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EVALUATION OF THE MECHANICAL AND PHYSICAL PROPERTIES OF A POSTERIOR RESIN COMPOSITE IN POSTERIOR ADULT TEETH

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ABSTRACT

Objective: To evaluate the mechanical and physical properties of a micro-hybrid resin composite used in adult posterior restorations

Materials and Methods: A micro-hybrid, light curing resin composite Unolux BCS Composite Restorative, (UnoDent, England) was used to restore 74 carious classes I and II cavities on posterior teeth of 62 adult patients. The restorations were evaluated immediately following placement (Baseline), at 1 week, 3months, 6months and 12months using the United States Public Health Service Criteria/Modified Ryge criteria for direct evaluation. Color matching, marginal stains and adaptation, wear and surface texture were evaluated. Ranging from best to the worst, the ratings were, Alfa, Bravo and Charlie.

Results: 58 restorations were available for review at the 12th month evaluation, 15 patients bearing 21.6% of the restorations were lost to recall. Colour match scores were 89.6% Alpha at baseline and 74.1% at 12-month review. Marginal staining were 100% Alpha at baseline and 98.3% Alpha at the end of the evaluation period.
Marginal adaptation at baseline was 100% Alpha this value dropped to 94.8% by the 12th month. Anatomical wear scores were 100% Alpha at baseline and scores dropped to 93.1% at the 12-month evaluation.
At baseline, Alpha scores for Surface texture were 100%. A drop in Alpha scores to 93.1% at the first week review was maintained till the 12 month.

Conclusion: Carefully controlled placement of micro-hybrid resin composite using the total etch and type 2 (one-bottle) adhesive can produce satisfactory posterior restorations on permanent teeth.

Key Words: evaluation, properties, posterior resin, composite adult teeth *(Accepted 24 February 2010)*

INTRODUCTION

Modern posterior composites utilize a combination of particle sizes to achieve superior strength and excellent aesthetics[1]. Minifilled hybrids (micro-hybrids) which can be used for both posterior and anterior restorations are available in a variety of shades to achieve excellent aesthetics. Their combination of particle sizes and heavy filler loading permits superior strength and wear resistance required for posterior restorations [1].
Successful posterior composite restorations can be accomplished by adhering strictly to clinical guidelines for case selection, proper material selection and adequate clinical techniques[2].
Packable or condensable composites are also indicated for stress-bearing areas and allow easier establishment of physiological contact points in class II restorations. Research has however shown that the physical properties of packable composites are not superior to conventional hybrids [3-5].

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These recent advances have been made based on studies of patients and materials derived from the main populations of the developed nations in
The mechanical and physical properties of composite material depend on the filler content, type, efficiency of the filler-resin coupling process and the degree of porosity of the set material[6].
Light activated materials supplied as single paste require no mixing and so tend to be less porous than their chemically activated counterparts which are supplied as two paste components[6]. A non-porous product has a higher-fatigue limit and longer fatigue life[6].
The fatigue limit and compressive strength of the composite material is improved by coupling agents enhancing the bond between filler and resin material. This bond also helps to produce a more flexible polymer matrix which transfer stresses to the stiffer filler particles[6,7].
The surface hardness, roughness and abrasion resistance are all properties that are mainly controlled by the filler content and particle size[7]. Abrasion is a very important factor when considering the use of

composite to restore posterior teeth. It can occur during contouring and polishing with devices such as silicone rubber points impregnated with abrasives as well as by foodstuffs and dentifrices [6]. Studies have reported differing opinions on the effectiveness of surface penetration sealants on the surfaces of resin composite restoration[8].

Wear process may occur due to fatigue of the material or from abrasive mechanisms. In both cases, wear may be accelerated by chemical factors such as solvents and acids present in drinks and food stuff. Wear resistance of composites designed for use in posterior cavities has improved remarkably over the years[6]. Wear can be seen typically at the cavity margins but it also occurs inter-proximally. Inter-proximal wear tends to be more rapid and difficult to evaluate[6,7].

Aesthetic restorations can be produced from resin composite as a result of varying shades and translucencies of the material which are features imparted by its filler content[7]. Stress cracks within the polymer matrix and partial de-bonding of the filler to resin due to hydrolysis causes an increase in opacity and alters the appearance of the restoration[7]. Eventually the surface of the restoration will become stained from deposition of coloured foodstuff such as tea, coffee, tobacco and red wine.

Composites bond to tooth substance via bonding agents. Improved bonding techniques have led to an increase in the applications of composite material. it has also led to reduced destruction of tooth tissue in the name of cavity preparation and ensures a better marginal seal with reduced chances of micro-leakage[6]. The one-bottle (5th generation) adhesive resin has been proven to provide adequate dentinal seal[9] when used under controlled clinical conditions.

