Data Article

Data for vancomycin elution, activity and impact on mechanical properties when incorporated into orthopedic bone cement

Aaron R. Bishop⁴, Sunjung Kim⁵, Matthew Squire⁶, Warren E. Rose⁷, Heidi-Lynn Ploeg⁴

¹ University of Wisconsin – Madison, Biomedical Engineering, United States
² University of Wisconsin – Madison, Mechanical Engineering, United States
³ University of Wisconsin – Madison, School of Pharmacy, United States
⁴ University of Wisconsin School of Medicine and Public Health, United States

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A B S T R A C T

In this article, we report data on the antibiotic elution and efficacy, and mechanical properties of Palacos bone cement with different amounts of added vancomycin (0.0, 0.125, 0.25, 0.5, 1.0, 2.0 g), see “Vancomycin elution, activity and impact on mechanical properties when added to orthopedic bone cement” (Bishop et al., 2018) [1].

Mechanical testing was performed for four-point bending, compression, and fracture toughness. The release characteristics of vancomycin was recorded for up to 60 days to estimate the elution profile. The eluted vancomycin efficacy at eliminating the four most common causative orthopedic implant pathogens is also reported.

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**Specifications Table**

| Subject area                  | Biomechanics, Pharmacy |
|-------------------------------|-------------------------|
| More specific subject area    | Orthopedic, Antimicrobial agent |
| Type of data                  | Image (X-ray, microscopy, etc.), figure, tabulated |
| How data was acquired         | SEM (Zeiss-LEO, Oberkochen, Germany), MTS (Criterion C43.104, MTS Systems, Eden Prairie, MN), High performance Liquid Chromatography (HPLC) |
| Data format                   | Analyzed data |
| Experimental factors          | Palacos bone cement different amounts of added vancomycin: 0.0, 0.125, 0.25, 0.5, 1.0, 2.0 g |
| Experimental features         | Mechanical testing using MTS machine measured flexural modulus, flexural strength, compressive modulus, compressive yield strength, and fracture toughness, according to ISO 5833. The drug elution test was determined using high performance liquid chromatography (HPLC) with a C18 column. Three cylindrical samples (6 mm diameter × 4.5 mm height) were sterilized by ethylene oxide gas and then submerged in 3.4 mL of tryptic soy broth inoculated with bacteria for each test condition for antimicrobial activity testing. Drug elution cements were stored in −20 °C freezer and all mechanical testing cements were wet cured in a phosphate-buffer solution (PBS) for 21 days at room temperature (22 °C) before testing. |
| Data source location          | Department of Mechanical Engineering and School of Pharmacy, University of Wisconsin Madison |
| Data accessibility            | Data is with this article. |
| Related research article      | Bishop A.R., Kim S., Squire M.W., Rose W.E., Ploeg H., Vancomycin elution, activity and impact on mechanical properties when added to orthopedic bone cement, Journal of Mechanical Behavior of Biomedical Materials S1751–6161(18)30459-4, https://doi.org/10.1016/j.jmbbm.2018.06.033 [1] |

**Value of the data**

- These data are of value in cemented joint arthroplasty using Palacos with added vancomycin as a prophylactic measure against infection.
- The mechanical test data of wet cured samples demonstrated that mechanical properties of Palacos bone cement with up to 0.5 g of vancomycin met all ISO minimum requirements.
- The release characteristic test data showed that the elution profile is suited for clinical use since the maximum elution occurs during the critical first week after surgery and would effectively eliminate *S. aureus* contamination that may inadvertently occur during the surgical procedure.
- The antimicrobial activity test data showed that the eluted concentration from samples with greater than 0.25 g vancomycin per Palacos packet was sufficient to eliminate a 10³ colony forming unit per mL (CFU/mL) initial inoculum of *S. aureus*, including methicillin-resistant *S. aureus* (MRSA).

1. **Data**

The data provided here are

- Mechanical test data: flexural modulus, flexural strength, compressive modulus, compressive yield strength, and fracture toughness calculated from the force-displacement curves.
- Scanning electron microscope (SEM) images from the fracture surfaces of four-point bending samples.
• Release characteristic test data for vancomycin added to Palacos bone cement.
• Antimicrobial activity test data for eluted vancomycin efficacy at eliminating four most common causative orthopedic implant pathogens (MRSA n315, ATTC MRSA 33591, ATCC S.aureus 29213, and ATCC S. epidermidis 35984).

### 1.1. Mechanical testing data

See Tables 1–3.

