A cost analysis of treating pediatric dental patients using general anesthesia *versus* conscious sedation

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Abstract

Purpose: The purpose of this pilot study is to report a cost comparison of general anesthesia (GA) versus oral conscious sedation (CS) for the treatment of pediatric dental patients.

Methods: The study sample included 22 children whose parents/guardian selected GA care for their child. Selection criteria limited inclusion to healthy children (ASA I) ages 24-60 mo. The subjects acted as their own comparison group to an estimation CS model. Models were developed to assess societal costs for treatment under GA and CS. Treatment rendered was equalized using the dental Relative Based Value Units Scale (RBVU).

Results: Ordinary Least Squares Regression analysis techniques showed the association of RBVU to the total societal costs of GA and CS to be significant (P<0.01) with an adjusted R^2 of .64 and .78 respectively. When regression lines were plotted, the intersection represented RBVU level at which societal costs of GA and CS were the same.

Conclusion: Under the conditions of this pilot study, it is concluded that CS costs exceed GA costs at a RBVU level of 66.4, which would equate to more than three CS appointments. (Pediatr Dent 22:27-32, 2000)

An overwhelming majority of pediatric dental patients can be treated in the conventional dental environment without the use of pharmocologic agents, except for the occasional use of nitrous oxide/oxygen inhalation analgesia for the mildly anxious child. Pharmocologic management may be essential to provide invasive dental procedures for children who are developmentally or medically compromised and sometimes this modality is the treatment of choice for preschool-aged children who have not developed the language skills or attention span to cope with conventional dental care. For such children, the two most popular modalities of pharmocologic management are general anesthesia and conscious sedation.[1]

General anesthesia (GA) is a controlled state of unconsciousness that is accompanied by loss of protective reflexes, including the ability to maintain an airway independently and to respond purposefully to physical stimulation or verbal commands.[2] Conscious sedation (CS) is a minimally depressed level of consciousness that does not affect a patient's abilities to maintain a patent airway independently and continuously or to respond appropriately to physical stimulation or verbal commands.[3]

Both GA and CS have higher levels of risks and costs than does conventional care. Although GA is viewed as the more expensive modality of treatment when direct costs only are assessed, this is not clear when societal costs are considered.[4] Economists generally agree that to calculate societal costs one must also consider opportunity cost. A broad definition of opportunity cost might be as follows: an action that represents the value of next most valuable action forgone or the value of the next best alternative that a decision forces the decision-maker to forgo. For example, if a dentist should decide to take a vacation from practice, the opportunity cost for this time off is the wage lost for the time out of the office. Gold and colleagues[5] state that "the best approximation of the opportunity cost for adults is the wage they are, or could be, making at work." For the purposes of this study, opportunity cost is defined as income forgone due to dental treatment.[6] The societal cost perspective is indeed even larger than the parents/family perspective. For example, income forgone for parents' wages is relatively easy to calculate, but there is also a societal cost for children missing school due to pain or dental appointments and for school nurses or teachers who must take time with such children. While such societal costs are incalculable for purposes of this study, the authors offer this as a part of the rationale for the importance of taking the societal perspective into account.

Little has been reported in the literature relative to societal cost comparisons for children's dental care. A recent study compared the use of inhalation sedation via nitrous oxide/oxygen *versus* outpatient general anesthesia for extractions and minor oral surgery in pediatric dental patients.[4] The patients were scheduled for one sedation appointment and one GA appointment. In examining the parents' satisfaction and costs of both treatments, the investigators concluded that for extraction only treatment, it was more cost-effective to use inhalation sedation than GA. The costs in the study were based on direct cost only, excluding indirect and opportunity costs.

Many factors can influence a parents' decision to choose GA and CS for their child. Consideration might include risks and safety of the procedure, the child's perceived comfort, the parent's assessment of child's cooperation, the impact of the procedure on the child's developing psyche, the amount of care needed, the probability that treatment can be completed with the given modality, and the cost of care.[7,8] Despite the widespread use of both GA and CS, there have been few cost analysis studies of either modality and there are no reports of cost analyses from the societal perspective for pediatric dental patients.[9]

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Table 1. Examples of RBVU for Selected Dental Procedures

Dental Procedures	ADA Code	RBVU
PA x-ray (1 film)	0220	0.5
Bitewing x-ray (2 films)	0272	0.6
Prophylaxis	1201	0.75
1 surface amalgam, primary	2110	1.0
1 surface resin, primary	2330	2.0
Stainless steel crown	2930	4.0
Pulpotomy, primary	3220	3.0
Extractions, primary	7110	2.0

The specific aims of this study were: (1) to determine the societal costs for treating pediatric dental patients using GA and CS; (2) to determine the relationship between cost and treatment need for GA and CS respectively; and (3) to determine the relationship between GA *versus* CS cost models.

