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Original Research Article

# A Simple and Effective Alternative to Antibiotic Beads in the Treatment of Open Fractures is Prophylactic Vancomycin-PMMA Strips

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**Conflict of interest: Nil**

**Abstract**

**Objective:** Even in the best-case scenario, infection is still a possibility during surgery and can be extremely dangerous after a compound fracture treatment. This study evaluated the effectiveness and practicality of locally applied antibiotic-impregnated polymethyl methacrylate (PMMA) strips to prevent infection and achieve functional union within a predetermined period of time following primary definitive stabilization of compound fractures.

**Method:** A study was conducted from January 2021 to February 2022 at Department of Orthopaedic, Veer Surendra Sai Institute of Medical Sciences and Research, Burla on patients who got PMMA-vancomycin strips during orthopedic surgery repair of open fractures. There were 105 patients in all (ages 25 to 60) with open fractures of types I through IIIC. In-depth wound cleaning, meticulous debridement, and final stabilization with PMMA-vancomycin strips were all performed on the patients. Measurements were made on the frequency of wound healing, fracture union, and infection rate. Radiographs and infection markers were used to monitor patients over the course of a year. The effectiveness of the PMMA strips used in this investigation was compared to that of PMMA beads used in techniques identical to those in published studies.

**Results:** 4 (4.6%) of 105 individuals developed a subclinical infection up until the implant was removed. There was no evidence of osteomyelitis or non-union in any patient. Comparable results in terms of infection rates were found between the PMMA strips used in this investigation and the antibiotic beads utilized in earlier experiments, according to a literature review. Vancomycin PMMA strips can be removed more easily than vancomycin beads in most cases.

**Conclusion:** PMMA vancomycin strips provide surgeons a simple, effective solution to the contentious problem of deciding how long to keep antibiotic beads in place.

**Keywords:** PMMA vancomycin strips, fractures, antibiotics beads

## Introduction

The first time antibiotic-loaded bone cement was applied during orthopedic endoprosthetic surgery on human patients by Buchholz and Engelbrecht [1]. The main results were a high local concentration of antibiotics and few systemic side effects [2]. Antibiotic concentrations 10 to 100 times greater than normal are needed to penetrate biofilm, and this is not safe for systemic usage. The thermostability of the antibiotic, the porosity of the antibiotic vehicle, and, most significantly, the surface area of the antibiotic PMMA construct for elution of the antibiotic [Figure 1; 3] are the main variables impacting the maintenance of the local higher concentrations of antibiotics with PMMA**.**

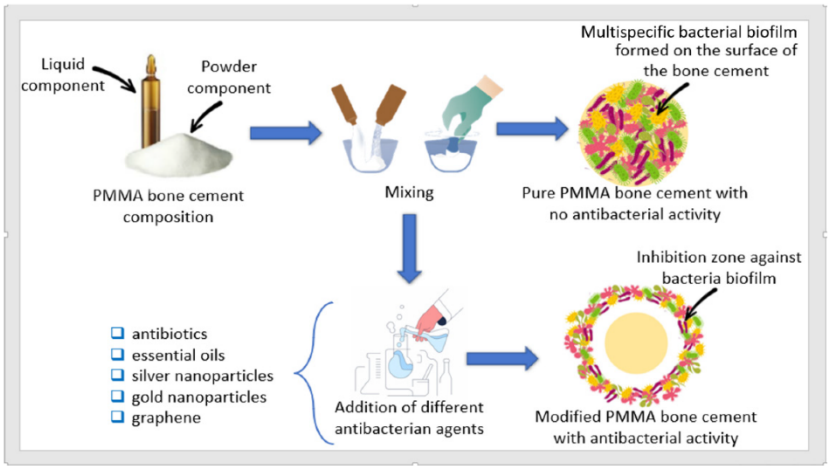


**Figure 1: Acrylic bone cement additives with antimicrobial properties**

In this investigation, the effectiveness of vancomycin PMMA strips in open fractures was compared to data on standard antibiotic PMMA beads. Because to its excellent thermostability, availability in powder form, simplicity of mixing prior to adding liquid monomer, and less allergenic qualities, PMMA vancomycin in strips was employed.

