Using a Dental Student Exercise on Shear Bond Testing to Both Provide Skills Practice and Demonstrate a Research Process

Karen A. Schulze, DDS, PhD; Victoria Wallace, LDA; Terry Hoover, DDS; Eric Salmon, DDS

Abstract: This article describes an exercise with junior dental students at the University of the Pacific Arthur A. Dugoni School of Dentistry designed in part to serve the requirement for dental accreditation Standard 6-3 (“Dental education programs must provide opportunities, encourage, and support student participation in research and other scholarly activities mentored by faculty”). The exercise has been conducted for seven years and has been found to provide a distinctive and important experience to the education of these dental students. The exercise has three aims. First, it is an exercise in which students practice their skills with dental bonding; second, it serves as a tool to give immediate feedback on these skills that is otherwise not possible in a real patient situation; and third, it demonstrates to the students how data from the exercise with the students as subjects can be used in a research study. The project thus serves as an innovative way to use a skill-building exercise to educate students about research at the same time.

Dr. Schulze is Associate Professor and Director of Research, Department of Integrated Reconstructive Dental Sciences, Arthur A. Dugoni School of Dentistry, University of the Pacific; Ms. Wallace is regional manager for dental school and dental hygiene programs, U.S. western region, Ultradent Products, Inc.; Dr. Hoover is Associate Professor and Vice Chair, Department of Dental Practice, Arthur A. Dugoni School of Dentistry, University of the Pacific; and Dr. Salmon is Assistant Professor and Clinical Informatics Liaison Representative, Department of Dental Practice, Arthur A. Dugoni School of Dentistry, University of the Pacific. Direct correspondence to Dr. Karen A. Schulze, Arthur A. Dugoni School of Dentistry, University of the Pacific, 155 Fifth Street, San Francisco, CA 94103; 415-929-6442; kschulze@pacific.edu.

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Engaging students in research is fundamental for predoctoral dental programs. It is also a part of the accreditation evaluation of each dental school. As defined in the Commission on Dental Accreditation (CODA) Standard 6-3, “Dental education programs must provide opportunities, encourage, and support student participation in research and other scholarly activities mentored by faculty.”

This article describes an exercise with junior dental students at the University of the Pacific Arthur A. Dugoni School of Dentistry that produces data which faculty members analyze and present as results to the students. The process thus demonstrates to the students how a research project is conducted using data from the exercise in which they served as subjects. The exercise has been conducted for seven years and has been found to provide a distinctive and important experience in the education of our dental students. The exercise has three aims. It is first an exercise for students to practice their skills with dental bonding; second, it serves as a tool to give immediate feedback on these skills that is otherwise not possible in a real patient situation; and third, it involves the students as subjects in a group experiment intended to ignite their interest in further scholarly work in this area. The project thus serves as an innovative way to use a skill-building exercise to educate students about research at the same time.

This student exercise tests the bond strength of an adhesive layer students create between dental hard tissue and dental composite. Students receive a lecture on the importance of the dental bonding process. This lecture includes a historical overview of the first use of cements on human teeth, the development of dental adhesives with their generations and differences, an introduction to the types of bond strength testing methods, a review of the past experience with our students, and a step-by-step explanation of sample preparation and bond strength testing for this exercise.

Several days later, the students are invited to the laboratory exercise session. For each three-hour laboratory session, we prefer to have about 36 students. Each session, four instructors supervise the exercise and operate the four testing machines with a student to faculty ratio of nine to one. Each student
creates six adhesive bonds to be tested. The method in creating the shear bond samples was developed by Ultradent Products, Inc. and introduced to the market with its current Ultratester in 2007.

Cross-sectioned human third molars with the roots removed are embedded in resin exposing a large amount of dentin. Recently, it was possible to obtain bovine incisors for use also as a bonding substrate. The bovine incisors were flattened on the facial surface to expose enamel, and the roots were removed. These samples come pre-manufactured by Ultradent Products, Inc., or they can be made in-house with a tool set that can be purchased from the company together with the testing machines. These embedded teeth serve as a base substrate for the shear bond exercise and can be reused for several years. The preserved samples are continually stored in water (with 0.05% Chlorhexidine).

On the day of the laboratory exercise, each student is provided a workstation supplied with materials and instruction sheets. Each station has six bonding samples (combination of dentin and bovine enamel samples) in a cup of water. There is also a set of instructions for each of the bonding systems to be tested. These instructions are copied from the manufacturers’ instructions for each individual bonding material to ensure exact protocols are followed.

The students first apply the bonding layer to either a dentin or enamel sample (Figure 1, step 1). Next, a special clamp surrounds the sample, and the flowable composite can be inserted perpendicular to the sample surface through a fixed plastic insert that contains a 2.3 mm diameter open cylinder (step 2). The composite is light-cured from the top, and when the clamp is removed, the composite cylinder stays on the dentin/enamel surface (step 3). Creation of the composite cylinder is a critical step in sample preparation and must be done carefully. It is important to hold down the cured composite when unscrewing the clamp to lift up the plastic insert to avoid creating stress at the dentin/enamel adhesive interface, which could reduce the bond strength. Using the tip of the syringe in rotating motion as the flowable composite is placed into the plastic cylinder eliminates air bubbles at the interface. The strength of the adhesive bond of the composite cylinder to the dentin or enamel is measured with the Ultratester (steps 4 and 5).