Materials and methods

The three principal types of cost-effectiveness studies include: 1) the cost-consequence model; 2) the cost-effectiveness model; and 3) the cost-minimization model. The cost-consequence model analyzes only the outcome of interest, under the assumption that there are no differences in costs. As an example, this model might be applied to a comparison of two dental materials where the cost of the materials and their application are relatively the same, but the outcome of interest is the material survival over time. The cost-effectiveness model examines the true cost-to-outcome ratio for the treatment and a comparator. Using a similar material science example, this model would be used in a study in which the restorative materials may differ in cost and survival. The cost-minimization model analyzes the cost differential between two treatments. The underlying assumption in this model is that the outcome of either treatment will be equal or similar. Using the material science example, the cost-minimization model would compare the costs of the restorative materials under the assumption that the materials performed the same over time.

This pilot study utilized a cost-minimization model for outpatient GA *versus* oral CS. This investigation relied upon each individual patient as the unit of analysis and each patient contributed cost data. The analyses evaluated the societal costs, defined as the sum total of direct, indirect and opportunity costs. Cost analyses usually employ mathematical, estimation or simulation modeling.[9] In this study, the GA model relied upon primary data and the CS model was an estimation model.

Sample

The sample included 22 children who required pharmocologic management for dental treatment because of acute situational anxiety in the conventional dental environment. All were scheduled for treatment using GA because their parent/guardian opted for this modality of care. The patients' ages ranged from 24-60 months at the time of the GA appointment. All were healthy children with no contraindications for routine dental care. All met requirements for American Society of Anesthesia (ASA) Class I anesthesia risk.

To maintain consistency and reliability, all patients were treated by the same dental operator in the GA setting. The patient sample served as its own comparison group to an estimation model for CS treatment.

Panel of experts

Expert judgement and consensus panels involve synthesis approaches used to estimate probabilities, costs, preference weights and other variables in cost-effectiveness studies.[5] For this study, a panel of four experts was used to determine values in the CS estimation model that could not be obtained from actual data. The panel consisted of two experts each in the area CS and GA. The experts were selected based on their extensive research and clinical experience. All were board-certified pediatric dentists who each have 20-25 years of clinical practice experience in the specialty.

Relative Based Value Units

The treatment rendered was assessed using the Dental Relative Based Value Scale/Units (RBVS/U).[10] RBVUs are based on the time and difficulty of procedures. The RBVU system has been used in medicine for many years as a way to value medical procedures across disciplines and specialties. The dental RBVU was developed in 1985 to equate dental procedures. Normal distribution and standard deviations and means were used to develop the scale. The data were analyzed for validity, statistically normalized and weighted.

RBVUs (Table 1) are considered to be valid and reliable measures of dental procedures. They are used widely by health insurance organizations such as Aetna, Blue Cross/Blue Shield, Prudential and Delta Dental, as well as Medicaid agencies in Vermont, Kentucky, and South Dakota to determine the value of procedures.[10]

To equalize treatment for the GA and CS models, RBVUs were calculated from the treatment rendered for the 22 children during their GA appointment. The same RBVU data for the GA appointment were utilized in the CS estimation model, so dental procedures were equal in both models. To determine the number of CS appointments to equate the same RBVUs rendered under GA, this study relied upon the clinical judgement of the same operator who completed the 22 GA cases. This approach allowed control for operator speed and judgement in determining the number of CS appointments that a given child might need.

Cost models

Models used in this study were taken from the *societal* perspective. This approach relies upon the perspective of the decision-maker, which in this study was the parent/guardian.[9] The cost models included costs incurred by the family for treatment and opportunity costs. Gusten and colleagues[6] define opportunity costs as income forgone for the decision of treatment. The accounting data included both indirect and direct costs.

Data for cost models were collected from hospital and dental school accounting records for the patients. There are many ways to calculate opportunity costs; for the purposes of this study, an aggregate measure was used. Income data by county were obtained for 1997 FY from the Economic Policy Unit of the North Carolina Department of Commerce.[11] The average wage earnings for each adult's county of residence were used to calculate lost income. In summary, opportunity costs in the model were calculated by multiplying the aggregate family wage earnings by the total hours lost because of the child's dental treatment.