#### Table 1
Results from four-point bend testing. Results are reported as median ± 1 standard deviation.

| Cement     | Antibiotic | Amount of antibiotic added [g] | Mixing | Conditioning | Testing condition | Bending modulus [MPa] | Bending strength [MPa] |
|------------|------------|---------------------------------|--------|--------------|-------------------|-----------------------|------------------------|
| Palacos    | –          | –                               | Vacuum | Ambient, saline, 21 days | Ambient           | 2192 ± 164.2^1        | 55.40 ± 3.531^2       |
| Palacos    | Vancomycin | 0.125                           | Vacuum | Ambient, saline, 21 days | Ambient           | 2349 ± 163.9^1        | 57.72 ± 1.515^3       |
| Palacos    | Vancomycin | 0.25                            | Vacuum | Ambient, saline, 21 days | Ambient           | 2357 ± 301.0^1        | 52.63 ± 2.221^3       |
| Palacos    | Vancomycin | 0.50                            | Vacuum | Ambient, saline, 21 days | Ambient           | 2267 ± 200.4^1        | 56.71 ± 2.331^3       |
| Palacos    | Vancomycin | 1.0                             | Vacuum | Ambient, saline, 21 days | Ambient           | 2369 ± 64.00^1        | 55.80 ± 1.541^3       |
| Palacos    | Vancomycin | 2.0                             | Vacuum | Ambient, saline, 21 days | Ambient           | 2038 ± 164.2^1,2      | 46.80 ± 1.700^4       |

^1 Significantly higher than the ISO minimum requirement of 1800 MPa.
^2 Significantly lower than control's bending modulus.
^3 Significantly higher than the ISO minimum requirement of 50 MPa.
^4 Significantly lower than control's bending strength.

#### Table 2
Results from compression testing. Results are reported as median ± 1 standard deviation.

| Cement     | Antibiotic | Amount of antibiotic added [g] | Mixing | Conditioning | Testing condition | Compressive modulus [MPa] | Compressive yield strength [MPa] |
|------------|------------|---------------------------------|--------|--------------|-------------------|---------------------------|---------------------------------|
| Palacos    | –          | –                               | Vacuum | Ambient, saline, 21 days | Ambient           | 1559 ± 207.4              | 82.71 ± 63.52^2               |
| Palacos    | Vancomycin | 0.125                           | Vacuum | Ambient, saline, 21 days | Ambient           | 1543 ± 246.7              | 78.61 ± 47.91^2,3            |
| Palacos    | Vancomycin | 0.25                            | Vacuum | Ambient, saline, 21 days | Ambient           | 1279 ± 230.1^1            | 77.01 ± 47.92^2,3            |
| Palacos    | Vancomycin | 0.50                            | Vacuum | Ambient, saline, 21 days | Ambient           | 1282 ± 301.2^1            | 73.12 ± 33.34^2,3            |
| Palacos    | Vancomycin | 1.0                             | Vacuum | Ambient, saline, 21 days | Ambient           | 1098 ± 182.9^1            | 69.62 ± 25.44^3             |
| Palacos    | Vancomycin | 2.0                             | Vacuum | Ambient, saline, 21 days | Ambient           | 980.7 ± 230.4^1           | 61.72 ± 11.54^3             |

^1 Significantly lower than control's compressive modulus.
^2 Significantly higher than the ISO minimum requirement of 70 MPa.
^3 Significantly lower than control's compressive yield strength.
1.2. Drug elution data

See Table 4.

Table 4
Drug elution results over 60 days. Results (all units are mg) are reported as mean ± standard deviation (SD).

| Days | 0.125 g | 0.25 g | 0.5 g | 1.0 g | 2.0 g |
|------|---------|--------|-------|-------|-------|
| Mean | SD      | Mean   | SD    | Mean  | SD    |
| 0    | 0.000   | 0.000  | 0.000 | 0.000 | 0.000 |
| 1    | 0.006   | 0.003  | 0.010 | 0.003 | 0.003 |
| 2    | 0.006   | 0.010  | 0.000 | 0.022 | 0.005 |
| 4    | 0.020   | 0.005  | 0.017 | 0.041 | 0.005 |
| 8    | 0.030   | 0.033  | 0.001 | 0.059 | 0.002 |
| 10   | 0.030   | 0.000  | 0.033 | 0.000 | 0.059 |
| 15   | 0.030   | 0.000  | 0.033 | 0.000 | 0.059 |
| 25   | 0.030   | 0.033  | 0.000 | 0.059 | 0.000 |
| 45   | 0.030   | 0.000  | 0.033 | 0.000 | 0.059 |
| 60   | 0.031   | 0.000  | 0.033 | 0.000 | 0.059 |

1.3. Antimicrobial activity testing

See Tables 5 and 6.

