

Submission ID #: 71208

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Title: Standardized Protocol to Evaluate the Effect of Surface Treatments, Luting Cements, and Thermocycling on PEEK–Composite Bond Strength

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Author Questionnaire

1. **Microscopy:** Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**
2. **Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **No**
3. **Filming location:** Will the filming need to take place in multiple locations? **No**
4. **Testimonials (optional):** Would you be open to filming two short testimonial statements **live during your JoVE shoot**? These will **not appear in your JoVE video** but may be used in JoVE's promotional materials. **No**

Current Protocol Length

Number of Steps: 19

Number of Shots: 29

Interviews

Videographer: Obtain headshots for all authors available at the filming location.

Authors: Please note that **the questions will not appear on screen**. Please answer in **stand-alone full sentence with sufficient context**

INTRODUCTION:

~~REQUIRED:~~ Summarize your research focus and the main questions it aims to answer.

- 1.1. **Selen Erkul:** This study presents a standardized protocol to evaluate the effects of surface treatment, cement type, and thermocycling on PEEK–composite bond strength.
 - 1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~Describe the research gap or limitation in existing methods and how this protocol addresses them.~~

- 1.2. **Selen Erkul:** The protocol facilitates consistent evaluation of bonding approaches that may improve the long-term performance of PEEK restorations.
 - 1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

CONCLUSION:

~~What does this protocol allow researchers to study or measure?~~

- 1.3. **Selen Erkul:** This protocol can be used to measure the durability of PEEK–composite adhesion under simulated clinical conditions.
 - 1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~Describe the most important consideration or challenge when performing this protocol.~~

- 1.4. **Selen Erkul:** Safe handling of sulfuric acid and laser equipment is essential to ensure operator safety and procedural consistency.
 - 1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~How can future studies build on this work? Describe the questions or research directions that can be investigated next.~~

- 1.5. **Selen Erkul:** Future studies can evaluate additional surface treatments, different cements, composites, and thermocycling conditions to optimize PEEK bonding.
 - 1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

Videographer: Obtain headshots for all authors available at the filming location.

Protocol

***Videographer:** Please always record an audio slate while filming each shot mentioned in the shotlist.*

2. Cementing the Treated PEEK Surfaces

Demonstrator: Selen Erkul

- 2.1. To begin, obtain poly-ether-ether-ketone or PEEK (*peak*) disc specimens [1] and surface-treat them according to the designated protocols [2 and 3].
 - 2.1.1. WIDE: Talent placing the PEEK discs on the work surface. ***Videographer:** Please obtain CU shot as well for this shot.*
 - 2.1.2. Talent sandblasting the disc. **Authors:** This is a representative shot only
***Video editor:** Please show 2.1.2 and 2.1.3 using split screen*
 - 2.1.3. TEXT ON PLAIN BACKGROUND
Surface treatment groups:
 - Sandblasted
 - Sulfuric acid-etched
 - Erbium-doped Yttrium Aluminum Garnet laser-treated
Control: Untreated
- 2.2. Prepare standardized indirect composite resin discs for bonding to the treated PEEK surfaces using different luting cements [1]. Divide each surface treatment group into zinc oxide non-eugenol cement and self-adhesive resin cement groups [2].
 - 2.2.1. Shot of the talent showing the prepared indirect composite resin discs.
 - 2.2.2. Talent separating PEEK discs into 2 containers labelled as zinc oxide non-eugenol cement and self-adhesive resin cement.
- 2.3. For the zinc oxide non-eugenol cement, dispense equal lengths of the base and catalyst pastes onto a mixing pad [1]. Mix for approximately 20 seconds until a homogeneous consistency is achieved [2]. Using a spatula, apply the mixed cement to the treated PEEK surface with gentle pressure to minimize air entrapment [3].
 - 2.3.1. Talent dispensing equal lengths of the base and catalyst pastes onto a mixing pad.
 - 2.3.2. Talent mixing the cement pastes on the mixing pad.

2.3.3. Talent applying the mixed cement to the treated PEEK surface with a spatula.

Author's NOTE: After Shot 2.3.3, we filmed Shots 2.5–2.8 for the first cement. We then filmed Shot 2.4, followed by Shots 2.5–2.8 again for the second cement.

