

Original Article

Heat-cured Acrylic Resin versus Light-activated Resin: A Patient, Professional and Technician-based Evaluation of Mandibular Implant-supported Overdentures

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INTRODUCTION

Implant-retained overdentures can profoundly influence patient satisfaction, quality of life, and oral tissue health.^[1] Many clinicians and authors recommend using two implant-retained mandibular overdentures as the primary treatment choice for edentulous patients.^[2,3]

Previously, polymethyl methacrylate (PMMA) resin was the most commonly used material for denture bases.^[4,5] PMMA shows satisfactory dimensional stability, low water absorption and high resemblance to oral tissue; its only

ABSTRACT

Context: Although light-activated resins (Eclipse) have been reported to possess superior physical and mechanical properties compared with the heat-cured acrylic resins (Lucitone-199), a few studies have compared overdentures with a locator attachment constructed from heat-cured acrylic resins with those constructed from light-activated resins. **Aims:** This clinical study was designed to compare the performance of a mandibular implant-supported overdenture constructed from a heat-cured acrylic resin (Lucitone-199) with that of an overdenture constructed from a light-activated resin (Eclipse). **Materials and Methods:** Ten participants received two identical mandibular implant-retained overdentures (Lucitone-199 and Eclipse) opposing one maxillary denture in a random order. Each mandibular overdenture was delivered and worn for 6 months, and two weeks of rest was advised between wears to minimize any carryover effects. Three questionnaires were devised. The first questionnaire (patient evaluation) focused on evaluating different aspects of the denture and overall satisfaction. The second questionnaire (professional dentist evaluation) was based on a clinical evaluation of soft tissues, complications, and the applied technique. The third questionnaire (technician evaluation) involved ranking the different manufacturing steps of the denture and overall preferences. The obtained data was statistically analyzed using an independent sample t-test and the Wilcoxon rank-sum test. **Results:** The clinician and technician preferred the Eclipse dentures because of their technical aspects, whereas the patients preferred the Lucitone-199 dentures for their aesthetic properties. **Conclusions:** Implant-supported overdentures constructed from a heat-cured acrylic resin showed superior aesthetics and had a better odor compared with those constructed from a light-cured resin.

KEYWORDS: Heat-cured acrylic resin, implant, light-activated resin, overdenture

drawback is its ability to fracture during clinical use.^[6,7] Various investigations have shown that heat-cured PMMA resin is limited with regard to its strength, particularly under impact and fatigue conditions.^[8] However, all acrylic dentures are subjected to intraoral or extra oral stresses in addition to stresses attributable to overdenture-wearing

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patients, who might apply an increased load to their prostheses. In turn, overdenture breakage is a common failure caused by increased forces and the thinning of the acrylic bases to accommodate implant components.^[9] Any type of acrylic denture base fracture presents a time-consuming and a costly challenge; furthermore, such fractures are problematic for patients.^[10] Accordingly, the risk of denture breakage might be minimized through the use of an alternative material that has considerably improved resistance to fracture, which would be a great advantage.

As an alternative to traditional PMMA, several visible light-cured resins (VLCRs) based on dimethacrylate are currently available. One such VLCR is Eclipse, the most recently developed denture base polymer.^[11,12] Several studies have shown that Eclipse exhibits dramatically higher surface hardness, flexural strength, flexural modulus, and transverse strength than other denture base acrylic resins. In addition, *in vitro* studies reported that VLCRs have more color stability than PMMA denture base polymers.^[13-15]

Pfeiffer *et al.*^[16] and Faot *et al.*^[17] investigated the technical parameters of VLCR materials. Grossmann and Savion^[12] used Eclipse to successfully fabricate a definitive obturator for clinical post-maxillectomy patients. The previous studies^[16,17] found that this polymer has many advantages, including its improved record base retention, stability, and support; the absence of free monomers; its decreased laboratory time and cost; and its capacity to promote a safer work environment due to the absence of the need to use an open flame. In a randomized long-term clinical study, Gohlke-Wehrße *et al.*^[18] compared VLCR and PMMA denture base materials using a split-mouth model with removable dental prostheses (RDPs) and reported no differences between these test materials with regard to tissue reactions.

