overhang. Mutilation of hard or soft tissue during finishing.</td>
</tr>
</tbody>
</table>

Table 2: Results of clinical evaluation of ten restored teeth

<table>
<thead>
<tr>
<th>Clinical feature</th>
<th>Number of satisfactory specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>8</td>
</tr>
<tr>
<td>Marginal integrity</td>
<td>9</td>
</tr>
<tr>
<td>Facial-lingual contour</td>
<td>10</td>
</tr>
<tr>
<td>Proximal contour</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3: Comparison between clinical and SEM evaluation of surface features in five restored specimens

<table>
<thead>
<tr>
<th>Clinical feature</th>
<th>Number of specimens with a satisfactory grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical</td>
<td>Clinical</td>
</tr>
<tr>
<td>Surface</td>
<td>4</td>
</tr>
<tr>
<td>Marginal integrity</td>
<td>4</td>
</tr>
<tr>
<td>Facial-lingual contour</td>
<td>5</td>
</tr>
<tr>
<td>Proximal contour</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4: SEM evaluation of internal features in five restored specimens

<table>
<thead>
<tr>
<th>Internal feature</th>
<th>Number of specimens with a satisfactory grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etched layer</td>
<td>4</td>
</tr>
<tr>
<td>Bonding agent thickness</td>
<td>3</td>
</tr>
<tr>
<td>Adaptation of composite</td>
<td>5</td>
</tr>
<tr>
<td>Uniformity of material</td>
<td>3</td>
</tr>
</tbody>
</table>
Internal features

The remaining five restored teeth were embedded in a 5:1 mix of Araldite M resin and HY956 hardener and ground in a transverse plane parallel to the incisal edge until an interface of the restorative material with both enamel and dentine could be seen. This was accomplished using an IMPTech 20 DVT grinder polisher and an ascending succession of wet silicone carbide papers of grit size 180 to 2500. Final polishing was with a diamond paste from 3.0 to 1.0 µm and using DP lubricant. All specimens were mounted, sputter coated, viewed and assessed using the following criteria.

Internal features were judged unsatisfactory if:

- the etched enamel layer showed areas of discontinuity.
- a bonding agent layer thickness less than 50 µm and greater than 100 µm was encountered at any point along the interface.
- the adaptation of the restorative material to the cavity surface was marred by voids, air bubbles and discrepancies.
- incremental packing lines, air bubbles and voids within the resin composite itself were features which condemned uniformity of the restoration itself.

Satisfactory internal features were:

- an etched layer visible along the entire enamel cavity margin.
- bonding agent that was visible around the entire cavity and 50 to 100 µm thick.
- uniform resin composite bonding agent–tooth surface interface.
- absence of inclusions within the restoration material.

All measurements were made during viewing with the aid of the onscreen scale bar.

RESULTS

Clinical evaluation by the demonstrator judged all ten restorations satisfactory for both aspects of contour, eight were satisfactory for surface finish and nine for marginal integrity (Table 2). Table 3 shows the clinical evaluation compared with the SEM surface evaluation for the same five restored teeth. SEM surface evaluation showed a favourable correlation for surface finish, marginal integrity and facial-lingual contour. Poor surface finish and marginal integrity can be seen in Figure 2 where the restoration surface is rough and displays an overhang at the margin. In contrast, Figure 3 illustrates a restoration with a satisfactory surface finish and marginal integrity. Proximal contour was notably different between clinical and SEM assessment.

Four of the five specimens examined for internal features were clinically satisfactory. When these were polished and evaluated (Table 4) all were satisfactory with regard to adaptation and four specimens had satisfactory etched layers (Figure 4). Two specimens each were unsatisfactory for bonding agent thickness and material uniformity (Figure 5). Bonding agent thickness was found to vary between 0 and 200 µm in both specimens which failed on this feature.

Porosities and voids within the resin composite caused specimens to receive poor grades for consistency of the material.

Overall, internal features caused more unsatisfactory grades than surface features.

DISCUSSION

The satisfactory results from the clinically based laboratory evaluation method as well as its correlation with the SEM surface examination indicate that fourth-year students are able to perform the restorative techniques adequately and that the evaluation method currently employed by the school appears to be fair and accurate. The clinical re-evaluation of restorations by only one staff member was to remove possible inter-examiner variability, which could occur if the original
clinical assessment grades were used. It was noted previously that subjectivity inherent in traditional types of grading had led to complaints from students of inconsistent grading by different instructors. Conversely, having only one individual perform the clinical evaluation causes the results to reflect only that individual's subjective interpretation of the evaluation criteria. For reasons of simplicity, however, only one examiner was employed.

While the criteria used for SEM quality evaluation assessment were factors considered important for long-term success of resin composite restorations, we acknowledge that in linking SEM assessment with clinical criteria, some clinically relevant features were seemingly overlooked. For instance, surface or marginal irregularities less than 80 μm could still be considered unsatisfactory, as a Streptococcus bacterium is on average only 1 μm in diameter. Discrepancies, which are judged clinically satisfactory by the crude detection instrument (the 80 μm diameter explorer), can harbour bacterial colonies. These colonies would be difficult to remove manually since a soft toothbrush bristle is on average 200 μm in diameter. This could therefore result in secondary caries and restoration failure. In vitro studies were unable to establish a relationship between surface porosity and bacterial adhesion. There are, however, indications that increased porosity may be associated with increased surface discolouration.