With a “notched knife” method, the composite cylinder is “sheared off” the dentin or enamel surface of the sample as the table of the Ultratester moves toward the knife at a fixed speed. The knife has to be flush with the sample to avoid any stress or ad-

ititional bending forces. The testing instrument and parts that hold the samples fit together precisely to avoid introducing any additional stresses as well. The force required to break the bond between substrate and composite cylinder (the shear bond strength) is displayed digitally on the display of the testing machine in MPa units.

There is a learning curve during the testing period, so students are encouraged to choose their test adhesives in random order from the list of the six being tested. This process eliminates the learning curve favoring testing results later in the day (as students’ skills improve). After the testing, all numbers are entered by the supervising faculty member directly into prepared spreadsheets on laptop computers. The students verify that the numbers are correctly entered.

Following all data collection, the course director calculates the average shear bond strength and standard deviation for each adhesive material tested. A variety of other calculations are done by the faculty as well: 1) the highest and lowest shear bond test value for each product tested; 2) the averages in the current year in comparison to the averages from the previous year (Student’s t-test applied to determine statistically significant differences at a 0.05% interval); 3) differences among materials tested using Student’s t-test; 4) the percentile of the class that achieved the desired 20MPa or more for each product; 5) the average bond strength for the female and male students in the class (fun factor); 6) the single highest bond strength achieved in tests from all class members; and 7) the three students with highest overall average test results.

All these results are presented by the course director one week after the shear bond testing to the students in a summary lecture. The statistics that were applied are explained. The students realize that there is a large operator variability and hence a high standard deviation. One important finding is that we have used products yearly for that exercise that had a mean value with only 2MPa difference from the previous year. This analysis confirms the consistency of the product content. We also have products whose testing results have varied over the years and we suspect may have had a different composition. A sample outcome is shown in the flow chart in Figure 1. In the summary presentation, students with the highest bond strengths are identified and given prizes for their performance, which has been enjoyable for the class.

The response has been very positive from the students involved as well as from the faculty supervising the testing. It is enlightening for the students.
Another more subtle learning experience for the students is the advice on technique from the course director. For example, the manufacturer’s written instructions do not detail the amount of microbrush pressure on dentin that is necessary to form an adequate hybrid layer. Previous studies have found that, in an acid etch bonding technique, the pressure to apply the bonding layer is not as important as the pressure and agitation when applying a self-etching primer on dentin. For a seventh generation bonding material, the motion of the microbrush and the agitation are crucially important. The air-drying pressure and distance of air tip from substrate surface are also key elements in creating the bonding interface.

Outcome measures of this exercise have been explored in three ways. First, student surveys immediately following the exercise have shown that the lecture and the exercise furthered students’ understanding of the shear bond testing exercise. More than 50% of the students agreed or strongly agreed they benefitted from the exercise (Figure 2).

The second outcome measure is the number of composite filling procedures that have been done in one-on-one coaching sessions. One suggestion from this experience is to use this exercise in the curriculum before students begin treatment with real patients. Students can improve tremendously their bonding performance through this exercise with an obvious benefit to their patients. The goal of this testing exercise was multifaceted. The students had already learned in previous lectures and simulation laboratory settings how to place a composite filling. The emphasis in that training was the composite filling anatomy, marginal adaptation, finishing, etc. A faculty member is unable to check if the bonding procedures on a typodont tooth are done correctly however.

This exercise emphasizes directly the bonding interface, which we believe makes it valuable. It enhances the ability of the students to transfer the knowledge of dental bonding to a live performance with real-time feedback and provides an opportunity to adapt to new protocols given the variety of different bonding systems available. Most importantly, the immediate feedback can single out students who need help or coaching in their bonding technique.

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The second outcome measure is the number of composite filling procedures that have been done in
our student clinic. During school year 2012-13, there were 6,375 composite fillings placed by students in our clinic patients, while in 2013-14 there were 8,559 placed and in 2014-15 there were 10,577. Of course, this increase may be the result of several factors. We know that patients are demanding more tooth-colored fillings over amalgam fillings. The experience from this exercise may increase student confidence in placing composite fillings.

In a third measure, a follow-up questionnaire of senior students was conducted to evaluate the impact of the exercise on clinical performance. Students were asked this question: “do you believe the shear bond testing exercise influenced your composite use in clinic?” Of these students, 51% responded the exercise had a highly positive influence, 40% said it had a positive influence, 7% answered it had no influence, and 1% recorded a negative influence. Overall, 91% of the students reported benefiting from the exercise. Their free text comments highlighted the importance of carefully following the manufacturer’s instructions and provided feedback for us in how to improve the exercise. We calculated the replacement rate for composites in our clinic when they showed flaws, recurrent decay, or lost material within two years after initial placement. The rates were 2.04%, 1.13%, and 1.18% for the years 2012-13, 2013-14, and 2014-15, respectively. These rates were consistently low throughout the years and are below the average of other published data: Kopperud et al. reported a 2.9% annual failure rate in studies of posterior composites, and a 2012 meta-analysis of 29 studies by Demarco et al. showed a variation of 0% to 12.4% for annual failure rates with an average of 2.7%.

We maintain that this exercise has not only an educational component but additionally it exposes students to a group experiment that helps fulfill CODA Standard 6-3 for school accreditation. Students’ participation with faculty in a testing environment is also intended to encourage interest in lifelong learning. Good student ratings as well as positive feedback from the senior students show the overall positive impact of the shear bond testing exercise.

REFERENCES


