Surface hardness of a resin composite cured with a transparent cone

Paula Drexler, DDS Franklin García-Godoy, DDS, MS Juan R. Boj, DDS, MS

Abstract

The purpose of this study was to evaluate the surface hardness of a resin composite (TPH) polymerized with and without the use of a transparent light-curing cone. Twenty composite blocks were made on a Teflon® mold with cylindrical holes of 3 mm depth and 6 mm radius, and were light cured following different procedures:

Group 1: Ten samples were pressed with a glass slide and light cured for two 40-sec exposures without the plastic cone; Group 2: Ten samples were light cured using the transparent plastic cone which was pressed down into the composite until the tip was 1 mm from the floor of the cylindrical Teflon mold. The curing light was activated for 40 sec. The cone was then removed and the remaining part of the mold was filled in one portion, pressed with a glass slide, and light cured for 40 sec. After curing, the samples were placed in distilled water for 48 hr. The hardness of the samples was then measured with a Rockwell Hardness Tester at three different points on each composite block; therefore, 30 measurements per group were taken. The data were statistically analyzed using an unpaired Student's t *test. The results revealed that the resin composite cured with the transparent plastic cone had a statistically significant higher surface hardness value (*$P < 0.0001$*) than the group cured without the cone. (Pediatr Dent 19:419–20, 1997)*

Resin composites with incomplete polymerization exhibit poor mechanical and chemical properties.[1, 2] In order to increase resin polymerization, several techniques have been proposed such as application and curing in small increments;[3,4] curing from buccal and lingual directions through part of the enamel;[1] use of translucent matrix bands and light-transmitting wedges;[5] use of mirror matrix bands;[6] and the use of a transparent cone attached to the end of the curing wand, which is then inserted into the bulk of the resin.[7]

The purpose of this study was to evaluate the surface hardness of a resin composite polymerized with and without the use of a transparent light-curing cone.

Materials and methods

Twenty composite blocks (TPH, LD Caulk Co., Milford, DE) were made on a Teflon mold with cylindrical holes of 3 mm depth and 6 mm radius, and were light cured (Optilux 400, Demetron, Danbury, CT) following different procedures:

Group 1: Ten samples were pressed with a glass slide and light cured for two 40-sec exposures without the plastic cone.

Group 2: Ten samples were light cured using the transparent plastic cone (Light-tip CDB, Huddinge, Sweden) which was pressed down into the composite until the tip was 1 mm from the floor of the cylindrical Teflon mold. The curing light was activated for 40 sec. The cone was then removed and the remaining part of the mold was filled in one portion, pressed with a glass slide, and light cured for 40 sec.

After curing, the samples were placed in distilled water for 48 hr. The hardness of the samples was then measured with a Rockwell Hardness Tester (Wilson Instruments, American Chain & Cable Company) at three different points on each composite block; therefore, 30 measurements per group were taken.

The data were statistically analyzed using an unpaired Student's *t*-test.

Results

The results are displayed in the Table. The resin composite cured with the transparent plastic cone had a statistically significant ($P < 0.0001$) higher surface hardness value than the group cured without the cone.

Discussion

The polymerization of composite resins always results in contraction[8] and this contraction is less evident closer to the light source.[9] The use of the cone pushes the resins towards the cavity walls (reducing the bulk of resin cured), therefore, a smaller contraction gap may be produced[7] as well as a reduced number of porosities.[10]

The hardness test has been used as a method to evaluate polymerization and depth-of-cure of resin composites[11] and has been correlated to the number of remaining double bonds.[12] One study[11] has shown that surface hardness cannot be used to assess the quality of a curing unit.

Studies have shown that hardness, tensile strength,

TABLE. MEAN ROCKWELL HARDNESS VALUES FOR THE DIFFERENT GROUPS

Group	*Curing Time*	*No of Samples*	*Mean*	*S.D.*
With cone	80 sec	10	63.52*	4.89
Without cone	80 sec	10	49.25	6.15

* Statistically significantly different ($P < 0.001$).

flexural strength, and fracture toughness increased with the degree of conversion of double bonds.[12-15] A high degree of double bond conversion depends not only on the quantity of the light but also on its quality.

The present study showed that the use of a transparent plastic cone attached to the wand of the curing light significantly increased the surface hardness of the resin composite tested.

The increased hardness obtained with the use of the transparent cone in our study agrees with others[10] and may be due to the higher degree of conversion and crosslinking in the resin. Surface hardness does not guarantee an acceptable depth-of-cure. Once the maximum level of cure has been achieved in the upper layers of the resin, it is difficult to extend cure at the lower levels by extending time, because the light simply cannot reach them.[11] Because of this, the incremental resin placement technique light-cured for 40 sec or the use of the plastic translucent cone is recommended to permit light penetration to the deepest portion of the resin. This is important in deeper restorations.