Assumptions underlying model development

This study relied upon the cost-minimization model for using GA *versus* CS. In cost analysis studies, many assumptions must be made to develop a model.[9] For the GA model, this investigation relied upon the panel of experts to estimate the parental time commitment for a pre-operative GA visit (4 hours) and for the GA appointment itself (8 hours). For the number of adults accompanying the child for appointment procedures, the actual numbers were used—either one adult or two adults depending on whom accompanied the child.

For the CS model, the panel of experts estimated that the pre-appointment physical examination would require four hours and that only one parent would accompany the child for this appointment. For the CS new patient exam, they reached a consensus that this appointment would require a two-hour appointment with one parent accompanying the child. Finally, they estimated that two adults would accompany their child for their CS appointment and a four-hour time commitment would be required for each sedation visit.

Cost of GA

$$(C_{total}=C_{screen}+C_{pre\text{-}op}+C_{tx}+C_{1st1/2hr}+C_{add1/2hr}X_1+C_{anesth}+C_{rec}+C_{pt/family})$$

For the GA model, the cost ($22) of screening ($C_{screen}$) was obtained from dental school records. The cost ($88) for the pre-operative medical appointment ($C_{pre\text{-}op}$) was obtained from the hospital accounting records for the pre-operative GA evaluation. The actual dental fees for the procedures rendered under GA were used for the cost of treatment (C_{tx}). This cost was equalized to the CS model using the RBVU scale. The hospital cost for the GA appointment ($C_{1st\ 1/2hr}$ and $C_{add\ 1/2hr}$) was obtained from the hospital accounting records generated for each patient. Because hospital fees vary from the first half-hour ($950) to each additional half-hour ($530), two separate variables were used. The variable representing the cost of each additional half-hour ($C_{add1/2hr}$) was multiplied by the time beyond the first half-hour (X_1). The cost of the anesthesia (C_{anesth}) was $145 for the first 30 minutes and $73 for each additional 30 minutes. The recovery room (C_{rec}) costs were $110/hour. The operating room time was obtained from hospital records.

The opportunity cost for each patient was calculated by average income for the county of residence multiplied by the time lost for treatment per adult. Opportunity costs were calculated for both the pre-operative and GA appointments. All hospital accounting information was obtained from the Office of Cost Accounting at the University of North Carolina Hospitals.

Cost of CS

$$(C_{total}=C_{screen}+C_{npe}+C_{ppe}+C_{tx}+C_{appt}X_2+C_{appt}X_3+C_{pt/family})$$

The cost ($22) of the screening appointment (C_{screen}) and the cost ($22) of the CS new patient exam (C_{npe}) were obtained from dental school fees. The estimated cost ($88) of the physician's physical evaluation (C_{ppe}) for CS examination was obtained from the University of North Carolina ambulatory care unit.

As noted already, the panel of experts estimated the time it took for a CS new patient examination, the physician's pre-operative physical exam and the number of adults accompanying a typical child to pre-operative appointment and sedation appointments. This information was necessary to quantify the opportunity cost for each family ($C_{pt/family}$). To estimate the opportunity cost for each sedation appointment, the average income for the county of residence was multiplied by total time lost due to all phases of treatment for each adult accompanying the child. The CS appointment length was estimated at 60-90 minutes by the consensus panel.

The cost of the each sedation appointment (C_{appt}) was defined as the fee charged by the dentist to perform the CS procedures. This fee ($250) reflects a charge for sedation medications, monitoring equipment and additional personnel dedicated to monitor and assist in the CS area. The C_{appt} was multiplied by the number of appointments (X_2) estimated for the same treatment to be completed under CS as was completed under GA.

As noted previously, the estimated number of CS appointments needed for each child was made by the same dental operator who completed the actual procedures in the operating room for the GA model. This approach allowed the control for the variable clinic speed. Furthermore, the dental operator who made this judgement had extensive experience in the sedation arena. Judgements were made on estimated CS appointments needed on the basis of the patient's treatment plan, quadrants of care needed and the patient's body weight. Body weight was used because this variable must be considered for the amount of local anesthetic used in a given visit.

After the number of CS appointments was determined, the probability that the patient would need to return for another appointment because CS was aborted due to patient behavior that made the dental care unsafe for the child and the dental team was estimated. This abortion rate (X_3) in the Pediatric Sedation Clinic of the Department of Pediatric Dentistry at UNC-CH is 5.6%.[12] The cost of actual dental treatment (C_{tx}) was equalized to GA treatment using the RBVU scale.

