

Original Research Article

Comparative efficacy of vancomycin and gentamicin soaked hamstring autografts in reducing infection rates following ACL reconstruction

Sachin C. Thagadur^{1*}, Prathap U. S.², Vijay Girish³

¹Department of Orthopedics, M. S. Ramaiah Medical College and Hospital, Bengaluru, Karnataka, India

²Department of Orthopedics, Shridevi Institute of Medical Sciences, Tumakuru, Karnataka, India

³Arthroscopy and Arthroplasty Surgeon, HOSMAT Hospital, Bangalore, Karnataka, India

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*Correspondence:

Dr. Sachin C. Thagadur,

E-mail: drsachinctortho@gmail.com

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ABSTRACT

Background: Deep knee infection after anterior cruciate ligament reconstruction (ACLR) is uncommon but carries a disproportionate clinical burden, often ending in graft loss and staged revision surgery. Because systemic antibiotics penetrate avascular tendon poorly, presoaking the harvested graft in a topical antibiotic solution has emerged as a practical adjunct to standard intravenous prophylaxis. Vancomycin has the largest published experience for this purpose, while gentamicin has been proposed as a comparably effective and more practical alternative. Objective was to directly compare vancomycin-soaked and gentamicin-soaked hamstring autografts for their effect on postoperative infection rate and functional recovery following arthroscopic ACLR.

Methods: Eighty patients undergoing primary ACLR over a six-month period were divided into two groups of 40: group 1 received autografts presoaked in vancomycin (500 mg/vial), and group 2 received autografts presoaked in gentamicin (40 mg/2 ml). Both groups received identical intravenous antibiotic prophylaxis, surgical technique, and rehabilitation. Functional recovery was assessed with the IKDC subjective knee score preoperatively and at three and six months.

Results: The cohort comprised 52 men and 28 women, with injuries distributed almost evenly between the right (36) and left (44) knee. Non-contact mechanisms accounted for the largest share of injuries (45), followed by road traffic accidents (20) and sport (15). One deep knee infection occurred in the entire cohort, in a patient from the gentamicin group (group 2), giving group-wise infection rates of 0% (group 1) and 2.5% (group 2). The combined IKDC score rose from a mean of 34 ± 3.1 preoperatively to 54 ± 2.6 at three months and 93.5 ± 1.5 at six months.

Conclusions: Both vancomycin and gentamicin graft-pres soaking were associated with a low overall infection rate and comparable functional recovery, supporting either agent as a reasonable, low-cost adjunct to intravenous prophylaxis during ACLR. Larger comparative trials are needed to establish whether either antibiotic carries a true advantage over the other.

Keywords: Anterior cruciate ligament reconstruction, Gentamicin, Graft presoaking, Hamstring autograft, Septic arthritis, Vancomycin

INTRODUCTION

The anterior cruciate ligament (ACL) is the primary restraint against forward translation of the tibia on the femur and against excessive internal rotation of the knee, and it is the ligament most frequently injured during sport

or accidental trauma. It runs as two intertwined fibre bundles (an anteromedial and a posterolateral band) from the medial wall of the lateral femoral condyle to the tibial plateau, and a sudden pivot, deceleration, or valgus load on a planted foot is enough to tear it.^{1,2} The majority of tears (commonly cited above 60%) occur without any

direct blow to the knee, the ligament simply failing under a rotational or deceleration force it was not built to absorb.³

Arthroscopic reconstruction remains the standard treatment once a tear is confirmed, and hamstring autograft is among the most widely used graft options because it avoids donor-site morbidity at the extensor mechanism and can be harvested through a small incision. Registries and meta-analyses have nonetheless shown that hamstring grafts carry a modestly higher infection risk than bonepatellar tendon-bone grafts, which has kept graft-related infection prevention an active area of research.^{4,5}

Deep knee (septic) infection after ACLR is rare, with published rates generally between 0.1% and 1.8%, but the consequences are severe and disproportionate to the incidence: repeated arthroscopic washouts, prolonged antibiotic courses, occasional hardware or graft removal, and in some cases a second-stage reconstruction months later.^{6,7} Coagulase-negative staphylococci and *Staphylococcus aureus* account for most culture-positive cases, and these organisms are believed to contaminate the graft chiefly during harvesting and back-table preparation rather than through the arthroscopy portals themselves—contamination rates as high as one in four harvested grafts have been reported in some series.^{8,9}