The results of this study should be interpreted with caution and should only be limited to the surface hardness of the resin. Previous studies have demonstrated that the assessment of surface hardness cannot distinguish between a well-cured and an inferiorly cured resin.[11, 16] Therefore, surface hardness does not necessarily indicate that an effective cure in the bulk of the resin has taken place.[11]

Many years ago, Leinfelder et al.[17] and Wilder et al.[18] demonstrated that light-cured resins revealed increased wear resistance on the occlusal surface compared with autocured resins; these results were probably because of the increased surface hardness obtained with light-curing. This also increases the resistance to abrasion by food.[19] From a practical standpoint, using the light intensity tester (radiometer) before light-curing can predict the degree of conversion of a resin,[15, 20] and, based on our results, using the transparent cone will increase surface hardness and may improve the clinical wear of the resin composite. The combination of the two procedures would increase the mechanical and chemical properties of the resin, improving its clinical performance.

Dr. Drexler was a postdoctoral student, Department of Pediatric Dentistry, University of Barcelona, Barcelona, Spain. Dr. García-Godoy is Professor, Department of Pediatric Dentistry, University of Texas Health Science Center at San Antonio, San Antonio, TX USA. Dr. Boj is Postdoctoral Director, Department of Pediatric Dentistry, University of Barcelona, Barcelona, Spain.

1. Swartz ML, Phillips RW, Rhodes B: Visible light-activated resins—depth of cure. J Am Dent Assoc 106:634–37, 1983.
2. Tirtha R, Fan PL, Dennison JB, Powers JM: In vitro depth of cure of photo-activated composites. J Dent Res 61:184–87, 1982.
3. Hassan K, Mante F, List G, Dhuru V: A modified incremental filling technique for Class II composite restorations. J Prosthet Dent 58:153–56, 1987.
4. Torstenson B, Oden A: Effects of bonding agent types and incremental techniques on minimizing contraction gaps around resin composite. Dent Mater 5:218–23, 1989.
5. Lutz F, Krejci I, Oldenburg TR: Elimination of polymerization stresses at the margins of posterior composite resin restorations: a new restorative technique. Quintessence Int 17:777–84, 1986.
6. Kays BT, Sneed WD, Nuckles DB: Microhardness of Class II composite resin restorations with different matrices and light positions. J Prosthet Dent 65:487–90, 1991.
7. Ericson D, Derand T: Reduction of cervical gaps in class II composite resin restorations. J Prosthet Dent 65:33–37, 1991.
8. Walls AW, McCabe JF, Murray JJ: The polymerization contraction of visible-light activated composite resins. J Dent 16:177–81, 1988.
9. Hansen EK: Visible light-cured composite resins: polymerization contraction, contraction pattern and hygroscopic expansion. Scand J Dent Res 90:329–35, 1982.
10. Von Beetzen M, Li J, Nicander JL, Sundström F: Microhardness and porosity of Class 2 light-cured composite restorations cured with a transparent cone attached to the light -curing wand. Oper Dent 18:103–109, 1993.
11. Yearn JA: Factors affecting cure of visible light activated composites. Int Dent J 35:218–25, 1985.
12. Asmussen E: Restorative resins: hardness and strength vs. quantity of remaining double bonds. Scand J Dent Res 90:484–89, 1982.
13. Cook WD, Johannson M: The influence of postcuring on fracture properties of photo-cured dimethacrylate based dental composite resin. J Biomed Mater Res 21:979–89, 1987.
14. Ferracane JL: Correlation between hardness and degree of conversion during the setting reaction of unfilled dental restorative resins. Dent Mater 1:11–14, 1985.
15. Rueggeberg FA, Craig RG: Correlation of parameters used to estimate monomer conversion in a light-cured composite. J Dent Res 67:932–37, 1988.
16. Hansen EK, Asmussen E: Correlation between depth of cure and surface hardness of a light-activated resin. Scand J Dent Res 101:62–64, 1993.
17. Leinfelder KF, Sluder TB, Sockwell CL, Strickland WD, Wall JT: Clinical evaluation of composite resins as anterior and posterior restorative materials. J Prosthet Dent 33:407–16, 1975.
18. Wilder AD, May KN, Leinfelder KF: Two-year clinical study of UV-polymerized composites in posterior teeth. J Dent Res 60:[ABSTR #1096], 1981;
19. Jörgensen KD: Restorative resins: abrasion vs. mechanical properties. Scand J Dent Res 88:557–68, 1980.
20. Peutzfeldt A: Correlation between recordings obtained with a light-intensity tester and degree of conversion of a light-curing resin. Scand J Dent Res 102:73–75, 1994.