Poor contour may result in poor aesthetics, impingement on embrasure space or open contacts. Assessment of contour in plaster-mounted teeth was facilitated by their positioning with proximal contacts intact and the plaster functioning as a "gingival" margin. During SEM viewing, these reference points were absent, making assessment difficult and subjective. However, in order to maintain comparison with the demonstrator assessment, we retained contour as a feature. The four criteria selected for evaluating the ground teeth included factors critical to the long-term success of composite restorations, which could not be evaluated by surface examination.

The quality of the etched layer was evaluated since it influences bonding agent penetration and thus the bond strength. Using the specified criteria, the etched layer was consistently regarded as satisfactory in four of the five restorations. The depth of the etched layer was ultimately not included for consideration as this could vary according to the polishing angle relative to the enamel prisms. The hybrid layer in dentine is not visualised using our SEM technique and could not be evaluated.

There was a marked variation in bonding agent thickness in the specimens even though only one method of application is taught. A uniform bonding agent seemed difficult to reproduce consistently due to individual methods of application, the fluid dynamics of the bonding agent within each prepared cavity and inconsistent air thinning of the bonding agent. Further studies could include a more detailed examination of all of the above-mentioned features in order to determine which variable is predominat.

Almost all aspects pertaining to placement of resin composites are subject to the risk of porosity incorporation. This ranges from cavity irregularities to the types of instruments used to handle the resins. The presence of voids, bubbles, inclusions and discrepancies within the resin and at the cavity bonding agent-resin composite interfaces are said to affect bacterial adhesion, abrasion resistance, tensile strength and marginal leakage. The unsatisfactory grades for uniformity of material indicate that students could be alerted to the critical role of placement technique via a similar SEM exercise.

CONCLUSION

The results of this study suggest that the present course was successful at teaching the evaluated group of students the skills required to place quality restorations. Internal restoration features were found to be the main reason for unsatisfactory grades. It is suggested that students would benefit if able to examine sectioned restorations to appreciate critical placement techniques, which would contribute to resin composite restoration success.

APPENDIX I

Dental education world-wide is currently undergoing intense scrutiny, critical appraisal and penetrating self-evaluation. It has become apparent that the traditional curriculum with its emphasis on factual knowledge and the acquisition of technical skills is no longer meeting the requirements of the present, let alone future, needs of the practitioner and the general community. The move to evidence-based treatment relies on an understanding, appreciation and critical evaluation of scientific and clinical research, the results of which can be extrapolated to treatment regimes. A thorough grasp of the process of basic research is a requirement for the transfer of such deductions into sound clinical judgement. Such proficiencies have never been formally taught to the aspirant South African dental health practitioner.

While steps are being taken to remedy the first situation by revitalising and restructuring the dental curriculum, little attention has been focused on how the research component can be integrated within the learning experience to prepare students for evidence-based treatment planning and to cultivate the scientific curiosity necessary to foster research talent. It is not in the interests of the dental fraternity as a whole to provide an extensive and time-consuming course in research techniques at the undergraduate level. The students attending the School of Oral Health Sciences are career dentists and teaching time should be devoted towards this aim. The above project (or something similar) should be seen as
a way of introducing a research component into the dental curriculum.

Hand in hand with fostering research enquiry is the concept of evaluation. Critical self-evaluation is a vital skill that has to be developed by students as an important part of learning. A study has found that students had a poor understanding of the criteria for cavity preparations, even though they had completed exercises that stressed component criteria. This project can be used during the pre-clinical course to establish the habit of critical evaluation resulting in a life-long pattern of continuing improvement of clinical ability.

ACKNOWLEDGEMENTS

The authors would like to thank the Departments of Restorative Dentistry (with special thanks to Dr V Karic and V Miller) and the Dental Research Institute MRC/ Wits School of Oral Health Sciences University of the Witwatersrand. We further wish to recognise the role of the late Prof. T M Arendorf who suggested we prepare the study for publication.

NOTES


Letter to Editor

The Editor
SADJ

Dear Sir

Concern: Year Planner

I am the provincial CPD coordinator for dentists working under the Government in Mpumalanga Province. In 2002, the Lowveld Dental Study Group (LDSG) organised a provincial congress which was a success.

However, this congress could have been more successful if it didn't clash with the FDI congress in Durban.

We would like to avoid in the future the clash of the Mpumalanga Dental Congress with major CPD activities within the country. For this purpose, we need to get the year planner of all 2003 dental congresses and workshops your Journal is informed of.

Best regards
Dr T Celliers
Chief Dentist
Dr M Kasilembo
LDSG coordinator
The Lowveld Dental Study Group

Fax 013 741 2406
E-mail: matesoK@social.mpu.gov.za
Tel 013 741 3031 ext 218
Private Bag 11223
Nelspruit,
1200

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