Systemic intravenous antibiotics, while a standard part of perioperative care, do not reliably solve this problem, because tendon is poorly vascularized and drug levels within the graft substance often fall short of the concentration needed to kill contaminating organisms.¹⁰ This has driven interest in treating the graft directly: soaking or wrapping the harvested tendon in a topical antibiotic solution during back-table preparation, before it is passed into the joint. Vancomycin-soaking has by far the largest published track record, with several large single-centre series and a systematic review reporting infection rates falling to near zero once the technique was adopted, without any corresponding rise in graft failure or arthrofibrosis.¹¹⁻¹⁵ Gentamicin has more recently been proposed as an equally viable— and in some respects more convenient— alternative: it achieves bactericidal effect after only a brief contact period, the soak solution is inexpensive and simple to prepare, and its antibacterial spectrum covers the Gram-positive skin commensals responsible for most ACLR infections.^{16,17}

What remains comparatively under-studied is a direct, within-institution comparison of the two agents rather than separate single-arm reports. Most of the published evidence for either antibiotic comes from series that examined only one agent against a historical or saline-soaked control, which makes cross-study comparison difficult given differences in patient population, graft type, and follow-up duration between institutions. A small number of recent series have attempted exactly this head-to-head comparison and found the two antibiotics to perform similarly, though sample sizes have generally been modest.¹⁸ A direct comparison within the same

institution, using an identical surgical technique, antibiotic protocol, and follow-up schedule for both arms, removes much of this between-study variability and allows a cleaner assessment of whether one agent offers any real advantage over the other.

This study was designed to add to that limited comparative literature: eighty patients undergoing primary ACLR were divided into two equal groups, one receiving vancomycin-soaked and the other gentamicin-soaked hamstring autografts, with infection rate as the primary outcome and IKDC-based functional recovery as a secondary outcome. Beyond the infection endpoint itself, we were also interested in whether either antibiotic protocol was associated with any delay in graft preparation or any difference in the trajectory of functional recovery, since a technique that reduces infection at the cost of added operative time or slower rehabilitation would carry a very different practical value than one that does neither.

METHODS

Study design and setting

This was a combined retrospective-and-prospective observational study conducted in the department of orthopedics at HOSMAT Hospital, Bangalore, a tertiary-care hospital, over a six-month period (July to December 2022).

Participants

Eighty patients undergoing primary arthroscopic ACL reconstruction were enrolled and allocated to two groups of 40 each: group 1 received vancomycin-soaked autografts, and group 2 received gentamicin-soaked autografts.

Inclusion criteria

patients aged 18-50 years with a confirmed ACL tear, with or without an associated meniscal tear.

Exclusion criteria

Pre-existing osteoarthritis of the knee; ACL tear associated with a concomitant posterior cruciate ligament (PCL) injury; and patients undergoing revision ACL reconstruction.

Preoperative work-up

Every patient underwent a standing knee radiograph, a full clinical examination (Lachman, anterior drawer, and pivot-shift assessment, along with a check for joint-line tenderness and effusion), an MRI to confirm the diagnosis and assess for associated meniscal or chondral injury, routine preoperative blood investigations, and a baseline IKDC subjective knee score.

Anesthesia

All procedures were performed under combined spinal and epidural anesthesia.

Graft harvest

Hamstring graft harvest

A 2-3 cm longitudinal incision was made over the pes anserinus, roughly 4-5 cm below the joint line. The sartorial fascia was incised, and the semitendinosus and gracilis tendons were identified, freed of their distal fascial bands and muscular slips using a combination of sharp and blunt dissection, and released distally. Each tendon was then harvested proximally using a closed tendon stripper, whipstitched at both ends with number 5 Ethibond, and quadrupled to the required diameter on the graft-preparation board.

Peroneus longus tendon harvest

A longitudinal incision of approximately 2-4 cm was made just proximal to the lateral malleolus over the course of the peroneal tendons. The peroneal tendon sheath was carefully opened, and the peroneus longus tendon is identified and separated from the adjacent peroneus brevis tendon. To preserve ankle function, the distal end of the peroneus longus tendon was sutured to the peroneus brevis tendon using non-absorbable sutures (tenodesis). The peroneus longus tendon was then divided proximal to the tenodesis site, and a tendon stripper was advanced proximally to harvest the required length of tendon.

Graft presoaking protocol

Both groups underwent an identical soaking sequence, differing only in the antibiotic used. In group 1, the vancomycin soak solution was prepared by dissolving a 500 mg vial of vancomycin in an appropriate volume of sterile normal saline. In group 2, the gentamicin soak solution was prepared from a 40 mg/2 ml ampoule diluted in sterile normal saline.