Data analyses

The study's first aim was to establish costs representative of the societal costs for treatment under GA and CS. This was accomplished using a combination of opportunity cost and accounting data that represent direct and indirect costs.

The study's second aim was to establish the relationship between dental treatment rendered and total costs. Ordinary Least Squares (OLS) regression analyses[13] were used to examine the association between societal costs of treatment and RBVU. The outcome measure was the societal costs of treatment and the major explanatory variable was treatment need as measured by RBVU. Two regression models were used [Cost for GA = $b_0 + b_1$ (RBVU), Cost for CS = $a_0 + a_1$ (RBVU)]. The first equation illustrates the relationship between total costs and RBVU for GA, while the second illustrates the same association for CS.

The study's third aim was to determine the relationship between the GA and CS models. The two regression equations were plotted against each other and the relationship of the predicted regression equations illustrates the association between the GA and CS models. STATA Statistical Software was used for all the data analyses.[14]

Table 2. General Anesthesia Results

	N	%
Operating Room time (mean 2 hours 32 minutes)		
1-2 hours	7	32
2-3 hours	7	32
3-4 hours	5	23
4+ hours	3	13
Total GA Charges• (mean=$2326)		
$1,000-$1,500	2	9
$1,500-$2,000	10	45
$2,000-$2,500	3	14
$2,500-$3,000	7	32
Total Societal Costs•• (mean=$2698)		
$1,000-$2,000	6	27
$2,000-$3,000	9	41
$3,000-$4,000	7	32
RBVU, treatment rendered (mean=53.75 ± 10.5)		
0-35	3	14
36-70	13	59
71-100	6	27

N=22

• Excluding costs for dental procedures and opportunity costs.

•• Excluding costs for dental procedures, but including opportunity costs.

Results

The sample included 12 males (55%) and 10 females (45%). The mean age of the sample was 40 months (SD±5) with an age distribution as follows: 24-35 months—32%, 36-47 months—32%, and 48-60 months—33%.

Table 2 illustrates the GA results. The mean time spent in the operating room was 2 hours 32 minutes. Most cases (64%) were completed in three hours or less. The mean GA charge, excluding the cost for dental procedures and opportunity cost, was $2,326. The mean societal cost was $2,698, a figure that includes opportunity costs, but excludes costs for dental procedures.

The mean RBVU (treatment rendered) for GA care was 53.75 (SD ± 10.5). Table 3 illustrates the results when the same RBVU values were then applied to the CS estimation model. In the estimation model, 23% of the sample required two sedation appointments to complete treatment, 41% required three sedation appointments, and 36% required four or more appointments to complete their care. The mean CS charge, excluding costs for dental procedures and opportunity costs, was $1,363 with the majority (54%) of the cases costing less than $2,000. The mean societal cost was $2,203, a figure that includes opportunity costs, but no costs for dental procedures.

Two separate OLS regression models were executed. In both the GA and CS models, the association between RBVU and total societal costs was found to be highly significant ($P<0.01$) with an adjusted R^2 of .77 and .63 respectively. The magnitude of effect was also significant with the coefficients being 24.29 (SD ± 4.21) for the GA model and 35.17 (SD ± 4.33) for the CS model.

Figure 1 illustrates the relationship between the predicted regressions lines for the GA and CS models. The intersection

Table 3. Conscious Sedation Results

	N	%
Number of Appointments		
2	5	23
3	9	41
4+	8	36
Total CS Charges• (mean=$1,363)		
$500-$1,000	5	23
$1,000-$1,500	9	41
$1,500-$2,000	6	27
$2,000-$2,500	2	9
Total Societal Costs•• (mean=$2,203)		
$1,000-$2,000	12	54
$2,000-$3,000	5	23
$3,000-$4,000	5	23

N=22

• Excluding costs for dental procedures and opportunity costs.

•• Excluding costs for dental procedures, but including opportunity costs.

of the predicted regression equations illustrates the level of treatment need at which there would be diminishing returns for using CS or the point at which cost savings would favor GA. At a RBVU of 66.5 and a cost of $2,677, the total cost for treatment using CS surpasses that for GA.

Discussion

There are several alternative designs that might be used to derive a cost comparison of GA *versus* CS. This investigation chose the cost-minimization model using a GA sample that served as its own comparator for a CS estimation model. The advantage of this design was the ability to control for social and demographic patient effects in both models. This design also reduced the selection that would be introduced by a parental choice of GA or CS on the basis of family convenience factors. While such factors are important, this design eliminates bias related to parental choices.

