Antiseptic Irrigation During Cement Curing Does Not Alter the Porosity of PMMA Bone Cement

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INTRODUCTION

Cemented joint replacement relies on polymethylmethacrylate (PMMA) bone cement to achieve stable implant fixation. During revision surgery, the two major failure mechanisms are periprosthetic joint infection and aseptic loosening.(1)

Intraoperative antiseptic irrigation is an established strategy to reduce the risk of periprosthetic joint infection.(2) However, surgeons often avoid lavage while the cement is curing because fluid contact is thought to increase cement porosity and thereby compromise mechanical integrity and fixation.(3–5)

Importantly, this concern is largely based on studies in which antiseptic solutions were introduced during cement mixing, an exposure that does not reflect clinical practice.(6,7) During surgery, irrigation typically reaches cement only after it has been applied and has already begun to cure.

The clinically relevant question, therefore, is whether irrigation during cement curing alters cement porosity, and whether this effect depends on the timing of exposure or the antiseptic solution used.

We investigated this clinically relevant exposure by defining irrigation timepoints from 24 primary total knee arthroplasties and reproducing these intervals experimentally. We hypothesized that cement porosity after irrigation would be equivalent to that of unirrigated cement at all clinically observed timepoints and for all solutions tested.

METHODS

Design. Two cements analyzed separately. Within each cement, three antiseptic solutions were applied at five curing timepoints, with unirrigated dry controls. Three discs per group, 96 discs in total.

Cements. Palacos R, high-viscosity (Heraeus Medical, Wehrheim, Germany); Simplex P, medium-viscosity (Stryker, Kalamazoo, Michigan). Hand-mixed, no antibiotic additive. Hand mixing is the worst case for entrained porosity.

Solutions. Saline 0.9%, povidone-iodine 0.35%, chlorhexidine gluconate 0.05%, at clinical dilutions.

Timepoints. Prospective intraoperative observation of 24 primary total knee arthroplasties performed by four fellowship-trained arthroplasty surgeons (Fig. 1). Timing began at the start of mixing, defined as the moment the liquid monomer contacted the polymer powder, and ended when irrigation was applied. The five laboratory timepoints correspond to the minimum, the three quartiles and the maximum of the observed distribution: 4:54, 5:55, 7:15, 8:33 and 11:34 min:sec. The tested window therefore spans the full range of irrigation times observed clinically.

Specimens and exposure. Discs 36 mm in diameter and 6 mm in height. At its assigned timepoint, each disc was fully submerged in the allocated solution for 3 minutes, then left to complete curing in air.

Micro-CT. 8 µm isotropic voxel (Scanco Medical, Brüttisellen, Switzerland); minimum pore diameter 24 µm. Center region of interest 5 × 5 × 5 mm, surface region of interest 2 × 1 × 2 mm.

Statistics. Two one-sided tests against the dry control, prespecified margin ±5 percentage points, 90% confidence interval. Each cement compared only with its own control.

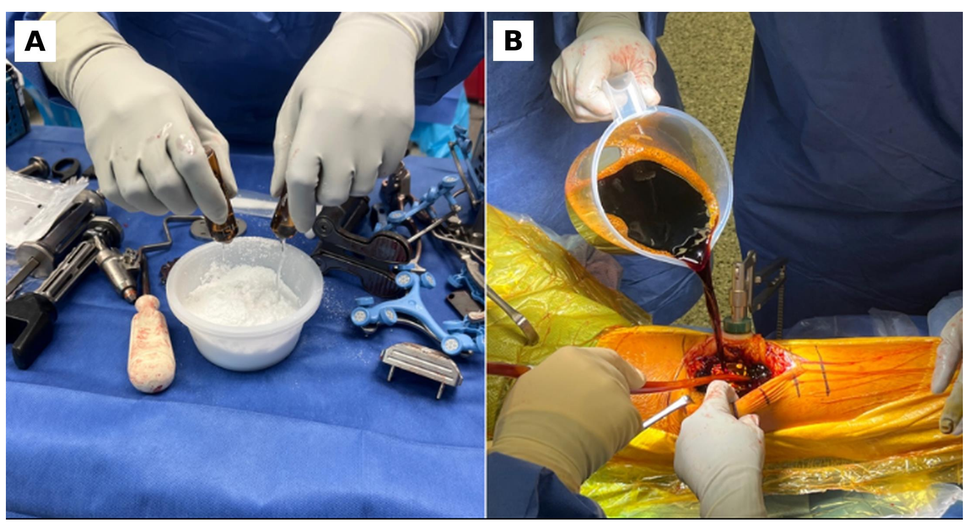

Fig. 1. Intraoperative timing. (A) Start of mixing. (B) Application of the irrigation solution.

