ICM ON OPEN INJURIES – CONSENSUS RECOMMENDATION DOCUMENT

Group: Dr Vikas Agashe, Dr Aditya Menon

RQ 1: Should cultures be obtained prior to every stage of reconstruction?

Section 1: Background (<300 words)

Open fractures carry a well-recognised risk of bacterial contamination, with positivity rates at initial presentation ranging from 15% to 68.3% in the studies reviewed. What remains far less certain is whether obtaining cultures at each stage of reconstruction —presentation, initiation of debridement, at wound reassessment, and at the time of closure — provides information that meaningfully changes management or improves outcomes. The routine practice of staged culturing has become embedded in many major centres, yet its evidence base is narrower than is often assumed.

What the literature does tell us: concordance between organisms identified on early cultures and those subsequently isolated from established infection is strikingly low in most series (3.3–5.7%), with the important exception of settings where patients present late and have had no pre-hospital wound care, where predictive values approaching 91% have been reported. Deep-tissue cultures obtained at the time of clinically suspected surgical site infection (SSI) are highly reliable (positivity 96.7%). Additionally open fractures are disproportionately associated with polymicrobial and Gram-negative organisms — findings with direct implications for empiric antibiotic choice.

What remains unresolved: whether routine surveillance cultures at each surgical stage alter antibiotic selection in a way that reduces infection, or whether the predominant infecting organisms — many of them nosocomial, multidrug-resistant Gram-negatives — could not have been predicted at any early stage regardless. The answer appears to depend significantly on the clinical setting, injury-to-treatment interval, and local microbiological ecology.

Section 2: Data extraction table

For each included study: Author/Year/Country, Study Design, Sample Size, Population, Culture Timing/Groups Compared, and Key Results.

S.no	Author, year, Country	Study Design	Sample Size	Population (Inclusion/Exclusion)	Groups Compared / Culture Timing	Key Results
1	Mangala et al., 2018, India	Prospective observational	n=100	Compound fractures of long bones; sequential swabs/tissue specimens submitted to microbiology	Pre-debridement vs debridement culture vs postoperative culture	Pre-debridement culture positive in 15%; debridement culture positive in 41%. Sensitivity of pre-debridement culture for

						postoperative infection = 21% (specificity 88%); sensitivity of debridement culture = 69% (specificity 77%). Debridement cultures better predicted the infecting organism.
2	Polmear et al. (PREP-IT),	Secondary analysis of 2	n=484 SSI cases	Patients with diagnosed surgical site infection (SSI)	Deep/organ-space culture at time of	Culture positivity 96.7% overall

	2025, Multinational (USA, Canada, Spain)	multicentre RCTs	(281 open, 203 closed fractures)	following operative fracture fixation; deep/organ-space cultures taken at time of SSI diagnosis	clinically diagnosed SSI; open vs closed fracture comparison	(97.2% open vs 96.1% closed, p=0.507). 43.3% polymicrobial overall; open fractures more often polymicrobial (47.8% vs 36.8%, p=0.029) and Gram-negative (50.4% vs

						37.4%, p=0.011). Gram-negative SSIs had shorter median time-to-infection (46 vs 70 days).
3	Sitati et al., 2017, Kenya	Prospective cohort	n=98	Open fractures presenting within 24h; pre-debridement swabs taken in A&E; 14-day follow-up	Pre-debridement (within 24h of injury) vs post-debridement cultures at infection	Pre-debridement culture positive in 52.2%. Infection rate at 14 days = 58.9%. Only 3/51 (5.7%) pre-

						debridement isolates matched the post-debridement infecting organism. Odds ratio of positive pre-debridement culture predicting infection = 1.86 (95% CI 0.82-

						4.21, not significant).
4	Hao & Peng, 2021, China	Retrospective cohort	n=61 infected cases (of 193 open fractures)	Open fractures who developed postoperative infection; samples taken after debridement and after infection. Excluded: non-infected cases	Post-debridement culture vs culture obtained at time of confirmed infection	Post-debridement culture positive in 14/61 (22.9%). Concordance between post-debridement and infection isolates = 2/61 (3.3%). 91.3% of infection isolates

						were Gram-negative (Acinetobacter baumannii 49.3%); 60.8% were multidrug-resistant.
5	Abel et al., 2024, India (CMC Vellore)	Prospective cohort	n=231 patients / 275 open fractures (Gustilo III only)	Open Grade III fractures of femur/tibia/fibula; deep intraoperative cultures sent on clinical suspicion of infection. Excluded: primary amputations, index surgery elsewhere	Deep intraoperative culture at clinical suspicion of SSI; culture-positive vs culture-negative; MDR-GNB vs non-MDR-GNB	Clinical suspicion of infection in 36.4%; culture positive in 51.2% of these (55.8% Gram-

						negative). MDR-GNB infection in 8.2% of all patients (44.1% of culture-positive infections). MDR-GNB infection: significantly more additional surgeries (2.2 vs 0.8, p<0.0001); lower return-to-