However, little information exists regarding the clinical performance of VLCR. To the authors' knowledge, no clinical study has yet compared an overdenture with a locator attachment constructed from PMMA with one constructed from Eclipse. Accordingly, this study compared a mandibular implant-supported overdenture, constructed from heat-cured acrylic resin (Lucitone-199) using a compression molding technique, to one constructed from light-activated resin (Eclipse).

MATERIALS AND METHODS

Study design, sampling procedures, study participants, randomization, and ethical considerations

A crossover, randomized (within-participant), clinical study was conducted at the Department of

Prosthodontics, College of Dentistry, King Saud University (KSU). We invited ten completely edentulous female patients with two successful osseointegrated mandibular implants who visited the prosthodontic clinic of the School of Dentistry and who required new complete overdentures to participate in this study. The requirements of the declaration for prospective clinical studies with humans ("informed consent") and those of KSU's ethics committee were fulfilled at the time of enrollment.

The patients between 45 and 65 years of age were eligible for study participation if they were fully edentulous; had two parallel-placed osseointegrated implants, 1.5-2.0 mm attached gingiva, sufficient sulcus depth, and sufficient inter-arch space; sought the construction of new implant-retained mandibular overdentures; had no history of resin allergy; and were able to read and respond to a written questionnaire in Arabic. The patients were blind to the denture they received and were not informed of the differences between the two dentures (randomized within-participant design). However, the treating dentist and the dental technician who fabricated all of the sets of dentures were not blind to the study condition.

Clinical procedures and follow-up

The patients removed their old dentures for 2 weeks to allow their oral tissue to rest. For standardization, the two types of investigated dentures were constructed using the same custom tray, and the two jaw relations were recorded during the same visit. Thus, both dentures had identical contours, equal vertical dimensions, and the same centric relations as determined by exchanging the recording blocks of the two dentures and using the equivalent teeth mold and size.

The custom tray was constructed, according to Asal,^[19] with the application of two layers of base plate wax at the locator abutments. Verification and border molding were performed while the impression copings were snapped onto the abutments. An abutment-level closed tray impression technique was used [Figure 1]. Two abutment analogues, two black female processing caps (for exchange after processing), and two locator attachments were used for each Lucitone-199 overdenture. After the final impression was taken, the abutment analogues were seated into the impression copings, and stone casts were poured. Heat-cured acrylic dentures were constructed from Lucitone-199 (DENTSPLY Trubyte, Int. Inc., York, PA, USA) using the manufacturer's recommended compression-molding technique. The locator attachments were indirectly seated into the denture during the denture processing.

Construction of Eclipse dentures

Four impression copings, four abutment analogues, two black female processing caps, and two locator attachments were used for each Eclipse overdenture [Figure 2]. While the impression copings were seated on the abutment analogues, a duplicate of the mandibular master cast/participant was obtained from a pourable silicone duplicating material (DeguformR Plus, Germany) after assembling the remaining two abutment analogues. After the application and drying of a layer of a thin tin-foil substitute (Alcote separating medium) on the original master cast, the cast was preconditioned to 120-130°F in the conditioning oven to 55°C for 2 min. The denture caps were seated onto the locator abutments and the permanent Eclipse baseplate ((DENTSPLY Trubyte, Int. Inc., York, PA, USA) was adapted onto the cast with the rounded side of the baseplate resin face placed upside down, the adaptation of the Eclipse began 30 seconds after its placement on the arch form of the cast. To avoid any air entrapment, slow and careful adaptation began from the crest of the ridge palatally joining the two sides at the midline and buccally into the vestibule. The resin baseplate/cast was cured in an Eclipse light-curing unit for 10 minutes after the Eclipse air-barrier coating (ABC) was applied to the entire surface of the resin baseplate [Figure 3]. After bench cooling, for constructing the wax occlusal rim, and replacing the damaged black processing caps with new ones (in a sequence), the jaw relation was recorded as previously mentioned.

Using a semi-adjustable articulator, the selected teeth were placed on an ABC-coated free denture base using the set-up resin. The set-up resin was slightly roughened on the outer surface of the relative alveolar ridge, and prepared with butt joints 1-2 mm above this depth. All of the set-up resin and the exposed denture base were covered with molten contour resin around the teeth to hold them in position and simulate the natural gingival contour. The denture/cast and mounting ring was cured in the Eclipse-curing unit for 10 minutes, after which it was bench-cooled, finished and polished.

