

SCIENTIFIC
SECTION

A clinical trial of light cure acrylic resin for orthodontic use

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Abstract

Objective To ascertain whether or not the less porous surface associated with visible light cure appliances and the absence of free monomer had any measurable affect upon mucosal erythema, and to assess the durability of such appliances in a clinical context.

Design A prospective randomized trial of visible light cure (Triad VLC) and autopolymerizing (Orthoresin) acrylic resin used as orthodontic base plate materials.

Setting University Dental Hospital and School.

Subjects Fifty subjects from a consecutively enrolled sample of 69 (19 drop outs) for removable appliance therapy (23 VLC, 27 AP).

Outcome measures Erythema meter scores and appliance breakages.

Results No statistical difference in mucosal erythema between the two materials was found. Fifty-two per cent of VLC appliances broke during a 6-month period, as opposed to 7 per cent of AP appliances.

Index words:

Light cure acrylic resin,
removable appliances.

Conclusions VLC appears to have no clinically beneficial effect on the oral mucosa compared with AP. VLC appliances are currently not sufficiently durable to make them a viable alternative to AP appliances.

Received 16 March 2001; accepted 6 September 2001.

Introduction

Acrylic resins were rapidly developed during the early years of the Second World War when the use of natural rubber for dental vulcanite was prohibited. Today they are still the most frequently used dental base plate materials for prosthodontic and orthodontic appliances. Since acrylic resins were introduced in 1936 in the monomer/polymer form, only minor changes in their composition have taken place.

The main problem with all acrylic resins is that the material is highly inflammable and irritant to the skin, and requires to be used within a fume-extraction unit. Autopolymerizing acrylic resins have sufficient unpolymerized monomer to cause reactions in patients sensitized to the monomer. Reports show that the reactions may be divided into those that affect technicians and dentists and those that affect the mouths of patients.

Technicians and dentists

- Contact dermatitis.^{1,2}
- Asthma, drowsiness, headache, anorexia, and decrease in gastric motor activity.³
- Paraesthesia of the finger tips in the form of a burning sensation, tingling and slight numbness.^{4,5}

Patients

- Unpleasant taste.
- Oedematous reaction accompanied by a burning sensation.

The Triad visible light cure (VLC) acrylic resin system was introduced by Dentsply De Trey (Dentsply De Trey GmbH, Postfach 101074, D-63264 Dreieich) in 1983. This was superseded in the 1990s with a second-generation system 'Triad 2000'. Some of the advantages ascribed to the VLC resins are accuracy of fit, superior strength, complete polymerization without residual

compounds, absence of free methyl methacrylate, colour stability, ease of fabrication, and ease of manipulation.⁶

It was further suggested by the same authors, using scanning electron microscopy, that the surface of VLC is less porous than AP resin. Under higher magnification, VLC was seen to have fewer microporosities than were apparent on the AP acrylic resin specimen. They further postulated that these microporosities lead to increased adherence of micro-organisms.

VLC resin has undergone extensive laboratory testing and compared with conventional heat-cured acrylic resin (HC) and orthodontic autopolymerizing acrylic resin (AP). Some of its properties are as follows:⁶

- Polymerization shrinkage for each of the three materials is nearly equal in value.
- Tensile strength for VLC resin was slightly higher than the values for HC and AP acrylic resin.
- The transverse deflection values at 3500 and 5000 g showed that deflection of the VLC resin was less than that of the HC and AP acrylic resins materials, indicating that VLC resin is comparatively stiffer.
- The elastic modulus (bending) was slightly higher than in HC and AP acrylic resin.
- Dimensional changes were evaluated by fabricating VLC, HC, and AP bases on identical casts with metal markers in five locations. After 10 days in water, the AP resin shows a +0.05 per cent expansion from ridge crest to ridge crest but no expansion was seen with HC or VLC.

From these preliminary tests, it was indicated that VLC resin is generally superior in fit compared to heat-cured and autopolymerizing acrylic resin.⁶

Little clinical data on the effectiveness of VLC as an orthodontic base plate material is available. Consequently, the aims of this study were to ascertain whether or not the smoother surface associated with VLC appliances had any measurable affect upon mucosal redness and to assess the durability of such appliances in a clinical context.

Hypotheses

The hypotheses to be tested were that VLC resin appliances caused less erythema of the palate than AP resin appliances and that their breakage rate showed they were sufficiently durable for routine orthodontic clinical use.

Material and methods

Sixty-nine patients attending for issue of upper removable appliances were randomly allocated an AP or a VLC appliance. Randomization was achieved by using a random number table that indicated which appliance material was to be used. The appliances included space maintainers, active plates with screws or springs, bite planes, Hawley retainers, and nudger appliances.

