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

How well do fourth-year Wits dental students place resin composite restorations?
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## 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.

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.

**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 and placement of restorations then follow. Beginning with Class I amalgams, the course progresses to complex resin composite restorations. On completion of each exercise, the restoration is handed to a demonstrator for examination and evaluation according to predetermined quality criteria (Table 1) as part of the course requirement. The grading of these criteria is based on quality evaluation as found in clinical practice.[1] Students complete an average of five restorations for each Class I to V cavity.

Resin composite placement is highly technique sensitive and requires meticulous placement to ensure longevity.[2] Prior to the commencement of this study the literature was consulted to compile a list of restoration assessment criteria. The criteria had to be clinically relevant and easily appraised in the scanning electron microscope (SEM). In addition, it was felt that the SEM surface finish criteria should be linked to the clinical evaluation to allow comparison between the two evaluation techniques.

### Surface finish

Surface finish is of concern because a rough irregular finish would make cleaning difficult, which ultimately increases the risk of failure.[3] A smooth surface was regarded as a satisfactory surface. Features that indicated an unsatisfactory finish were the presence of grooves, ridges, voids, tamping or placement marks. The tooth restoration margin was also used as an indicator to evaluate placement technique as a defective marginal seal would add to a questionable long-term prognosis for the restoration.

A threshold of 80 µm was set for all surface irregularities and marginal gaps to enable comparison with the clinical assessment. This threshold was based on the consideration that a sharp explorer tip is 80 µm in diameter.[4]

During clinical evaluation, any feature measuring less than 80 µm in diameter would not have been detected by the evaluator using an explorer.

Poor contour may result in poor aesthetics, impingement on embrasure space or open contacts. To compare with the clinical assessment, restoration contours were assessed in two axes: facial-lingual (labio-lingual) and proximal (mesio-distal) for evidence of disharmony with the tooth form.

**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.[5] 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[6] while a thickness greater than 200 μm causes decreased tensile bond strength, crack propagation and microleakage.[7] 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.[8] Both Burke[9] and Leinfel-der[10] suggest a bonding layer of less than 10 μm while others[11] 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.[12]

The presence of voids, bubbles, inclusions and discrepancies can indicate poor handling of the material and errors in placement technique.[13] 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.[14]

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[a] 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[b] 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.

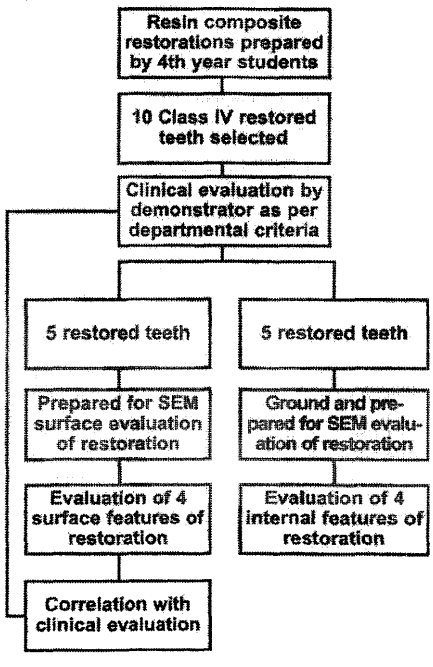


**Figure 1 Flowchart of experimental method.**

***Table I Departmental quality evaluation criteria for completed resin composite restoration (class IV)***

| Rating | Surface (finish) | Margin integrity | Axial contour | |
|---|---|---|---|---|
| | | | Facial-Lingual | Proximal |
| SATISFACTORY | Surface of composite smooth, absence of voids | No evidence of a crevice along the margin detectable with explorer. | Marginal ridge, lingual and/or facial contours continuous with existing tooth form. Functional occlusal contact restored. | Axial contour continuous with existing tooth form. Proximal embrasure and proximal contact restored. |
| | Surface of composite slightly rough. Evidence of small, localised voids | Slight evidence of a crevice along the margin detectable with explorer. | Slightly under-contoured: marginal ridge low. Composite not continuous with enamel. Height reduced locally or flattened. Silghtly over-contoured: Marginal ridge high. Contour over-accentuated: Anatomy of contour lacks definition. Occlusal contact slightly heavy. | Proximal slightly under-contoured. Contact flattened, not in harmony with existing tooth form. Proximal slightly over-contoured. Contour bulky or full. Composite not continuous with enamel. Proximal contact visually closed but light. |
| | Surface of composite moderately rough. Evidence of moderate voids. | Evidence of a moderate crevice along the margin detectable with explorer. | Moderately under-contoured: Marginal ridge low. Composite not continuous with enamel. Height reduced locally or flattened. Moderately over-contoured: Marginal ridge high. Contour over-accentuated: Anatomy of contour lacks definition. Occlusal contact moderately heavy. | Proximal moderately under-contoured: Contact flattened, not in harmony with existing tooth form. Contour bulky or full. Composite not continuous with enamel. Proximal contact visually closed, but very light. |
| UNSATISFACTORY | Surface of composite decidedly rough. Evidence of voids generalised. | Visible evidence of a crevice along the margin into which an explorer will penetrate. | Under-contoured: Enamel wall exposed. Excessive depth of lingual anatomy. Labial and/or lingual contours decidedly flattened and inharmonious. Over contoured: Composite extending beyond external outline. Labial and/or lingual contours decidedly bulky and inharmonious. Occlusal contact negative unnecessarily. | Proximal decidedly under-contoured: Flat or concave, decidedly not in harmony with tooth form. Enamel wall exposed. Axial decidedly over- contoured: Impinges on embrasure space or soft tissue. Decidedly not in harmony with tooth form. Composite extends beyond external outline; cervical overhang. |
| | Surface of composite deeply grooved. | Margin open; explorer can penetrate to dentine or base | Traumatic occlusion. Enamel reduced during finishing. | Proximal contact open. Gross overhang. Mutilation of hard or soft tissue during finishing. |