Polymerization shrinkage is related to the polymer matrix content of the composite material. Incremental insertion of composite material and independent polymerization of each increment ensures a reduction in shrinkage. This method allows for contraction in each increment between successive additions or layers of material[7].

The silane coupling agent controls the bond between the filler and the matrix. Deterioration of this bond leads to water sorption on the mass of the composite material[7]. Hybrid composites exhibit less expansion when exposed to water compared with other types of composite material[7].

While in-vitro tests are essential during the development of a material; experience shows that the ultimate evaluation should be conducted in vivo, in a clinical setting[10]. This principle forms the basis of this study which sort to evaluate the mechanical and physical properties of a micro-hybrid composite resin used for posterior restorations in an adult Nigerians.

MATERIALS AND METHODS

This study involving the evaluation of a micro-hybrid resin composite on posterior teeth of adults was based on the 2001 American Dental Association Acceptance Program Guidelines for Resin Based Composites for Posterior Restorations [10].

A total of 74 carious classes I and II cavities were restored on the posterior teeth of 62 adult patients at the Dental Clinic of the Lagos University Teaching Hospital. They were aged between 17 and 59 years.

A micro-hybrid, light curing resin composite Unolux BCS Composite Restorative, (UnoDent, England) was used to restore all the cavities. Isolation was achieved with rubber dam (Dental Dam, Hygenic®, Coltene/Whaledent Inc, USA).

Anatomically carved sycamore wedges (Premier, Dental products Co. Canada) were used for inter-proximal lesions. Cavity preparations were very conservative, with the size of the presenting carious lesions dictating the cavity size and shape. Multiple carious lesions on a tooth surface were prepared independently. Proximal lesions were not extended into the occlusal surfaces except there were adjacent caries. Cavo-surface margins of all the restorations were finished at a 90^0 joint. Pulp protection was achieved in deep cavities with hard setting calcium hydroxide (Dycal® Radio-opaque Calcium Hydroxide, Dentsply Caulk) prior to acid etching with 35% phosphoric acid (Unogel, Tooth Enamel Etching Gel, UnoDent, England) for 15-20s. The etching agent was rinsed off copiously with water spray for about 15s. and cavities were then dried for 5s.

Bond Resin (Unolux Dual Bond Chemical/Light curing Dentine and Enamel Bond, UnoDent, England) was applied unto the enamel and dentine walls with soft, fine-tipped brush. This was air blown gently to ensure a thin film application and light cured for 20s.

A thin tofflemire matrix band was burnished into tight contact with the adjacent tooth surface of class II restorations.

Cavity lining was achieved in areas of difficult access with flowable composite resin (Unolux BCS Flow UnoDent, England). Otherwise shallow and medium cavities were covered only with the bonding resin prior to inserting the hybrid composite.

The hybrid composite material is then inserted into the cavity in successive increments in an oblique layering technique. Each increment is cured for 40s with the light source from an occlusal direction. The final increments are shaped to form the marginal and cuspal ridges and pits and fissures before curing is completed. An additional curing was done in proximal lesions after removal of the matrix band by applying the light-source from bucally and lingually for 40s each.

The restorations were finished occlusaly with white polystone finishing burs and finishing strips inter-proximally. Polishing was achieved with a rubber cup and aluminum oxide paste under a jet of water.
Further curing of the functional surface of the restoration was done by applying the light source for another 40s.

Clinical Evaluation

The restorations were evaluated immediately following placement (Baseline) at 1 week, 3months 6months and 12months using the United States Public Health Service Criteria/Modified Ryge criteria for direct evaluation. Color matching, Marginal stains, Marginal adaptation, Wear and Surface texture were evaluated. Ranging from best to the worst, the ratings were, Alfa (satisfactory restoration) Bravo (defect present but restoration is clinically acceptable and does not require replacement) and Charlie (clinical failure of the restoration which requires immediate attention).
With the aid of magnification, dental mirror and explorer the restorations were evaluated by the authors who were calibrated in the technique. Clinical photographs were taken at review visits to further assess changes in shape and degree of wear. The results were analysed using MEDCALC x SPSS 11.0. The USPHSC data was analysed by calculating percentages of restoration with A, B and C scores for the evaluated clinical sites. Chi-Square analysis was performed to compare the clinical criteria. P value was set at <0.05.