Antibiotic beads have been shown to be effective in managing open fractures, however, their elution qualities are compromised by issues such as damaged local anatomy, significant scarring, labor-intensive hand preparation procedures in underdeveloped nations, and fibrosis around the beads [4]. When it comes to delivering high-concentration local antibiotics, strips are just as effective as beads, but they have the advantages of causing less fibrosis scar tissue and being simpler to apply and remove.

## Methods

**Study Design*:*** Between January 2021 and February 2022, at Department of Orthopaedic, Veer Surendra Sai Institute of Medical Sciences and Research, Burla.

**Methodology*:*** Gustilo and Anderson were added to the list of subcategories [5]. Type II, Type IIIA, Type IIIB, and Type IIIC open fractures with high-velocity injuries. 68 patients who had type I, II, or IIIA wounds had them thoroughly cleaned with povidineiodine and normal saline. They received initial stabilisation and the insertion of PMMA strips laced with vancomycin on the same day. For five days, metronidazole, third-generation cephalosporin, and aminogycoside were given as systemic antibiotics.

Patients in 5 tibia cases arrived 2 weeks after the initial injury with substantial contamination from grass and dirt particles. Due to a lack of resources, ignorance, and available facilities, they were late. Swab

cultures were collected, wounds were extensively cleaned with povidone iodine scrub and normal saline, debridement was carried out under anesthesia, and external fixation was placed. After two weeks of daily debridement and cleaning, final stabilization was carried out by inserting PMMA strips that had been vancomycin-impregnated. Soft-tissue release and split-thickness skin grafts, where necessary, were used to seal the incisions. Five days after the culture results, responsive systemic antibiotics were continued. Debridement was carried out for fractures of types IIIB and IIIC, along with soft tissue and neurovascular healing, and external fixation for a period of two to three weeks. After internal fixation, vancomycin-impregnated PMMA strips were used, and the incision was then stitched shut using split-thickness skin grafting, soft tissue release, or transposition flaps.

On the fifth postoperative day, the patients who had their sutures removed between three and four weeks earlier were released. On the third postoperative day, isometric, range-of-motion, and partial weight-bearing exercises were introduced. Leukocyte count, serum protein, total lymphocyte count, and C-reactive protein were some of the infection indicators that were checked on a monthly basis for the patients. Radiographs were done as a follow-up at 1, 3, 5, 8, and 12 months.

**Sample Size*:*** 105 open fractures were included in this study. Among these fractures, 88 involved the tibia, 12 involved the femur, and 5 included the forearm.

**Inclusion criteria*:*** Ages 21 to 65, open fractures within days 2 to 8 of presentation, and anesthesia-eligible.

**Exclusion criteria*:*** any comorbidity, such as immune-compromised patients, diabetes mellitus, prior underlying chronic infections, pathological fractures, and polytrauma with head or chest traumas, as well as known intolerance to vancomycin.

**Ethical Consideration*:*** The study was approved by the ethical committee of Veer Surendra Sai Institute of Medical Sciences and Research, Burla after written consent was obtained from the subjects.

## Results

All patients with grade I, II, or IIIA fractures had fractures that were joined in 68/68 (100%) cases. After suture removal, there were sterile discharge sinuses in 2/5 (51%) of open grade IIIC fractures and 3/33 (5.87%) subclinical infections in grade IIIB fractures. For them, no special debridement or systemic antibiotics were used; simply twice-daily soap water washes and wound expression were necessary for full recovery to occur within 4 months. The infection rate in this study group was 4/105, or 4.6%.

At follow-up exams after a year, there was a 100 percent union rate. With upper limb open fractures, the time to union was 7–11 weeks, and for lower limb open fractures, it was 11–35 weeks. Seven to eleven weeks after surgery, PMMA vancomycin strips were removed [**Figure 2**].