The redness of the patient's palate was measured approximately 30 minutes after issue of the appliance, after 1 month and finally after 3 months. This was done by means of an erythema meter, a sensitive optical device designed originally to measure cutaneous erythema induced by ultraviolet radiation.⁷ Its sensitivity and reproducibility as an objective means of measuring erythema of the palatal mucosa was evaluated by Cross *et al.*⁸ The results showed very good reproducibility with a coefficient of 88 per cent. The erythema meter is based on the principle that when white light, between 400 and 700 nm is reflected off a cutaneous or mucosal surface, oxyhaemoglobin in the vasculature selectively absorbs green light, but has little effect on red. Erythema results in more green light being absorbed, rather than reflected, while the reflectance or absorption of red light remains the same. A specially small tip was designed for the meter to allow measurement of palatal erythema in dentate subjects in two locations on the palate, repeated three times and averaged. Therefore, by comparing the amount of reflected red and green light, an index may be obtained. The levels of erythema have been defined as:

- <20 Absence of inflammation of the palatal mucosa.
- 20–40 Mild inflammation.
- 40–80 Moderate inflammation.
- >80 Severe inflammation.

Generally, patients with healthy palatal mucosa would give a range of erythema indices below 40.⁸

The Silness and Løe Plaque Index,⁹ was used to assess the surface area and thickness of plaque from grades of 0–3 by a calibrated operator, as the level of oral hygiene might influence the erythema of the palate.

The above procedures were repeated at routine visits for appliance adjustment at 1 and 3 months. The details of any breakage of the appliances were noted over a 6-month period. The mean intervals between visits were 5.3 ± 4.0 weeks, 8.9 ± 5.2 weeks, and 11.1 ± 4.1 weeks.

Error study

Twenty readings of palatal sites were taken of persons who did not wear any appliances. These were repeated 5–6 hours later and the readings compared. A *t*-test was used to find any significant systematic error in the method used and the Bland Altman method¹⁰ and Intra-class Correlation were utilized to show any random error. No significant differences were found and agreement was excellent (ICC = 0.63).

Results

Nineteen subjects dropped out of the study for various reasons (9 VLC, 10 AP). The most common were lack of co-operation, failed appointments, not wearing the appliance or lack of tolerance of removable appliances. This left a group of 50 patients.

The age and distribution of the sample according to the appliance allocated is shown in Table 1.

Erythema indices and plaque score

At the start of the study there was no significant difference in plaque score between the two appliance groups. (VLC = 0.45, AC = 0.42). The mean erythema meter indices and the mean plaque scores for Orthoresin and Triad VLC acrylic resin subjects combined made during the three visits (1, 2, 3) are shown in Figure 1. When the erythema meter indices and plaque scores for all three visits were stacked and analysed, we found that there was no significant correlation between erythema meter indices and plaque scores ($r = -0.12$).

Erythema indices and materials

Figure 2 shows the comparison of the mean erythema index values between the two materials. There was no significant difference at any stage.

Table 1 [Q1]

	<i>n</i>	Mean age ± SD (years)
Orthoresin subjects		
Male	11	13.6 ± 1.7
Female	16	13.8 ± 2.4
Total	27	13.4 ± 2.2
Triad VLC subjects		
Male	13	12.9 ± 2.4
Female	10	17.0 ± 7.7
Total	23	14.6 ± 5.6

Erythema indices across time

To test for mean differences in the erythema response for each material across time, the repeated measures Analysis of Variance (ANOVA) test was carried out. Results showed that, for Orthoresin, there was a significant ($P = 0.044$) change on average over time, that is the value decreased over the 3-month period of wearing the appliance. However, for the Triad VLC acrylic resin, there was no significant ($P = 0.213$) change.

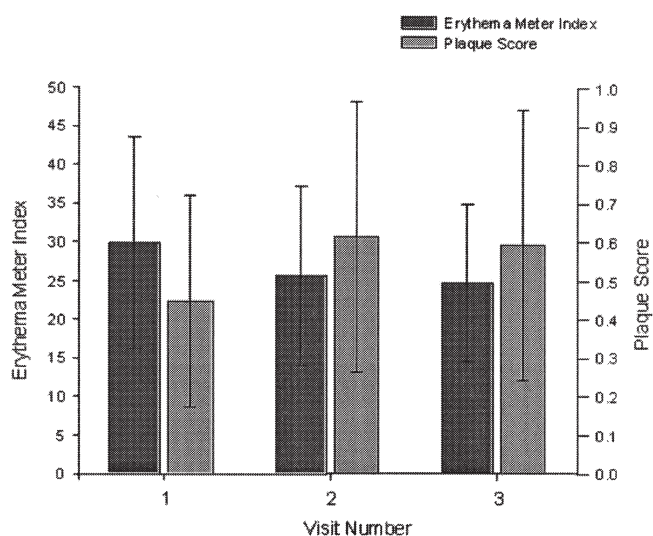


Figure 1 Graph showing the relationship between means (±SD) for erythema meter index and plaque score at each visit for the whole sample.