Video editor: Let us show the footage for any 1 cement for steps 2.5 and 2.8 (zinc oxide non-eugenol cement). Then show step 2.9 is for the self-adhesive resin curing. Contact poornimag@jove.com if there is any confusion.

2.4. For the self-adhesive resin cement, attach an automix tip to the syringe [1-TXT] and dispense a small initial amount to ensure proper mixing [2]. Then, apply the cement directly to the treated PEEK surface while keeping the tip in contact to maintain continuous flow and reduce air entrapment [3]. Cover the entire bonding area with a uniform layer [4].

2.4.1. Talent attaching an automix tip to the syringe.

2.4.2. Talent dispensing a small initial amount of the self-adhesive resin cement to test.

2.4.3. Talent starting to apply the self-adhesive resin cement directly to the treated PEEK surface.

2.4.4. Talent continuing and covering the entire bonding area with a uniform layer.

Authors: Show the fully covered sample at the end of this shot

NOTE: Treat this as a separate section

Composite Disc Placement and Cement Setting

2.5. Position the composite disc centrally onto the cement-covered PEEK surface [1].

2.5.1. Talent positioning the composite disc centrally on the cement-covered PEEK surface.

2.6. Next, apply a constant vertical load of 500 grams for 10 seconds to standardize cement thickness and ensure uniform adaptation [1-TXT].

2.6.1. Talent applying a constant vertical load to the specimen. **TXT: Disc positioning and load application steps are identical for both cement types**

2.7. Remove excess cement from the margins using a microbrush [1].

2.7.1. Talent removing excess cement from the margins with a microbrush.

2.8. For the zinc oxide non-eugenol cement, allow a setting time of 6 minutes under the applied load [1].

2.8.1. Talent keeping the zinc oxide non-eugenol cement specimen aside under the applied load.

2.9. For the self-adhesive resin cement, polymerize with a light-curing device from all directions for a total of 80 seconds at a distance of 5 millimeters [1].

2.9.1. Talent polymerizing the self-adhesive resin cement specimen with a light-curing device.

2.10. Thermocycle the designated specimens between 5 and 55 degrees Celsius for a total of 5,500 cycles under standardized conditions [1]. Then, mount the embedded specimen in a universal testing machine and perform the shear bond strength test [2-TXT].

2.10.1. LAB MEDIA: Figure 6B

2.10.2. LAB MEDIA: Figure 7 **TXT: Shear force: 1 mm/min until failure**

NOTE: Sections 3 and 4 were not filmed because the equipment was not available. Added 2 lines of summarised narration in step 2.10 as per the author's request.

~~3. Thermocycling PEEK-Composite Assemblies~~

Demonstrator: ~~Click here to enter name of demonstrator(s)~~

~~3.1. Divide each cement subgroup into two additional subgroups and subject the samples from one of the groups to thermocycling [1].~~

~~3.1.1. Talent dividing each cement subgroup into thermocycling and non-thermocycling subgroups.~~ **Authors: Keep the containers labelled**

~~3.2. Subject specimens in the thermocycling group to 5,500 cycles between 5 and 55 degrees Celsius using a thermocycling device [1].~~

~~3.2.1. Talent placing the thermocycling group specimens into the thermocycling device.~~

~~3.3. Set the dwell time in each bath to 30 seconds [1] and set the transfer time between baths to 2 seconds. Maintain identical cycling conditions for all specimens throughout the procedure [2].~~

~~3.3.1. Talent setting the dwell time on the thermocycling device.~~

~~3.3.2. Talent adjusting the transfer time on the thermocycling device.~~

4. ~~Shear Bond Strength Testing~~

Demonstrator: ~~Click here to enter name of demonstrator(s)~~

~~4.1. Embed each cemented PEEK-cement-composite assembly in self-curing acrylic resin using stainless-steel molds measuring 15 millimeters in diameter and in height [1].~~

~~4.1.1. Talent embedding the cemented polyetheretherketone-cement-composite assembly in self-curing acrylic resin using stainless-steel molds.~~