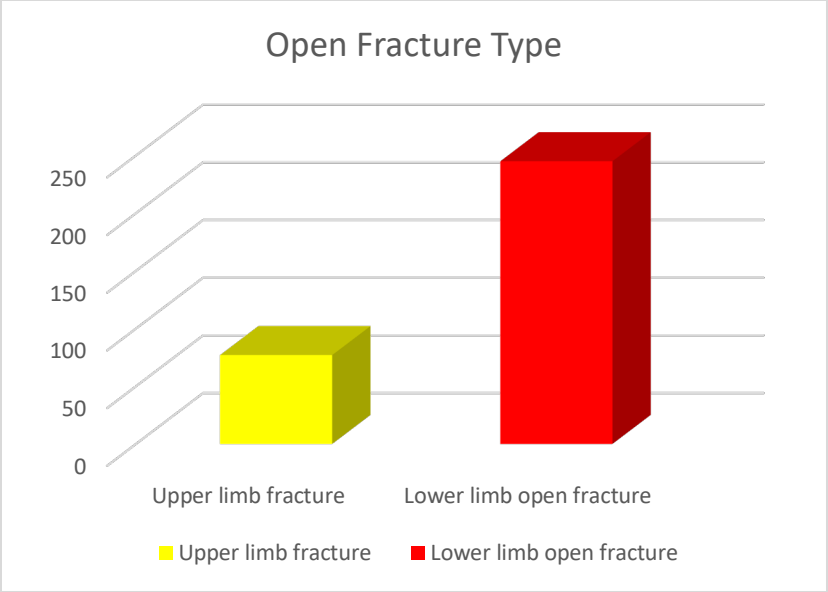


**Figure 2: Representation of time to union in fractures**

Three out of 105 patients were lost to follow-up after a year. The patients came back after a year with a discharge of serous matter and exposed strips at the distal tibia. Nonetheless, these issues did not delay a sound union within the allotted period, and after the strips and implants were removed, the wound entirely healed. There were no acute wound infections or local or systemic infections linked to antibiotics or implants.

## Discussion

Local vancomycin strips exhibit equal efficacy to antibiotic beads used for similar procedures in large trials in the current investigation of open fractures with definitive fixation. No of their socioeconomic standing or gender, all of the patients in our study had full wound healing within periods of time comparable to those of previously documented open fracture repairs using the use of antibiotic beads.

After reviewing 845 open fractures with thorough debridement, extensive irrigation, and local PMMA antibiotics, Ostermann *et al*. [6] came to the conclusion that 3.7% of patients had postoperative infections. All fracture types had a lower infection rate, which was statistically significant for types IIIB and IIIC [6].

Prophylactic antibiotic impregnation with systemic antibiotics had a considerable impact on type III open fractures, according to Henry *et al*. [7]. Local PMMA antibiotics were deemed advantageous for sustaining local concentrations without systemic symptoms by several authors [8–10]. According to Calhoun *et al*. [11], the presence of microorganisms around beads had no effect on how well wounds and fractures healed. Antibiotic beads have been shown to have similar advantages by Zalavras *et al* [4]. They brought up the contentious subject of revision surgery and the elimination of PMMA antimicrobial beads. Without a drain, a wound must be sealed in order to decrease fluid turnover, which is crucial for maintaining local antibiotic concentrations. Due to sustained subtherapeutic antibiotic doses, a bead left in place acquires resistant bacteria and behaves like a foreign body, predisposing the patient to secondary infection.

Henry *et al*. [12] noted that fibrosis soft tissue near joints hindered movement, resulting in problems connected with emotional and

financial burden from beads. We introduced antibiotic PMMA strips to readily remove at 7 to 11 weeks even after 1 year while retaining desired local antibiotic concentration in order to test these entire theories.