RESULTS

Of the 74 restorations placed in all, 58 were available for review at the 12th month evaluation. 15 patients (Nine males and six females) constituting 21.6% of the restorations were lost to recall.
Table I shows that 56.9% of the restorations were class II of which 29.3% occurred on premolars with statistical significance in the greater value of proximo-occlusal restorations.
The gender distribution (Table 2) shows a greater number of restorations in females; however more of the proximo-occlusal restorations on molars were recorded in males.
More restorations were recorded on molars (63.8%) than on premolars (36.2%) in both genders (Tables1 and 2). However majority of the premolar restorations (29.3%) were proximo- occlusal (Table 1).
Colour match scores were 89.6% Alpha and 10.4% Bravo at baseline. A drop in Alpha scores to 74.1% at 6months remained unchanged at the 12-month review. Charlie scores were zero at baseline, 1.7% was recorded at 6months and maintained at 12months. Though, there were percentage differences between colour match at baseline compared with the 12-month review, there was no statistical significance in the results.
Marginal staining records were 100% Alpha at baseline. At the end of the evaluation period, 98.3% Alpha, 0% Bravo, and 1.7% Charlie scores were recorded for marginal staining. There is no statistically significant difference between baseline results and 12 months.
Rating for marginal adaptation at baseline was 100% Alpha. At 1 week this value dropped to 94.8% till the end of the evaluation period. Bravo scores were 0% at baseline, climbed to 5.2% at 1 week. At 12 months 3.4% was recorded. A Charlie score of 1.7% was recorded from the 3rd to the 12th month. Only proximo-occlusal lesions showed Bravo and Charlie ratings for marginal adaptation. None of these showed a significant statistical change.
Anatomical wear scores were 100% Alpha at baseline. At 6months Alpha scores dropped to 93.1% till the 12-month evaluation. From 6months a Bravo score of 5.2% and 1.7% Charlie were recorded till 12 months. All the Bravo and Charlie scores recorded for anatomical wear were on molars.
At baseline, Alpha scores for Surface texture were 100%. A drop in Alpha scores to 93.1% at the first week review was maintained till 12 months. Bravo scores of 5.2% were recorded at 1week; this increased to 6.9% Bravo at 6weeks and a further drop back to 5.2% at 3months review. Bravo scores remained at 5.2% till the end of the 12-month evaluation. Charlie scores for surface texture were zero from baseline up on till 6weeks. At 3months 1.7% Charlie score for surface texture was recorded and maintained till 12 months.
Though there are differences in USPHC ratings from baseline to 12 months, the changes are not statistically significant. All the classes I and II restorations with Bravo and Charlie scores were all molar restorations.

Table 1: **Distribution of Restorations.**

	Molars	Premolars	Total
Class I	21 (36.2%)	4 (6.9%)	**25 (43.1%)**
Class II	16 (27.6%)	17 (29.3%)	**33 (56.9%)**
Total	**37 (63.8%)**	**21 (36.2%)**	**58 (100%)**

$x^2 = 4.385$, $P = 0.012$, $df = 1$

Table 2: Tooth Type and Gender Distribution of Restorations.

	Class I		Class II		
	Molars	Premolars	Molars	Premolars	Total
Males	8 (13.8%)	0 (0%)	9 (15.5%)	5 (8.6%)	**22 (37.9%)**
Females	13 (22.4%)	4 (6.9%)	7 (12.1%)	12 (20.6%)	**36 (62.1%)**
Total	**21 (36.2%)**	**4 (6.9%)**	**16 (27.6%)**	**17 (28.2%)**	**58 (100%)**

$X^2 = 9.95, P = 0.019, df = 3$

DISCUSSION

Though a 21.6% patient loss was experienced in this study, the total number of restorations available for review falls within the ADA guidelines[11] that require a minimum of 50 restorations at the beginning of the project and not less than 40 at the end of the evaluation period. Of the 21.6% patient loss recorded, 12.96% were males and 8.64% were females. Sarrett et al[5] reported 8% loss in tooth type and restored surfaces between baseline recall and 36-month recall. This had limited impact on their results while Lundin and Rasmusson[10] recorded a low patient loss to review; 5% at the end of a 2-year evaluation. Fifty-eight (78.4%) restorations on forty-seven patients were available for review at 12 months in this study (Table 1).

Colour match ratings at baseline was 89.6% Alpha, and by one-week review, 75.8% Alpha. Colour match was stable for both the Alpha and the Bravo rated restorations, which were established in the first week. Yip et al[4] were able to demonstrate that under controlled clinical conditions, at the end of the one-year clinical evaluation period, all the teeth evaluated in their study had acceptable shades.