~~4.2. Mount each specimen in the universal testing machine using a custom jig to ensure stable positioning [1].~~

~~4.2.1. Talent mounting the specimen in the universal testing machine with a custom jig.~~

~~4.3. Align the loading blade parallel to the bonding interface [1] and position it as close to the interface as possible [2].~~

~~4.3.1. Talent aligning the loading blade parallel to the bonding interface.~~

~~4.3.2. Talent adjusting the positioning such that the blade is close to the interface.~~

~~4.4. Apply shear force at a crosshead speed of 1 millimeter per minute until failure occurs [1].~~

~~4.4.1. Talent applying shear force to the specimen in the universal testing machine.~~

~~4.5. Record the maximum load at failure in newtons for each specimen [1].~~

~~4.5.1. Talent recording the maximum load at failure.~~

4.6. Finally, calculate shear bond strength in megapascals using the formula **[1-TXT]**.

4.6.1. Talent calculating the shear bond strength values in the notebook or computer.

TXT: $SBS\ (MPa) = Load\ (N) / bonding\ area\ (mm^2)$

Results

5. Results

5.1. Self-adhesive resin cement showed higher shear bond strength values **[1]** than zinc oxide non-eugenol cement across all surface treatment groups **[2]**.

5.1.1. LAB MEDIA: Table 2. *Video editor: Highlight the columns for “RelyX U200”*

5.1.2. LAB MEDIA: Table 2. *Video editor: Highlight the columns for “TempBond NE”*

5.2. The specimens luted with temporary cement after thermocycling showed the lowest shear bond strength values compared to other groups **[1]**.

5.2.1. LAB MEDIA: Table 2. *Video editor: Highlight the “TempBond NE+thermocycling” column*

5.3. Thermocycling reduced the shear bond strength values for both cement types **[1]**.

5.3.1. LAB MEDIA: Table 2. *Video editor: Highlight the columns “TempBond NE+thermocycling” and RelyX U200 + thermocycling”*

5.4. The sandblasted specimens luted with resin cement without thermocycling showed the highest shear bond strength values **[1]**.

5.4.1. LAB MEDIA: Table 2. *Video editor: Highlight the “Sandblasting” row under “RelyX U200 + no thermocycling” showing 25.134 value*

5.5. The sulfuric acid-etched and laser-treated specimens demonstrated intermediate shear bond strength values **[1]**.

5.5.1. LAB MEDIA: Table 2. *Video editor: Highlight the rows labeled “Acid etching” and “Laser irradiation”*

5.6. The untreated polyetheretherketone surfaces luted with temporary cement showed shear bond strength values comparable to or higher than the treated surfaces [1].