From Egypt to India, wounds have been treated topically since prehistoric times. Several clinical researchers from all over the world have discussed the effectiveness of local antibiotic therapy for open wounds in order to prevent resistant infections and the morbidity of long-term intravenous antibiotic use [13, 14], as well as to maintain a greater local concentration of antibiotics to dissolve biofilms.

The two-stage local PMMA antibiotic release reaches its peak concentration within hours to days and maintains high concentrations for up to five years [10]. Matrix-like surface area, concentration, post-implantation duration, and fluid turnover are a few variables that affect how well antibiotic PMMA elutes. Elution occurs through the matrix's pores, voids, cracks, and passive diffusion. Without effective treatment, localised high doses of antibiotics are insufficient. removing debris [15]. While germs are being suppressed by antibiotics at 10 to 100 times the typical concentration, resistance is being discouraged [9].

Effective biofilm dissolution and utilisation of the blood-bone barrier also guard against systemic toxicity. Walenkamp *et al*. [16] and Salvati *et al*. [17] showed that these techniques for delivering local high-concentration antibiotics did not cause renal toxicity and that serum levels were less than 0.5 g/mL. Similarly, at larger doses (10.5 g vancomycin; 12.5 g gentamycin) than those used in our investigation, Springer *et al*. [18] and Hsieh *et al*. [19] reported clinical safety.

The clinical results in our series and two-year follow-up were comparable to those of open fracture cases treated with different antibiotics or different techniques for local PMMA antibiotic impregnation. The main benefits of the strips are their ability to fit anywhere into myofascial compartments in the limbs without impairing wound healing, their huge surface area for antibiotic elution, [20] and how easy they are to remove with just a single stab incision.

## Conclusion

PMMA beads and PMMA vancomycin-impregnated strips both work well for complex fractures. They both function similarly in terms of elution and preserving antibiotic local tissue concentration. As a result, wound closure in situations of the open tibia and forearm fractures is easier with strips than it is with beads. This is important because the strips may be easily accommodated in the osteo-muscular plane. The easy removal of the strips that were only a few centimeters long was the study's most significant finding.

## Limitation of the study

In assessing the clinical role, the undetermined extent of devitalized tissue following debridement, and the removal or necessity to remove the antibiotic vehicle matrix, impersonations continue to exist. The main disadvantages of utilizing beads are that they cannot be used as mechanical fillers, there is a chance that the wound won't heal completely, and if the beads get embedded in fibrous tissue or calluses, elution is reduced and removal is more difficult.

A significant component in preserving a high local concentration of antibiotics is incomplete wound closure, which boosts local fluid turnover and raises the risk of subsequent infections. If not, a PMMA matrix with decreased elution may act strangely and bacteria that are resistant to antibiotics will grow when antibiotic concentrations are below therapeutic levels. These issues can be resolved by switching

from beads to PMMA strips. The contentious issues of how long to maintain the antibiotic vehicle, where to put it, and how to remove it properly are all addressed by antibiotic-loaded PMMA strips. In the current trial, we were able to quickly and successfully remove all strips from every patient.