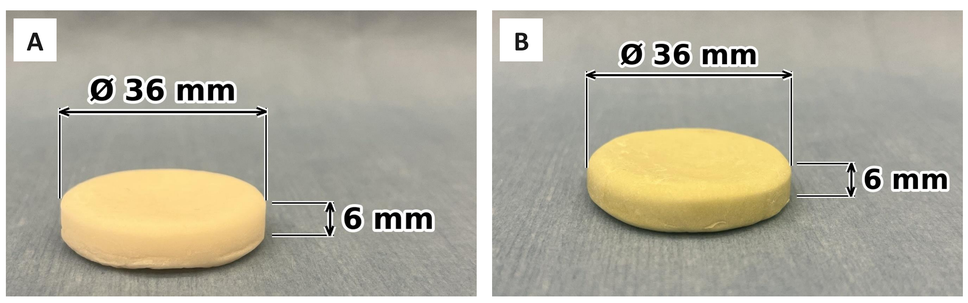

Fig. 2. Cured specimen discs, 36 mm in diameter and 6 mm in height. (A) Simplex P, medium-viscosity. (B) Palacos R, high-viscosity.

RESULTS

All twelve antiseptic-versus-control comparisons were equivalent to the unirrigated control (TOST, P ≤ 0.001). No difference exceeded 0.81 percentage points, and even the widest confidence bound, 1.73 percentage points, stayed at about a third of the ±5 percentage-point margin.

Solution		Center porosity difference (90% CI), pp	P	Surface porosity difference (90% CI), pp	P
Palacos R (high-viscosity)					
Saline 0.9%		+0.20 (−0.26 to +0.64)	<0.001	+0.12 (−0.10 to +0.35)	<0.001
Povidone-iodine 0.35%		+0.19 (−0.25 to +0.64)	<0.001	+0.01 (−0.17 to +0.20)	<0.001
Chlorhexidine 0.05%		−0.01 (−0.45 to +0.44)	<0.001	+0.04 (−0.18 to +0.26)	<0.001
Simplex P (medium-viscosity)					
Saline 0.9%		−0.22 (−1.31 to +0.87)	0.001	+0.70 (−0.22 to +1.62)	<0.001
Povidone-iodine 0.35%		−0.25 (−1.33 to +0.84)	0.001	+0.81 (−0.10 to +1.73)	<0.001
Chlorhexidine 0.05%		−0.11 (−1.19 to +0.96)	0.001	+0.73 (−0.19 to +1.65)	<0.001

Table I. Each active-solution group (n = 15, pooling the five curing timepoints) was compared with the unirrigated dry control (n = 3) of the same cement. Differences are in percentage points; a positive value indicates higher porosity than the control. P values are the larger of the two one-sided tests against a margin of ±5 percentage points.

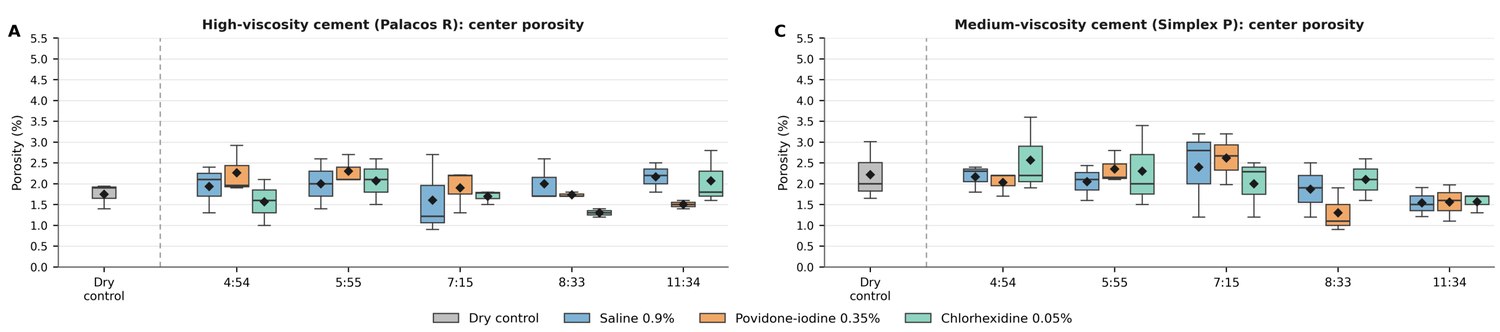

Fig. 3. Center porosity by irrigation timepoint. Panels show the high-viscosity cement (A) and the medium-viscosity cement (C) against their own dry controls.