The finished dentures (Lucitone-199 and Eclipse) were delivered to the patients. After replacing the black processing males with the blue replacement males (1.5 lbs/680 g) using the locator core tool, 5 patients received the Eclipse dentures first and the other 5 received the heat-cured acrylic resin dentures. Neither patient group was provided with information about which type of dentures had been received.

Patient evaluations

A modified patient satisfaction questionnaire was designed according to Burns *et al.*^[20] All of the participants were asked nine questions about denture

aesthetics, comfort, speaking, stability, ease of cleaning, occlusion, and ability to chew after using the assigned denture for 6 months. The denture satisfaction scales had a response format that ranged from 0 to 2, where 0 denoted dissatisfied (DS, i.e., there were major problems); 1 denoted partially satisfied (PS, i.e., there were minor problems); and 2 denoted completely satisfied (CS, i.e., there were no problems). The data were obtained after 6 months of using each denture (i.e., the tissue rested for 2 weeks in between sets), thus enabling intra-individual comparisons.

The patient preference was recorded at the end of the second sequence (i.e., upon completion of the investigation). Each patient compared the two dentures directly with respect to retention and odor. The patient preference scales allowed responses that indicated preference for the dentures constructed from heat-cured acrylic resin (Lucitone-199), preference for those constructed from light-cured resin (Eclipse), or no preference.

Professional evaluation

The dentist compared the two techniques used to construct the two dentures with regard to length of time spent and difficulty in performing each clinical step (jaw relation, try-in, and denture placement). The numbers of required post-placement visits and registered patient complaints (e.g., overextension, pressure areas, and ulcers) were also recorded. At the end of the study period, the practitioner recorded her preference.

Technician evaluation

The technician responded to a questionnaire that compared the two laboratory techniques used to construct the two sets of dentures with regard to the preparation steps, time of construction, and difficulty, along with his preferred technique.

Statistical analysis

The data was analyzed using frequencies and descriptive statistics. The Wilcoxon signed rank test was used to test the two materials. The Chi-square tests were used to determine the association between patient satisfaction and either retention or odor. The level of significance was set at $p < 0.05$. All of the data analyses were performed using SPSS, version 19.

RESULTS

Patient evaluations

All patients completed the study and the questionnaires resulting in a response rate of 100%. [Table 1] shows the patient satisfaction responses for both sets of dentures with regard to aesthetics, comfort, speaking, stability, ease of cleaning, occlusion, and ability to



Figure 1: Abutment level final impression.

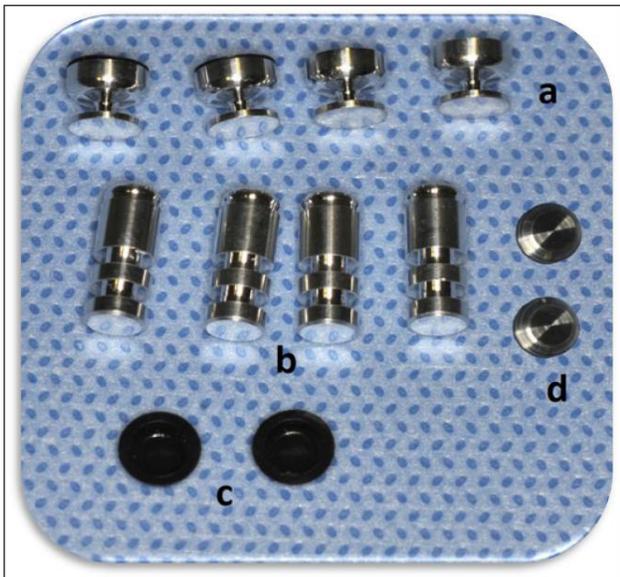


Figure 2: Processing attachment components needed for each Eclipse overdenture.



Figure 3: Curing of the baseplate/cast in an Eclipse light-curing unit.