Table 5
Antimicrobial activity of eluted vancomycin (0.5 g) for three S. aureus strains. Results (all units are log$_{10}$CFU/mL) (colony forming units, CFU) are reported as mean ± standard deviation (SD).

| Days | ATCC 29213 | n315 | ATCC 33591 |
|------|------------|------|------------|
| Mean | SD         | Mean | SD         | Mean | SD   |
| 0    | 3.070      | 0.150| 3.150      | 0.010| 3.150| 0.050|
| 1    | 1.620      | 0.320| 1.000      | 0.000| 1.000| 0.000|
| 2    | 1.000      | 0.000| 1.000      | 0.000| 1.000| 0.000|
| 3    | 1.000      | 0.000| 1.000      | 0.000| 1.000| 0.000|
| 4    | 1.000      | 0.000| 1.000      | 0.000| 1.000| 0.000|
| 5    | 1.000      | 0.000| 1.000      | 0.000| 1.000| 0.000|
| 6    | 1.000      | 0.000| 1.000      | 0.000| 1.000| 0.000|
| 7    | 1.000      | 0.000| 1.000      | 0.000| 1.000| 0.000|
| 15   | 1.000      | 0.000| 1.000      | 0.000| 1.000| 0.000|
2. Experimental design, materials, and methods

2.1. Sample preparation

Cement, stored at 22 °C ± 1 °C, was prepared [2] with vacuum, − 50 to 100 mbar (Zimmer Compact Vacuum Cement Mixing System®). The six experimental groups were: control (Palacos® R Cement), and five treatments with 0.125 g, 0.25 g, 0.50 g, 1.0 g, and 2.0 g of vancomycin powder added to the polymer powder. Six samples per test were molded: drug elution disks (6 mm diameter × 4.5 mm height), compression cylinders (6 mm diameter × 12 mm height), four-point bend beams (75 mm × 10 mm × 3.3 mm), and fracture toughness beams (44 mm × 10 mm × 5 mm with crack length between 4.5 mm and 5.5 mm and width of 0.37 mm, Buehler® IsoMet™).

2.2. Mechanical testing

After 21 days in 1x PBS at 22 °C, mechanical testing was performed (Criterion C43.104, MTS Systems) according to ISO 5388 with force and displacement data recorded at 100 Hz. Displacement rate was 5 mm/min for four-point bending and compression tests and 10 mm/min for fracture toughness tests.

2.3. Release characteristic testing

Five cement disks per group were submerged in 5 mL PBS in an incubator shaker at 37 °C and 100 rpm. At 1, 2, 4, 8, 10, 15, 25 and 45, and 60 days, 1.5 mL of the PBS was aspirated off, stored at − 20 °C, and samples were submerged in 5 mL fresh PBS. Vancomycin content was measured (high performance liquid chromatography with a C18 column [3]) in triplicate. Ten microliters of the sample was developed isocratically with 50 mM potassium phosphate buffer (pH 6.8) and acetonitrile (17:3) at a flow rate of 0.5 mL/min. Absorbance was monitored at 210 nm with peak intensity correlated to concentrations [4].

2.4. Antimicrobial activity testing

Three cement disks per group were sterilized (ethylene oxide gas), submerged in 3.4 mL tryptic soy broth (TSB; Becton Dickenson) and inoculated with bacteria (1000 CFU/mL): Methicillin-resistant Staphylococcus aureus (MRSA) n315 with a vancomycin minimum inhibitory concentration (MIC) of 0.5–1 mg/L [5], ATCC MRSA 33591 (vancomycin MIC 2 mg/L), ATCC S. aureus 29213 (vancomycin MIC 0.5 mg/L), and ATCC S. epidermidis 35984 (vancomycin MIC 1 mg/L) [6]. MRSA n315 was also tested at 10^6 CFU/mL. TSB samples, taken at inoculation, daily for 7 days, and again at 14 days, were serially

| Days | 0.125 g | 0.25 g | 0.5 g | 1.0 g | 2.0 g |
|------|---------|--------|-------|-------|-------|
| Mean | Mean    | Mean   | Mean  | Mean  | Mean  |
| SD   | SD      | SD     | SD    | SD    | SD    |
| 0    | 3.090   | 0.040  | 3.090 | 0.040 | 3.090 |
| 1    | 4.500   | 1.000  | 2.610 | 2.330 | 1.700 |
| 2    | 5.040   | 0.790  | 4.000 | 0.870 | 3.680 |
| 3    | 4.900   | 1.040  | 4.400 | 1.250 | 3.380 |
| 4    | 5.250   | 0.350  | 5.270 | 0.140 | 5.040 |
| 5    | 5.500   | 1.000  | 5.500 | 1.000 | 5.500 |
| 6    | 5.500   | 1.000  | 4.320 | 1.140 | 3.810 |
| 7    | 5.500   | 1.000  | 5.330 | 0.150 | 4.940 |
| 15   | 5.500   | 1.000  | 5.500 | 1.000 | 5.500 |

Table 6: Antimicrobial activity of eluted vancomycin (0.125–2.0 g) for S.epidermidis 35984. Results (all units are log_{10}CFU/mL) are reported as mean ± 1 standard deviation (SD).
diluted (Mueller Hinton II agar plates, Sigma-Aldrich) for bacterial enumeration. Bacterial colonies were quantified after 18–24 hours incubation. All testing was performed in triplicate.

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Transparency document. Supplementary material

Transparency document associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.07.028.

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