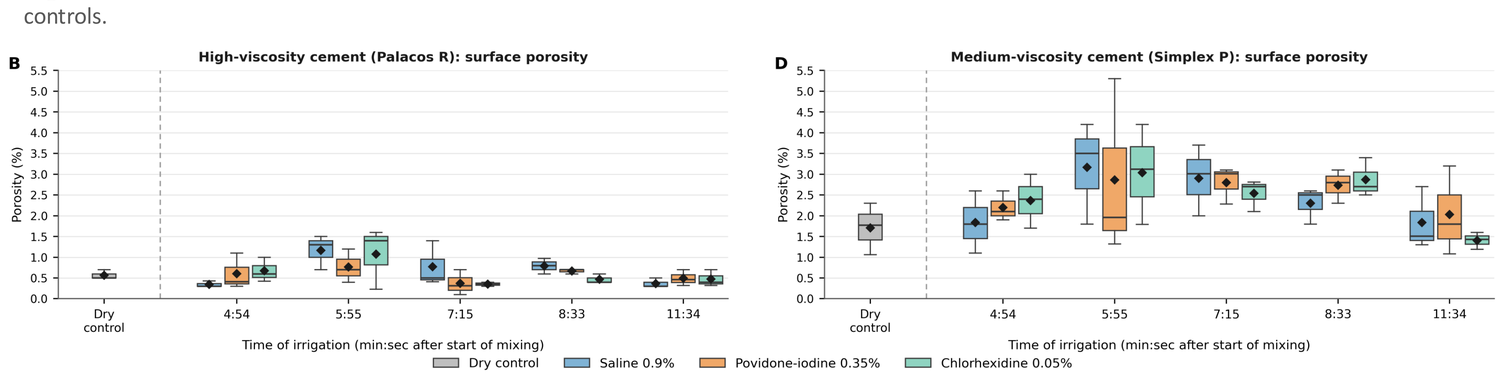

Fig. 4. Surface porosity by irrigation timepoint, high-viscosity cement (B) and medium-viscosity cement (D).

Timing. Porosity did not vary with the time at which the lavage reached the cement, in either cement or region.

Between-cement surface porosity. Approximately 0.6% in Palacos R versus 2.4% in Simplex P. The divergence was present in the dry controls and reflects an intrinsic viscosity effect, not an effect of irrigation.

Macropores and reliability. Macropore counts were comparable across solutions within each cement (Kruskal-Wallis P = 0.88 and P = 0.99). Inter-observer ICC was 0.79 for center porosity and 0.87 and 0.67 for surface porosity in Simplex P and Palacos R.

Compression. In exploratory axial testing to the 4,500 N limit of the load cell, no disc fractured and displacement stayed below 1 mm.

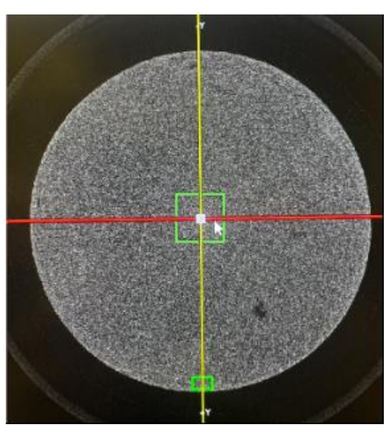

Fig. 5. Representative micro-computed tomographic section of a cured disc, showing the two regions of interest. The central square (5 × 5 mm) defines the center region and the peripheral rectangle (2 × 1 mm) the surface region.

References

1. Datta S, et al. J Arthroplasty. 2025;40(9):2219-25.
2. Hernandez NM, et al. J Bone Joint Surg Am. 2019;101(13):1144-50.
3. Kim S, et al. J Biomech Eng. 2022;144(1):011006.
4. Barratt H, et al. Proc Inst Mech Eng H. 2026;240(5):498-507.
5. Mann KA, et al. J Orthop Res. 2007;25(3):340-50.
6. Wu M, et al. Orthop Traumatol Surg Res. 2022;108(4):103243.
7. Karpinski R, et al. Materials. 2019;12(23):3963.

CONCLUSION

Antiseptic irrigation during cement curing did not increase the porosity of either PMMA cement, regardless of the antiseptic solution or the timing of its introduction.

Clinical implications. Pre-closure antiseptic lavage does not need to be deferred until the cement has hardened. Irrigation within the curing window did not compromise the cement mantle in this model.