5.6.1. LAB MEDIA: Table 2. *Video editor: Highlight the “Control” row under both the “TempBond NE” columns*

1. Poly-ether-ether-ketone

Pronunciation link: No confirmed link found

IPA: /ˌpɑːli ˈiːθər ˈiːθər ˈkiːtoʊn/

Phonetic Spelling: paa·lee ee·ther ee·ther kee·tohn

2. PEEK

Pronunciation link: <https://www.merriam-webster.com/dictionary/peek>

IPA: /ˈpiːk/

Phonetic Spelling: peek

3. Specimens

Pronunciation link: <https://www.merriam-webster.com/dictionary/specimen>

IPA: /ˈspesəmən/

Phonetic Spelling: speh·suh·mun

4. Sandblasting

Pronunciation link: <https://www.merriam-webster.com/dictionary/sandblasting>

IPA: /ˈsændˌblæstɪŋ/

Phonetic Spelling: sand·blas·ting

5. Sulfuric

Pronunciation link: <https://www.merriam-webster.com/dictionary/sulfuric>

IPA: /səlˈfjʊrɪk/

Phonetic Spelling: suhl·fyur·ik

6. Acid-etched

Pronunciation link: No confirmed link found

IPA: /ˈæsɪd ˌetʃt/

Phonetic Spelling: as·id echt

7. Erbium-doped

Pronunciation link: No confirmed link found

IPA: /'ɜːbiəm ˌdɒpt/

Phonetic Spelling: ur·bee·um dohpt

8. Yttrium

Pronunciation link: <https://www.merriam-webster.com/dictionary/yttrium>

IPA: /'ɪtriəm/

Phonetic Spelling: it·ree·um

9. Aluminum

Pronunciation link: <https://www.merriam-webster.com/dictionary/aluminum>

IPA: /əˈluːmənəm/

Phonetic Spelling: uh·loo·muh·num

10. Garnet

Pronunciation link: <https://www.merriam-webster.com/dictionary/garnet>

IPA: /'gɑːrnət/

Phonetic Spelling: gaar·nut

11. Luting

Pronunciation link: <https://www.merriam-webster.com/dictionary/luting>

IPA: /'luːtɪŋ/

Phonetic Spelling: loo·ting

12. Zinc oxide

Pronunciation link: <https://www.merriam-webster.com/dictionary/zinc%20oxide>

IPA: /'zɪŋk ˈɑːk,said/

Phonetic Spelling: zingk aak·side

13. Eugenol

Pronunciation link: <https://www.merriam-webster.com/dictionary/eugenol>

IPA: /'juːjəˌnɔːl/

Phonetic Spelling: yoo·juh·naal

14. Self-adhesive

Pronunciation link: <https://www.merriam-webster.com/dictionary/self-adhesive>

IPA: /ˌself ədˈhiːsɪv/

Phonetic Spelling: self uhd·hee·siv

15. Catalyst

Pronunciation link: <https://www.merriam-webster.com/dictionary/catalyst>

IPA: /ˈkætələst/

Phonetic Spelling: kat·uh·list

16. Homogeneous

Pronunciation link: <https://www.merriam-webster.com/dictionary/homogeneous>

IPA: /ˌhoʊməˈdʒiːniəs, ˌhɑːməˈdʒiːniəs/

Phonetic Spelling: hoh·muh·jee·nee·uhs, haa·muh·jee·nee·uhs

17. Spatula

Pronunciation link: <https://www.merriam-webster.com/dictionary/spatula>

IPA: /ˈspætʃələ/

Phonetic Spelling: spach·uh·luh

18. Entrapment

Pronunciation link: <https://www.merriam-webster.com/dictionary/entrapment>

IPA: /ɪnˈtræpmənt/

Phonetic Spelling: in·trap·munt

19. Automix

Pronunciation link: No confirmed link found

IPA: /ˈɔːtoʊˌmɪks/

Phonetic Spelling: aw·toh·miks

20. Syringe

Pronunciation link: <https://www.merriam-webster.com/dictionary/syringe>

IPA: /səˈrɪndʒ/

Phonetic Spelling: suh·rinj

21. Adaptation

Pronunciation link: <https://www.merriam-webster.com/dictionary/adaptation>

IPA: /,ædæp'teɪʃən/

Phonetic Spelling: ad·ap·tay·shun

22. Microbrush

Pronunciation link: No confirmed link found

IPA: /'maɪkrəʊˌbrʌʃ/

Phonetic Spelling: my·kroh·brush

23. Polymerize

Pronunciation link: <https://www.merriam-webster.com/dictionary/polymerize>

IPA: /pə'liməˌraɪz/

Phonetic Spelling: puh·lim·uh·ryze

24. Light-curing

Pronunciation link: No confirmed link found

IPA: /'laɪt ˌkɜːrɪŋ/

Phonetic Spelling: lite·kyur·ing

25. Thermocycle

Pronunciation link: No confirmed link found

IPA: /'θɜːmoʊˌsaɪkəl/

Phonetic Spelling: thur·moh·sy·kul

26. Universal testing machine

Pronunciation link: No confirmed link found

IPA: /ˌjuːnəˈvɜːsəl ˈtestɪŋ məˈʃiːn/

Phonetic Spelling: yoo·nuh·vur·sul tes·ting muh·sheen

27. Shear

Pronunciation link: <https://www.merriam-webster.com/dictionary/shear>

IPA: /'ʃɪr/

Phonetic Spelling: sheer