Turkun and Aktener[2] in their study demonstrated excellent colour matching of the restorations they evaluated at the end of a twenty-four month study.The results obtained for colour match in this study are also within the limits of the ADA guidelines[10] of no more than 10% Charlie for maintenance of colour.

Essentially the results for marginal staining at baseline compared with 12 months showed no significant statistical change.

Alpha rating for marginal staining at the end of one-year review was 98.3%. A Bravo score of 1.7% was recorded for a restoration at one week. At 6months this restoration scored a 1.7% Charlie score.

The restoration was a class II molar that eventually failed. The possibility of a faulty technique in the insertion of the restoration may have led to the penetration of stains at the margins. This can result from either a faulty etching procedure or application of resin bonding agent. ADA guidelines require marginal integrity failures to be no more than 5% Charlie at 12months review. In a study by Sarrett et al [5], they recorded 2% Charlie at 12 months review.

There was no appreciable change between baseline and one-year review results for marginal adaptation. The favourable results of marginal adaptation in this study may be attributed to the incremental oblique layering technique used in the insertion of the resin composite. The incremental method has been shown to provide better seal than bulk placement techniques [13].

The restorations with Bravo scores for marginal adaptation at evaluation had slight crevices between the composite and tooth interface, which were detectable with the tip of the explorer. None of the patients complained of post-operative sensitivity or discomfort, including the patient whose restoration eventually fractured.

Difficulty in achieving a perfect marginal adaptation especially at the gingival or occlusal enamel cavosurface margins has been documented. Enamel is highly mineralized and has a modulus of elasticity higher than dentine resulting in lower flexibility and decreased ability in relief of shrinkage stress. Thus poor margin adaptation and seal can occur when bonding composites to enamel. More so if the adhesive is applied incorrectly, micro-cracks develop at the cavo-surface margin due to polymerization shrinkage and these micro-cracks represent a way for micro-leakage to occur.

Restorations with Bravo and Charlie scores for marginal adaptation were all class II molars. This may be due to the difficulty in condensing hybrid composites in proximal cavities. Handling properties of hybrids are quite unlike amalgam, which can be easily condensed and tightly packed into cavities. Baratieri and Ritter[9] demonstrated 100% Alpha ratings for marginal adaptation in their study. Lundin and Rasmusson[10] recorded 17.5% Bravo scores for marginal adaptation in class II restorations in their study at 24 months.

Anatomical wear was not detected in the evaluated restorations in this study, until the Anatomical wear was not detected in the evaluated restorations in this study, until the sixth month. 5.2% of the restorations were observed to have occlusal surface wear and for this reason were rated Bravo. A slight under contouring on the occlusal and proximal surfaces can result from three-body wear due to mastication. As such wear will be noted after a reasonable amount of

time has elapsed following placement of the restorations. Anatomical wear was observed on both classes I and II molar restorations. This may be an indication of greater masticatory forces on the molars compared with the premolars. Despite these, there were no statistical significant changes in results analysed at the end of the review period compared with baseline (Table 6).

Baratieri and Ritter[9] demonstrated that none of the restorations evaluated in their study had clinically detectable wear, even at the end of four years. While Busato et al [12] claimed no statistical significance in wear rates in the posterior resin composites used in their study after six years. Two-year evaluation studies of both Lundin and Rasmusson[10] and Turkun and Aktener[2] also demonstrated favourable scores for wear rate. Surface characteristics recorded in this study were 6.9% Bravo at 6 weeks. The surfaces of these restorations were not as smooth as the surrounding enamel. The initial loss in surface smoothness is usually due to a loss of the glossy sealed surface of the finished composite restoration. Over time the self-polishing effect of wear help to maintain smoothness. The results for surface integrity recorded in this study are closely related to those for anatomical wear. Bravo and Charlie scores were recorded for both classes I and II molar restorations. This may be an indication that wear plays a part in maintaining surface smoothness in these restorations.

Turkun and Aktener [2] had a 99% Bravo rating for surface texture for a particular composite in their study, yet the other two materials in the same study yielded almost 100% alpha scores at the end of the 24month review. At 12 months, Sarrett et al[5] had 26% Bravo scores for the composite material they evaluated. At the end of their study at 36 months, surface texture Bravo rating was 4%.

CONCLUSION

Though there exists variability in resin composite materials used in different studies, it can be summarized that adequate aesthetics, anatomical wear, surface texture and marginal integrity can be achieved and maintained with the use of micro-hybrid resin composite on posterior teeth as evidenced in the above mentioned studies.

It is therefore concluded that carefully controlled placement of micro-hybrid resin composite using the total etch and type 2 (one-bottle) adhesive can produce satisfactory posterior restorations on permanent teeth.

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