In both groups, sterile gauze swabs were saturated in the freshly prepared solution and the graft was wrapped tightly in the impregnated gauze for approximately ten minutes while tunnel drilling proceeded in parallel, so that the soaking step did not add to overall operative time. Immediately before insertion, each graft was rinsed with sterile saline to clear residual antibiotic solution from its surface.

Tunnel preparation and fixation

Tibial and femoral tunnels were drilled arthroscopically using standard anatomical landmarks, and grafts in both groups were fixed with bioabsorbable interference screws on the femoral and tibial sides.

Postoperative protocol

Both groups followed an identical postoperative antibiotic and rehabilitation pathway, progressing from protected weight-bearing and range-of-motion exercises in the first days to jogging by three months and a graded return to sport by six months.

Outcome definitions

A postoperative deep knee infection was defined as either (i) a positive culture on aspiration of a painful knee, or (ii) a negative culture with a rising or persistently elevated CRP together with a synovial white cell count of 15,000 cells/ μ l or higher in a painful effusion, in the absence of hemarthrosis. Functional recovery was assessed using the IKDC subjective knee form preoperatively and at three and six months postoperatively.

Statistical analysis

Data were entered in Microsoft Excel and analysed in SPSS version 21. Categorical variables are reported as frequencies and percentages, and continuous variables as means with standard deviations. Group comparisons were tested for statistical significance, with $p < 0.05$ taken as the threshold.

RESULTS

Overall demographics. Of the 80 patients enrolled, 52 were male and 28 females. Group 1 (vancomycin, $n=40$) comprised 24 men and 16 women, and group 2 (gentamicin, $n=40$) comprised 28 men and 12 women, together accounting for the overall totals of 52 men and 28 women across the cohort.

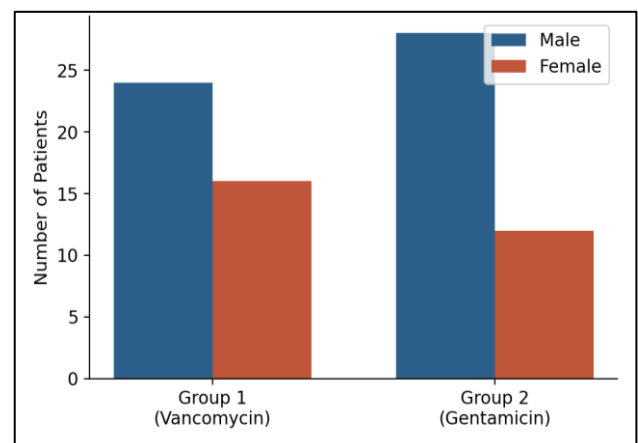


Figure 1: Sex distribution by treatment group.

Side of injury

Across the cohort, the left knee was affected more often than the right (44 versus 36 cases).

Mechanism of injury

Non-contact injury was the leading mechanism (45 cases), followed by road traffic accidents (20 cases) and sport-related injury (15 cases).

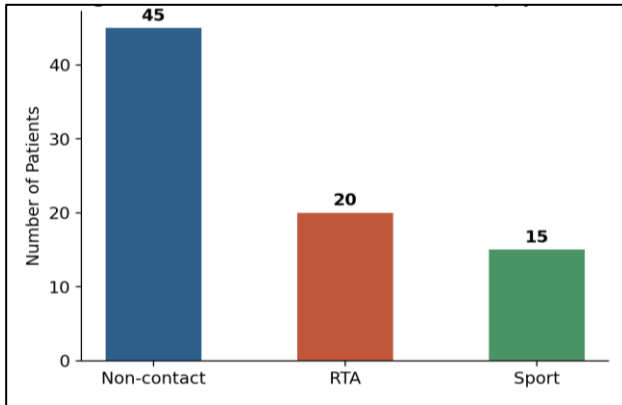


Figure 2: Distribution of mechanism of injury across the cohort (n=80).

Infection outcome

A single deep knee infection occurred across the entire 80-patient cohort, and it occurred in a patient from group 2 (gentamicin). This corresponds to an infection rate of 0% (0/40) in group 1 (vancomycin) and 2.5% (1/40) in group 2 (gentamicin). No infections were recorded in the vancomycin group during the follow-up period. This difference was not statistically significant (Fisher's exact test, $p=1.0$).