Table 1: Frequencies and percentages of patient satisfaction characteristics 6 months after each denture placement

		Lucitone-199 Frequency (%)	Eclipse Frequency (%)
Aesthetics	PS	-	6 (60%)
	CS	10 (100%)	4 (40%)
Comfort	PS	-	-
	CS	10 (100%)	10 (100%)
Speaking	PS	-	-
	CS	10 (100%)	10 (100%)
Stability	PS	-	-
	CS	10 (100%)	10 (100%)
Cleaning	PS	-	8(80%)
	CS	10 (100%)	2 (20%)
Occlusion	PS	4 (40%)	-
	CS	6 (60%)	10 (100%)
Chewing	PS	4 (40%)	-
	CS	6 (60%)	10 (100%)

PS: partially satisfied, CS: completely satisfied

Table 2: Patient satisfaction 6 months after denture placement

	Lucitone-199 (Mean ± SD)	Eclipse (Mean ± SD)	P-value
Aesthetics	3.00 ± 0.000	2.40 ± 0.516	0.014
Comfort	3.00 ± 0.000	3.00 ± 0.000	1.000
Speaking	3.00 ± 0.000	3.00 ± 0.000	1.000
Stability	3.00 ± 0.000	3.00 ± 0.000	1.000
Cleaning	3.00 ± 0.000	2.20 ± 0.422	0.005
Occlusion	2.60 ± 0.516	3.00 ± 0.000	0.046
Chewing	2.60 ± 0.516	3.00 ± 0.000	0.046

chew. 40% of the patients were PS with the occlusion and chewing associated with the heat-cured acrylic resin dentures, which significantly differed from the same characteristics for the Eclipse dentures (P = 0.046). However, 60% and 80% of the patients who wore the dentures constructed from Eclipse were PS with the denture aesthetics and cleaning, respectively, and these values significantly differed from those associated with the Lucitone-199 dentures (PS = 0.014 and 0.005, respectively) [Table 2].

By the end of the study (after 12 months), 80% of the patients preferred the retention of the Eclipse dentures, whereas 20% reported no preference. Moreover, 70% of the patients preferred the odor of the Lucitone-199 dentures, whereas 30% reported no preference [Table 3]. A Chi-square test revealed an association between patient satisfaction and the satisfactory retention of the Eclipse denture and an association between patient satisfaction and the odor of the Lucitone-199 dentures after 6 months

Table 3: Patient preference regarding retention and odor after 12 months

	Lucitone-199	Eclipse	No Preference	Total (%)
	Frequency (%)	Frequency (%)	Frequency (%)	
Retention	-	8 (80%)	2 (20)	10 (100%)
Odor	7 (70%)	-	3 (30%)	10 (100%)

Table 4: Frequencies and percentages of the patients' clinical issues regarding the two sets of dentures

	Frequency (%)	Lucitone-199	Eclipse
		Frequency (%)	Frequency (%)
At denture placement	Overextension	No overextension	10 (100%)
		Localized area	-
24 hours after denture placement	Redness	One area	4 (40%)
		Two areas	6 (60%)
		> Two areas	3 (30%)
	Ulcers	No ulcers	10 (100%)

Table 5: Mean ratings of the Lucitone-199 and Eclipse dentures

Time of record	Clinical observation	Lucitone-199	Eclipse	P-value
		Mean ± SD	Mean ± SD	
At denture placement	Overextension	1.00 ± 0.000	0.00 ± .000	0.002
24 hours after denture placement	Redness	2.40 ± 0.516	1.9 ± 0.876	0.096
	Ulceration	0.00 ± .000	0.00 ± .000	1.000

(P = 0.002). Because of their aesthetics, the overdentures constructed from Lucitone-199 was preferred by the patients overall [Figure 4].



Figure 4: Heat-cured acrylic resin denture (a) and Eclipse denture (b) after 6 months.

Professional evaluation

The practitioner reported that the time spent acquiring jaw relation measurements and obtaining initial fittings was approximately the same for both sets of dentures (Lucitone-199 and Eclipse), whereas the time spent for Eclipse denture placement was less than that required to place the Lucitone-199 dentures. In addition, the Eclipse dentures were easier to work with throughout the denture construction.