***Table 2: Results of clinical evaluation of ten restored teeth***

| Clinical feature | Number of satisfactory specimens |
|---|---|
| Surface | 8 |
| Marginal integrity | 9 |
| Facial-lingual contour | 10 |
| Proximal contour | 10 |

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

| Clinical feature | Number of specimens with a satisfactory grade | |
|---|---|---|
| | Clinical | SEM |
| Surface | 4 | 4 |
| Marginal integrity | 4 | 4 |
| Facial-lingual contour | 5 | 4 |
| Proximal contour | 5 | 3 |

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

| Internal feature | Number of specimens with a satisfactory grade |
|---|---|
| Etched layer | 4 |
| Bonding agent thickness | 3 |
| Adaptation of composite | 5 |
| Uniformity of material | 3 |


**Figure 2: This restoration has an unsatisfactory marginal integrity with an overhang at the margin (large arrow). Note the irregular surface finish (small arrows). E = enamel; R = resin composite restoration.**

**Figure 3: This restored specimen has a satisfactory surface finish and contour. M = restoration margin; E = enamel; R = resin composite restoration.**

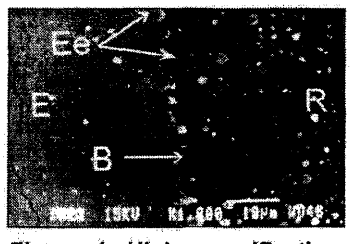


**Figure 4: High magnification of the enamel–resin composite restoration interface. Note the satisfactory etched enamel layer (arrowed Ee) and thin bonding agent layer (arrowed B). E = enamel; R = resin composite restoration.**

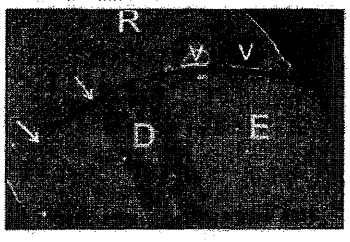


**Figure 5: Note the uneven bonding agent layer (arrowed) in this polished, restored specimen. Voids are apparent (V) within the resin composite. D = dentine core; E = enamel; R = resin composite restoration.**

**Internal features**

The remaining five restored teeth were embedded in a 5:1 mix of Araldite M resin and HY956 hardener[e] 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[d] and an ascending succession of wet silicone carbide papers of grit size 180 to 2 500. Final polishing was with a diamond paste from 3,0 to 1,0 µm and using DP lubricant.[e] In between diamond polishing, the surface was cleaned ultrasonically.[f] 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.[15] 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.[16]

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.[17] There are, however, indications that increased porosity may be associated with increased surface discolouration.[14]

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.[18]

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.[19] Further studies could include a more detailed examination of all of the above-mentioned features in order to determine which variable is predominant.

Almost all aspects pertaining to placement of resin composites are subject to the risk of porosity incorporation.[13] 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.[14] 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.[20] 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,[21] 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**

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**NOTES**

a. Acheson Colloids Company, Prince Rock, Plymouth PL4 OSP, UK

b. JEOL Ltd., Tokyo 196, Japan

c. Plastomax cc. Persequor 0020, Pretoria, South Africa

d. IMP, Boksburg, South Africa

e. Struers A/S, Denmark

f. B-220 Brandson Smith Kline Co. USA

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# 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.

This will allow us to choose the date of our 2003 Mpumalanga dental congress accordingly and avoid the repetition of unnecessary clashes between our activities and major CPD activities in the country.

***Best regards***

***Dr T Celliers***
Chief Dentist

***Dr M Kasilembo***
LDSG coordinator

***The Lowveld Dental Study Group***

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