The first aim of this study was to determine the societal costs of treating pediatric dental patients using GA and CS. The opportunity costs values that were used ranged from $73-136 per day depending on the county of residency. The state average was $105 per day or $22,583 per year for the average working adult. The mean total societal costs for treating children using GA *versus* CS was $2,698 and $2,203, respectively.

The second aim was to determine the relationship between societal costs and treatment rendered for both GA and CS models. The goal with this aim was to develop a model that would explain cost of GA and CS, respectively. Using regression analyses for the GA model, this study found that the RBVUs explained over 70% of the variance in cost. For the CS model, the study found that the RBVUs explained over 60% of the variance in cost. This can be interpreted to mean that treatment rendered, measured in RBVU, and had a significant affect on the costs of both GA and CS.

The third aim was to determine the relationship between GA and CS cost models. When the GA *versus* the CS regression lines were plotted, the intersection represents the point at which the cost of GA and CS would be equal. The study found that at a RBVU of 66.4 and a cost of $2,677, CS cost surpassed GA cost. This critical intersection equates to 3.6 CS appointments.

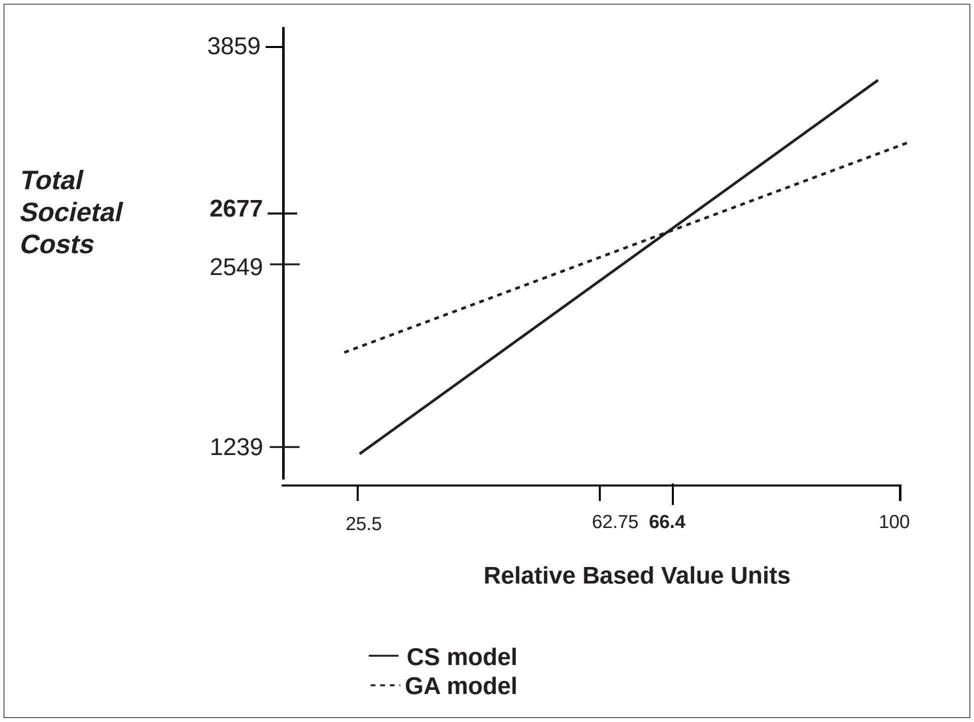

Fig 1. Relationship between GA and CS predicted regression lines.

Outcomes for GA *versus* CS

One of the major underlying assumptions in this study was that the treatment outcomes for GA *versus* CS would be the same. The authors recognize that this is a difficult assumption to make. For example, for CS some practitioners may be faced with making treatment decisions with no or poor quality radiographs. However, the premise in undertaking a cost-minimization study was based on the assumption of *all other things being equal*, including outcomes of the treatment.