During the clinical denture placement visit, the practitioner reported localized overextension areas that significantly differed in favor of the Lucitone-199 dentures (P = 0.002); [Table 4] Exactly 24 hours after denture placement, an insignificant difference between the two sets of dentures was reported with regard to areas of redness (P = 0.096); [Table 5]. Two to three post-placement visits (on average) were necessary to address patient complaints about the Lucitone-199 dentures and to correct for overextension and occlusion, whereas 3-4 post-placement visits were necessary to correct for pressure areas and repair teeth that had fallen out of the Eclipse dentures. The voids in the fitting surface, pressure areas at gingival margins around the implants, and the line of demarcation between the setup material and the denture base were also reported. The dentist preferred the technical aspects of the Eclipse dentures, although the Lucitone-199 denture was preferred for its aesthetics, aftercare, and longevity.

Technician evaluation

[Table 6] shows the technician's responses to the comparison questionnaire with respect to the two applied techniques for each resin type. Using an indirect pick-up locator attachment technique, the technician preferred the Eclipse denture for its implant-supported construction.

Table 6: Comparison of the techniques used to construct the Lucitone-199 and Eclipse dentures

	Materials used	
	Lucitone-199	Eclipse
Master cast	One cast required	Two master casts required
Post-dam preparation	After try-in of the trial denture and before processing	Before construction of the denture base (before jaw relation was recorded)
Teeth preparation	Unnecessary (chemical bond)	Mandatory for mechanical retention
Setting of teeth	Can be performed by any technician	Requires expert technician
Demounting	Required for processing	Not necessary (processed with the mounting ring)
Investing, flasking and boil-out	Required	Not necessary
Laboratory remounting	Using the split-mounting technique	Re-screwing the mounting rings into its place
Processing time	1.5 hours or 9 hours through flasking, wax elimination, packing, and curing	10 minutes in the processing machine
Finishing and polishing time	Approximately 1 h	10-15 minutes
Laboratory implant component	Two impression copings, two abutment analogues, two black female processing caps	Four impression copings, four abutment analogues, two black female processing caps

DISCUSSION

Both the clinical and laboratory-based aspects of prosthodontic treatment play a vital role in overall patient satisfaction, which is the primary indicator of treatment success. This study's results failed to completely reject the null hypothesis. The null hypotheses regarding patient satisfaction concerning aesthetics, cleaning, occlusion, chewing, retention, and odor along with the clinician and technician's preferences were rejected. With respect to comfort, speaking, and stability, the null hypothesis was not rejected.

Different factors can affect a patient's satisfaction with their dentures, including their general health, soft- and hard-tissue factors, age, muscle efficiency, and ridge relationship. A crossover study was implemented to eliminate any effects due to variation. The indirect locator attachment pick-up was used based on the clinician's experience and preference of a skillful technician.

The different factors that affect denture aesthetics (e.g., the size, shape, color and position of the teeth) were standardized. In this study, the color stability and cleanliness of the denture base material were the controlling aesthetic factors. A previous *in vitro* study comparing the chromatic stability of light-activated resin and heat-cured acrylic resin concluded that the former was more color-stable than the latter.^[13] Khan *et al.*^[21] did not find a significant difference between the two materials; however, the outcomes of our study contrast. These reports of the patients enrolled in the current study, 60% were PS with the Eclipse dentures because of their rough contour resin and the line of demarcation that exists between the set-up and base plate resins. These findings might have contributed to the differences between the two studies. Using a

standardized mechanical finishing and polishing protocol, Asal *et al.*^[13] measured color changes at a specific area on a sample disc constructed from the base plate resin only, whereas in this study, the dentures were constructed from denture base, set-up and contour resins that required mechanical union. Moreover, in this study, the dentures were subjected to a non-standardized manual finishing and polishing protocol. An Eclipse's inferior clinical aesthetics might be attributed to the presence of a line of demarcation at the meeting of different layers as well as insufficient finishing and polishing. The line of demarcation at the border of the set-up resin might be caused by insufficient ledge preparation and the presence of contour resin flashes on the ledge border.^[22-24]