## References


1. Buchholz HW. Depotwirkung einigen Antibiotica bei Vermishung mit dem kunstharz Palacos. Chirurg. 1970; 40:511.
1. Hauser CJ, Adams Jr CA, Eachempati SR. Prophylactic antibiotic use in open fractures: an evidence-based guideline. Surgical infections. 2006 Aug 1;7(4):379-405.
2. Penner MJ, Masri BA, Duncan CP. Elution characteristics of vancomycin and tobramycin combined in acrylic bone—cement. The Journal of arthroplasty. 1996 Dec 1;11(8):939-44.
3. Anderson JT, Gustilo RB. Immediate internal fixation in open fractures. Orthopedic Clinics of North America. 1980 Jul 1;11(3):569-78.
4. Zalavras CG, Patzakis MJ, Holtom P. Local antibiotic therapy in the treatment of open fractures and osteomyelitis. Clinical Orthopaedics and Related Research (1976-2007). 2004 Oct 1; 427:86-93.
5. Penner MJ, Masri BA, Duncan CP. Elution characteristics of vancomycin and tobramycin combined in acrylic bone—cement. The Journal of arthroplasty. 1996 Dec 1;11(8):939-44.
6. Ostermann PA, Seligson D, Henry SL. Local antibiotic therapy for severe open fractures. A review of 1085 consecutive cases. The Journal of bone and joint surgery. British volume. 1995 Jan;77(1):93-7.
7. Henry SL, Ostermann PA, Seligson D. The prophylactic use of antibiotic impregnated beads in open fractures. Journal of Trauma and Acute Care Surgery. 1990 Oct 1;30(10):1231-8
8. Skaggs DL, Friend L, Alman B, Chambers HG, Schmitz M, Leake B, Kay RM, Flynn JM. The effect of surgical delay on acute infection following 554 open fractures in children. JBJS. 2005 Jan 1;87(1):8-12.
9. Hoff WS, Bonadies JA, Cachecho R, Dorlac WC. East Practice Management Guidelines Work Group: update to practice management guidelines for prophylactic antibiotic use in open fractures. Journal of Trauma and Acute Care Surgery. 2011 Mar 1;70(3):751-4.
10. Pollak AN. Timing of debridement of open fractures. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2006 Oct 1;14(10): S48-51.
11. Calhoun JH, Henry SL, Anger DM, Cobos JA, MADER JT. The Treatment of Infected Nonunions with Gentamicin—Polymethylmethacrylate Antibiotic Beads. Clinical Orthopaedics and Related Research®. 1993 Oct 1; 295:23-7.
12. Henry SL, Hood GA, Seligson D. Long-term implantation of gentamicin-polymethylmethacrylate antibiotic beads. Clinical Orthopaedics and Related Research (1976-2007). 1993 Oct 1; 295:47-53.
13. Skaggs DL, Friend L, Alman B, Chambers HG, Schmitz M, Leake B, Kay RM, Flynn JM. The effect of surgical delay on acute infection following 554 open fractures in children. JBJS. 2005 Jan 1;87(1):8-12.
14. Evans RP, NELSON CL. Gentamicin-impregnated polymethylmethacrylate beads compared with systemic antibiotic therapy in the treatment of chronic osteomyelitis. Clinical Orthopaedics and Related Research (1976-2007). 1993 Oct 1; 295:37-42.
15. Van Vugt TA, Arts JJ, Geurts JA. Antibiotic-loaded

polymethylmethacrylate beads and spacers in treatment of orthopedic infections and the role of biofilm formation. Frontiers in microbiology. 2019 Jul 25; 10:1626.
16. Walenkamp GH, Vree TB, Van Rens TJ. Gentamicin–PMMA Beads: Pharmacokinetic and Nephrotoxicological Study. Clinical Orthopaedics and Related Research®. 1986 Apr 1; 205:171-83.
17. Salvati EA, Callaghan JJ, Brause BD, Klein RF, Small RD. Reimplantation in infection: elution of gentamicin from cement and beads. Clinical Orthopaedics and Related Research®. 1986 Jun 1; 207:83-93.
18. Springer BD, Lee GC, Osmon D, Haidukewych GJ, Hanssen AD, Jacofsky DJ. Systemic safety of high-dose antibiotic-loaded cement spacers after resection of an infected total knee arthroplasty. Clinical Orthopaedics and Related Research (1976-2007). 2004 Oct 1; 427:47-51.\
19. Hsieh PH, Huang KC, Tai CL. Liquid gentamicin in bone cement spacers: in vivo antibiotic release and systemic safety in two-stage revision of infected hip arthroplasty. J Trauma. 2009; 66:804–8.
20. Holtom PD, Warren CA, Greene NW, Bravos PD, Ressler RL, Shepherd L, McPherson EJ, Patzakis MJ. Relation of surface area to in vitro elution characteristics of vancomycin-impregnated polymethylmethacrylate spacers. American Journal of Orthopedics (Belle Mead, NJ). 1998 Mar 1;27(3):207-10.