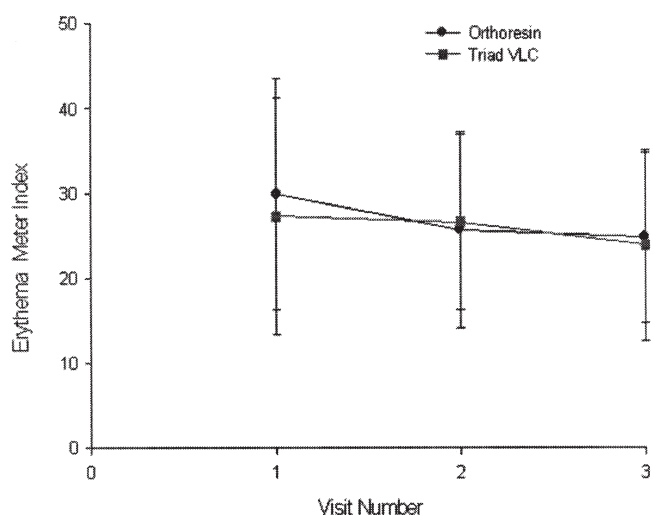


Figure 2 Graph showing the mean (±SD) erythema index reading at each visit for Orthoresin and Triad VLC.

Breakages

Chi-square tests showed a significant difference ($P < 0.001$) between the proportion of subjects who experienced at least one breakage, that is VLC material broke significantly more often. Fifty-two per cent of VLC appliances broke as compared with 7 per cent of AP appliances.

Most fractures or breakages of the appliances were located within the acrylic base plate except for one fractured Adams clasp with an Orthoresin appliance.

Importantly, the majority of breakages occurred outside the mouth. Fourteen out of 18 VLC breakages occurred within the first 3 months compared with one in each of the 3-month periods with Orthoresin.

Discussion

There did not appear to be any relationship between the plaque scores and erythema indices. The plaque scores for the whole sample during the study were observed to be generally low. This may be attributed, at least in part, to the inclusion criteria for the study that included good oral hygiene as an essential factor, and the fact that better motivated patients were more likely to comply with the requirements of the study and not drop out. The plaque score of the whole sample was low corresponding to the values of 0–2 and only occasionally reached the score of 3. The means for the whole sample varied between 0 and 1 at the three visits, which reflects a good level of oral hygiene. Consequently, any differences in palatal erythema should be attributable to the base plate material.

None of the subjects showed erythema readings of more than 80, which corresponds to severe inflammation of the palatal mucosa. The mean erythema index for the whole sample over the three visits was 26.41 ± 11.88 . It appeared that most healthy palatal mucosae have erythema meter readings of below 40.⁸

In Figure 2 it appears that the erythema readings for the first visit were higher than the next two visits for the whole sample. This finding is not significant clinically because the erythema readings are still within the normal range, i.e. mean erythema readings during visit 1 was 28.7. The results showed that for the autopolymerized resin (Orthoresin), there was a significant change ($P < 0.05$), on average, over time. This may be explained by the fact that in time any free monomer has disappeared and any initial irritation has been resolved.

During the clinical trial, it was also observed that the

different anatomical sites of the palate gave different readings, although the mucosa appeared to be healthy. This coincides with the different levels of vascularity in a normal palate. A diagram of the palate was kept to enable the site where measurements were recorded to remain constant throughout subsequent visits.

Any claimed advantages of Triad VLC with regard to the absorption of bacteria seem to be of little practical significance. However, due its safe handling properties as compared with autopolymerizing resin if it were equally durable in a clinical context it would be the preferred material. Unfortunately, the much higher frequency of breakages render it, at present, unsuitable for clinical orthodontic use. The high frequency of breakages confirms the laboratory findings of several workers that VLC is stiffer and more brittle than AP because its impact strength is lower.^{11–13} Nine of the 12 breakages experienced in this study with VLC occurred among male subjects. This effect may have been slightly exaggerated due to the higher proportion of male subjects in the VLC group, but does not affect the overall conclusion of the material's lack of clinical durability. On closer examination of the circumstances and sites of fracture, it seems that most of the fractures occurred while the appliance was outside the mouth and involved the acrylic resin base plate. Repeated offences were observed to occur only among the male patients. The female subjects (three) who broke VLC appliances were once-only offenders. This concurs with a previous study of generalized lack of compliance or carelessness of male patients compared to females.¹⁴ Both breakages in the Orthoresin group were also by male subjects.

Three patients with VLC appliances experienced repeated breakages at the beginning of the study and this was due to the thinness of the plate during construction. After the problem was addressed, the breakages were reduced, but they still occurred more frequently relative to Orthoresin. This also suggests that because of the low impact strength, the material has to be constructed to at least 2–3 mm in cross-section to sustain clinical durability.

Conclusions

Visible light-cured resin, in contrast to autopolymerizing resin, contains no residual methyl methacrylate. This therefore eliminates the potential risk of health problems not only to the patients, but also to technicians and dental surgeons. However in this study, no adverse mucosal reactions were noted with either material.

Regrettably, the results of this study indicate Triad VLC is less durable than Orthoresin, and further modifications are required to improve its physical properties before its widespread introduction for use as a routine material in orthodontics can be recommended. Although the precise constituents of the material are unknown, improved strength is likely to be achieved by manipulation of the filler content.

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