High patient satisfaction (100%) was reported, and no differences were observed with regard to comfort, speaking or stability between the Lucitone-199 and Eclipse dentures. Despite these similarities, an *in vitro* study using micro-computed tomography (micro-CT) to investigate and compare the dimensional accuracy of the Lucitone-199 and Eclipse dentures; the results suggested that Eclipse is more dimensionally stable than Lucitone-199, given that it is in close contact with the cast at the crest of the ridge.^[25] One possible explanation is that a denture that bears mucosa is compressible; thus, dimensional changes might be of little clinical relevance to the success of the denture base material.^[26-28]

Only 40% of patients were PS with the occlusion and chewing associated with the dentures constructed from the heat-cured acrylic resin, and this result showed a small, significant difference ($P = 0.046$). This result might be attributed to the increased polymerization shrinkage of Lucitone-199 compared to Eclipse.

However, Lucitone-199 shows more water absorption and less dimensional stability than Eclipse after storage in water at 37°C.^[13,29]

The scheduled post-placement aftercare is mandatory for a successful long-term denture performance. Hirarto *et al.*^[30] reported that light-cured resin requires more aftercare (i.e., repair of denture fractures and cracks, aesthetics, and correction of anterior tooth length) than PMMA, whereas the present study demonstrates that the primary aftercare associated with Eclipse involves relieving pressure spots around the implants, repairing missing teeth (mostly canines), and providing extra finishing and polishing compared to Lucitone-199.

In 2000, Cunningham^[31] reported the bond failure between acrylic resin teeth and a VLCR denture base. This observation corroborates the findings of the current study suggesting that this failure might have been caused by insufficient preparation of the retention device, mechanical errors or remnant wax on the teeth.

Schwinding *et al.*^[22] reported an increased number of pressure spots associated with VLCR dentures. This finding matches our data showing concentrated pressure points around the implants in the Eclipse dentures, which might be due to the intimate fit between the denture base and the ridge crest^[13] along with greater dimensional stability after storage in water.^[29]

Smooth denture surfaces are easier to clean and have better aesthetics than rough denture surfaces. A previous study found an increased roughness in unpolished VLCR surfaces compared with PMMA,^[28] and the unpolished dentures lost their shine, encouraged the retention of food residues and other deposits and increased plaque adherence.^[23,24] These characteristics might explain why 70% of patients did not prefer the odor of the Eclipse dentures. The authors believe that well-taken final impressions and strong pouring should overcome this problem.

The professional's preference for the Eclipse dentures was primarily based on their successful retention of permanent denture bases during the different steps of construction because this retention eliminated investing, flasking, boil-out, de-mounting, and re-mounting; in addition, it offered reduced processing time. These findings are consistent with previous reports.^[18]

The clinician and technician preferred the technical aspects of the Eclipse dentures, which is contrary to the patients' preferences. This divergence might be because of the differences in the aspects of dentures that each group considers being most important. Many studies have obtained a poor correlation between patient and clinician ratings.^[32-35]

The clinician preferred the Eclipse dentures for the following reasons: satisfactory record base retention, stability, and support during jaw relation measurements and try-in steps. Gohlke-Wehrße *et al.*^[18] also reported praise for these dentures with respect to decreased denture placement time and the ability to perform same-day adjustments.

The technician preferred the Eclipse dentures because of their simpler construction steps, decreased lab time, and safer work environment due to the absence of an open flame. However, this technique does have disadvantages; for instance, these dentures require a duplicate master cast and tooth preparation for mechanical retention along with an extra laboratory armamentarium and additional training. Furthermore, previous studies have found that grinding artificial teeth (where inter-arch space is limited) can interfere with tooth retention.^[12]

CONCLUSIONS

- Within the limitations of this study, the current paper concludes the following:
- Patients preferred the Lucitone-199 dentures primarily because of their aesthetics.
- The clinician preferred the Eclipse dentures because of their well-retained permanent base during construction.
- The technician preferred the Eclipse dentures because of their decreased construction time and number of construction steps (excluding the time needed to prepare additional teeth and cast duplicates).
- Eclipse is a sensitive system that requires a committed, well-trained technician.
- Despite aesthetic concerns, Eclipse is the material of choice for implant-supported overdentures using the locator indirect pick-up attachment technique.
- It is necessary to conduct additional investigations that apply not only different impression techniques but also varying finishing and polishing approaches.

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Conflicts of interest

There are no conflicts of interest

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