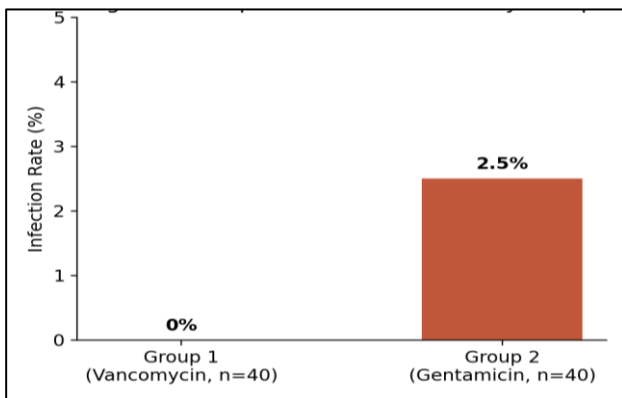


Figure 3: Deep knee infection rate by treatment group (Fisher's exact test, $p=1.0$).

Functional outcome

Across the combined cohort, the mean IKDC score improved from 34 ± 3.1 preoperatively to 54 ± 2.6 at three months and 93.5 ± 1.5 at six months, representing a substantial and progressive recovery of subjective knee function in both groups over the study period. The greatest single increment in score occurred between the three- and

six-month assessments, consistent with the expected pattern of knee-function recovery following ACLR, in which early gains are limited by protected rehabilitation and swelling while later gains reflect maturation of the graft and return of confidence in the operated limb. No patient in either group required a delay in the standard rehabilitation timeline, and the single infected patient in group 2 was managed without graft removal, allowing continuation along the same functional-recovery pathway as the rest of the cohort.

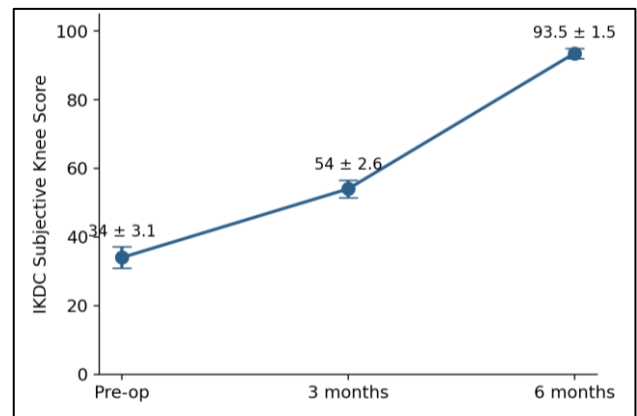


Figure 4: Combined IKDC subjective knee score across follow-up (mean ± SD).

DISCUSSION

Infection after ACL reconstruction

General considerations. Septic arthritis following ACLR remains an uncommon but disproportionately costly complication, with published incidence figures generally sitting between 0.1% and 1.8% depending on the graft and prophylaxis protocol used.^{6,7} The organisms responsible are overwhelmingly skin commensals- coagulase-negative *Staphylococci* and *S. aureus*- introduced at the point of graft harvest and handling rather than through the arthroscopic portals, and their capacity to form biofilm on tendon and suture material makes established infection difficult to eradicate without surgical debridement.^{8,19} This biological reality, more than any single surgical error, is what has pushed the field toward treating the graft itself rather than relying on systemic prophylaxis alone.

Graft choice and the rationale for topical antibiotics

Hamstring autograft, used in the majority of cases in this series, has been repeatedly shown across registries and pooled analyses to carry a modestly higher infection risk than bone-patellar tendon-bone graft, a difference generally attributed to the proximity of the harvest site to the tibial tunnel and to a somewhat higher rate of graft contamination at harvest.^{4,5} Because intravenous antibiotics achieve poor tissue levels within avascular tendon, direct application of an antibiotic to the graft surface- rather than expecting the bloodstream to do the

work- has become the more biologically rational approach, and this is the premise both arms of the present study were built around.¹⁰

Vancomycin-soaked grafts in the literature

Vancomycin has the deepest evidence base for graft presoaking. Vertullo et al described a technique using vancomycin-pres soaked hamstring grafts and reported a marked reduction in postoperative infection compared with historical controls.¹¹ Offerhaus et al, in a cohort of 1,779 ACL reconstructions followed for 28 months, found the deep infection rate fell from 2.4% with intravenous prophylaxis alone to 0% once vancomycin-soaking was introduced, without any increase in graft failure or arthrofibrosis.¹² Pérez-Prieto et al demonstrated that graft contamination detected at harvest- present in a meaningful proportion of specimens- could be reliably eradicated by vancomycin soaking before implantation.⁹ Phegan et al reported no infections at all across 1,300 ACL reconstructions using vancomycin-pres soaked hamstring grafts, and a subsequent systematic review and meta-analysis by Naendrup et al confirmed a consistent reduction in septic arthritis across the pooled vancomycin literature.^{13,14} A large single-centre review of 1,640 cases by Baron et al similarly found infection rates falling from 1.2% to 0.1% with the introduction of intraoperative vancomycin soaking.¹⁵ Taken together, this body of work represents one of the more consistent findings in ACLR infection-prevention research.