Decisions Based on Risks

In this clinical environment, when parents consider GA *versus* CS treatment for their child, they have already made an informed decision that no treatment is not an option with which they are comfortable. Typically, these children have more extensive restorative and surgical needs and many have already received emergency care for pain and swelling. For these parents who consider GA *versus* CS care, it seems logical that their decision should begin with a comparison of risks for the two modalities. However, such risk data are elusive. With reference to pediatric mortality using GA, 1:20,000 is cited in the literature by several authors.[15] In the United States, there are no published risk data of GA specific to the dental cases. In England and Wales, the dental GA mortality rate remained constant at 1:215,000 between 1970 and 1990. These data included all dental GA cases, both pediatric and adult.[4]

There are no published incidence data for the morbidity and mortality of pediatric conscious sedation. Goodson and Moore's classic review in 1983 focused on 14 cases of sedation misadventures, but no incidence data were cited.[16] A tragedy of pediatric CS does surface occasionally in the media. However, since the publication of the "Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures" in 1985, subsequently revised in 1992 by AAP, and 1996 by AAPD, the authors are aware of no pediatric patient fatalities that have occurred when the original 1985 Guidelines have been fully utilized as the standard of care.[17]

A parental decision to choose GA *versus* CS is difficult to make on the basis of risks, so parents often must consider other factors, one of which is *cost*. In selecting costs models, this investigation chose a model that values parents' time away from work for appointment activities.

Conclusion

Under the conditions of this study, if a child needed more than 3 CS appointments, the GA option offered cost-savings over the CS treatment option.

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Abstract of the Scientific Literature

Temporomandibular Joint Remodeling During Herbst Treatment

The purpose of this study was to investigate the adaptive changes in the TMJ of adolescents and young adults who were treated with the Herbst appliance. 25 adolescents with a mean age of 12.8 years and 14 young adults with a mean age of 16.5 years were evaluated. All subjects had a class II malocclusion and were treated with a fixed casted splint Herbst appliance. Treatment time was for a mean of 7.1 mo. for adolescents and 8.5 mo. for young adults. MRI's were taken before treatment, at the start of treatment, during the first 6-12 weeks of treatment, and at the end of treatment. These were evaluated for signals of intensity which would indicate bone remodeling. After 6-12 weeks 48 of 50 adolescents and 26 of 28 young adults showed signs of condylar remodeling in the posterosuperior region. "In most adolescents, a normal condylar MRI appearance without signs of remodeling was seen at the time of removal of the appliance". The glenoid fossa showed signs of remodeling in 36 of 50 adolescents and in 22 of 28 adults. "Magnetic resonance imaging renders an excellent opportunity to visualize the temporomandibular joint remodeling growth processes."

Comments: MRI is a very useful tool to examine growth and treatment changes. As newer observational technologies are developed, it will be interesting to compare what they reveal against data that has been derived from more traditional studies. JEP

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Temporomandibular joint remodeling in adolescents and young adults during Herbst treatment: A prospective longitudinal magnetic resonance imaging and cephalometric radiographic investigation. Ruf S, Pancherz H. J Ortho/ Dentofacial Orthopedics. 115(6),607-618,1999.

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Abstract of the Scientific Literature

Effect of Storage Media on Polyacid-Modified Composite Resins

Polyacid-modified composite resins or compomers combine fluoro-silicate-glasses with polymerizable composite resin ingredients such as dimethacrylates. The purpose of this investigation was to measure the surface microhardness and the release of fluoride from four compomers after storage in various aqueous environments. Samples made from four different compomers i.e., Compoglass (Vivadent), F2000 (3M), Experimental compomer (Voco), and Dyract AP (De Trey), were stored for 6 days in de-ionized water, acidic buffer (pH 4.2), neutral buffer (pH 7.0), or neutral buffer with esterase. Fluoride release was measured every 48 hours; surface microhardness measurements were recorded initially and after 24, 48, and 144 hours of storage in the various solutions. The surface microhardness of all of the compomers decreased significantly following storage. In general, the compomers released the greatest amount of fluoride in the acidic buffers and esterase treatment increased the fluoride released from three of the compomers. The results of this study suggest that fluoride release from the compomers investigated in this study will increase under acidic conditions and hydrolytic enzymes in the saliva will also increase fluoride release. The surface degradation in the presence of the hydrolytic enzymes suggests that under clinical conditions these materials may experience increased wear and decreased load resistance.

Comments: The relatively poor wear resistance of glass ionomer-like restorative materials, i.e. conventional, resin-modified, and compomers, continues to limit the clinical use of these materials. The results of this study suggest that the surface of compomers will be degraded by hydrolytic enzymes in the saliva; under clinical conditions, such enzymatic degradation will translate to decreased wear resistance and overall, a weakened restoration. PS

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Effect of storage media on the fluoride release and surface microhardness of four polyacid-modified composite resins ("compomers"). Geurtsen W, Leyhausen G, and Garcia-Godoy F. Dental Materials 15(3):196-201, May 1999.

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