Gentamicin-soaked grafts in the literature

The gentamicin-specific literature is smaller but points in the same direction. Moriarty et al., in what the authors describe as the first study to specifically examine gentamicin pre-soaking of hamstring grafts, found no cases of septic arthritis among gentamicin-soaked grafts compared with a 0.85% rate in saline-soaked controls, a statistically significant difference.¹⁶ Yazdi et al took a different approach, adding gentamicin to the arthroscopic irrigation fluid rather than soaking the graft directly, and did not find a statistically significant reduction in septic arthritis- a result that suggests direct graft contact, rather than dilute intra-articular exposure, may be what drives gentamicin's protective effect.¹⁷

Head-to-head and pooled antibiotic-soaking evidence

Comparative data pitting the two agents directly against one another remain limited, which is precisely the gap this study aimed to address. Bansal et al compared vancomycin- and gentamicin-pres soaked hamstring grafts in 578 patients and found closely matched, low infection rates in both groups with no statistically significant difference between them, concluding that either antibiotic is a reasonable choice for graft presoaking.¹⁸ Broader reviews of antibiotic-soaking technique as a category-spanning vancomycin, gentamicin, and occasionally tobramycin- have consistently found the approach safe,

with no clear evidence of increased chondrotoxicity or antibiotic resistance at the concentrations used clinically, though the same reviews note that most of the supporting evidence remains retrospective rather than randomised.^{15,20}

Comparing our infection rates with the published literature. The findings of this study sit comfortably within, and in some respects favourably compared with, the ranges reported above. Group 1 (vancomycin) recorded zero infections among 40 patients, consistent with the near-zero rates reported by Offerhaus, Phegan, and Baron et al for vancomycin-soaked cohorts.^{11-13,15} Group 2 (gentamicin) recorded one infection among 40 patients (2.5%), a figure numerically higher than the 0% reported by Moriarty et al for gentamicin-soaked grafts, though this difference did not reach statistical significance ($p=1.0$), reflecting the limited power of a single-event outcome in a sample of this size rather than true equivalence between the two agents, and the very small denominator in both studies means a single additional or absent case can shift the percentage considerably; the difference should not be over-interpreted as evidence that one antibiotic is superior to the other.¹⁶ Taken together with the comparable, low infection rates reported by Bansal et al when the two agents were compared directly, our results are broadly consistent with the position that both vancomycin and gentamicin are effective graft-pres soaking agents, and that the choice between them can reasonably be guided by local cost, availability, and allergy profile rather than by a clear efficacy advantage of one over the other.¹⁸ Functional recovery. The steady rise in IKDC scores across the follow-up period- from a markedly limited baseline to a near-normal score by six months- mirrors the functional trajectories reported in the wider graft-pres soaking literature, including series comparing vancomycin and gentamicin directly, none of which found a significant difference in functional outcome between the two antibiotics.^{16,18} This is reassuring from a practical standpoint: whichever agent a unit chooses to adopt, it does not appear to compromise graft incorporation or the patient's subjective recovery of knee function.

This study carries several limitations. The sample size of 40 patients per arm is modest, and given how uncommon deep ACLR infection is in absolute terms, a single infection in either direction can meaningfully shift the reported percentage- a study adequately powered to detect a true difference between antibiotics would require a substantially larger cohort. The six-month follow-up period is relatively short and may not capture late presentations of infection or graft failure. The design was observational rather than randomized, with antibiotic allocation determined by unit protocol during the study period rather than by randomization, which introduces the possibility of unmeasured confounding between the two groups. Finally, the IKDC functional outcome was analyzed for the cohort as a whole rather than broken down separately by group in this dataset, which limits our ability

to comment on any group-specific difference in functional recovery.

CONCLUSION

In this comparative series of 80 patients undergoing primary ACL reconstruction, both vancomycin- and gentamicin-soaked hamstring autografts were associated with a low rate of deep knee infection- 0% in the vancomycin group and 2.5% in the gentamicin group-alongside a substantial and progressive improvement in IKDC-based functional outcome across six months. These findings support either antibiotic as a reasonable, inexpensive adjunct to standard intravenous prophylaxis during ACL reconstruction. Larger, ideally randomized, comparative studies are needed before either agent can be recommended over the other with confidence.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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