						work at 9 months (5.3% vs 30.7%, p=0.03).
6	Lingaraj et al., 2015, India	Prospective pilot study	n=32	Open fractures presenting within 24h; antibiotic-naive at presentation; minimum 6-month follow-up	Predebridement swab vs postoperative wound infection at 48h and follow-up	Predebridement culture positive in 18/32 (56%); 14/32 (44%) developed postoperative infection. No patient's infecting organism matched the

						predebridement isolate. Predebridement contamination did not predict postoperative infection (McNemar p=0.523).
7	D'Souza et al., 2008, India	Prospective cohort	n=108	Open tibial fractures; no other site of infection; antibiotic-naive at presentation. Excluded: prior antibiotics or surgery	Pre-debridement vs post-debridement qualitative culture swabs; correlation with subsequent infection	Predebridement culture: sensitivity 83%, specificity 71%, odds ratio 12.5.

						Postdebridement culture: sensitivity 42%, specificity 87%, odds ratio 4.7. Both have a role; predebridement cultures more sensitive, postdebridement more specific.
8	Lenarz et al., 2010, USA	Prospective protocol-based cohort	n=422 open fractures	All open extremity fractures managed at a Level I trauma centre; serial post-	Serial post-debridement culture-guided timing of wound closure (closure	Overall deep infection rate 4.3% (Type II 4%;

			(346 with long-term follow-up)	debridement cultures obtained after each debridement until culture-negative	withheld until two consecutive negative cultures)	IIIA 1.8%, IIIB 10.6%, IIIC 20%). 24 wounds closed with positive cultures (protocol breach); 2 developed deep infection (p=0.0501).
9	Palmer et al., 2014, USA	Prospective cohort	n=34 long-bone	Patients undergoing revision surgery for long-bone nonunion (12 open,	Conventional intraoperative culture vs molecular	Routine culture positive in 8/34 (23.5%). Ibis

			nonunions	20 closed); intraoperative tissue/hardware/membrane samples	diagnostics (Ibis PCR-MS) + FISH confirmation	identified bacteria in 30/34 (88%), confirmed by FISH. Of 30 Ibis-positive cases, 22 were culture-negative, demonstrating substantial under-detection of biofilm organisms by

						conventional culture.
10	Al Kindi et al., 2024, Oman	Retrospective cohort (n=166) + pooled literature review (n=539)	n=640 Gustilo II/III (pooled)	Open Gustilo II/III fractures with post-debridement cultures taken; minimum 6-month follow-up. Excluded: delay >48h to surgery, no follow-up, amputation at index admission	Post-debridement screening culture followed by culture-guided antibiotics/debridement if positive	Post-debridement cultures positive in 59/640 (9.2%); of these, only 4 (6.8%) developed deep infection with the same organism after culture-guided treatment. Of

						remaining 581, 72 (12.4%) still developed deep infection despite negative screening (81.8% of all infections occurred despite negative screening).
11	Ojo et al., 2010, Nigeria	Prospective cohort	n=60	Open fractures presenting to a resource-limited hospital (mean delay 5.45h;	Superficial swab at presentation vs swab at established infection	Initial culture positive in 41/60 (68.3%);

				range 15 min-21h); superficial swabs at presentation and at infection. Excluded: prior antibiotics, prior debridement		11/60 (18.3%) developed infection, all polymicrobial. In 10/11 (90.9%), the infection isolate included an organism from the initial swab. Mean injury-to-presentation interval significantly

						longer in infected wounds (15.2h vs 2.9h, p<0.01). Predictive value ~91%.

Section 3: Results summary write-up (upto 500 words)

Eleven studies were reviewed, comprising eight prospective cohorts (Mangala et al.; Sitati et al.; Lingaraj et al.; D'Souza et al.; Ojo et al.; Abel et al.; Lenarz et al.; Palmer et al.), two retrospective cohorts (Hao & Peng; Al Kindi et al.), and a secondary analysis of two multicentre randomised trials (Polmear et al., PREP-IT).

Pre-debridement (admission) cultures: Positivity rates ranged widely, from 15% (Mangala et al.) to 68.3% (Ojo et al.), reflecting differences in injury-to-presentation intervals and pre-hospital care. Where patients reached hospital early,

pre-debridement cultures were consistently poor predictors of infection — sensitivity of just 21% in Mangala et al., no association in Lingaraj et al. (p=0.523), and only 3.3% concordance with infecting organisms in Hao & Peng. In the Nigerian cohort of Ojo et al., where patients presented late (mean 15.2h in those who became infected vs 2.9h in those who did not, p<0.01) with wounds exposed and without pre-hospital care, predictive value approached 91%. However, Sitati et al., working in a similarly resource-limited East African setting, found only 5.7% concordance — confirming that delayed presentation alone does not reliably confer predictive value.

Debridement and post-debridement cultures: Cultures taken at debridement performed better than pre-debridement swabs. Mangala et al. found debridement cultures had a sensitivity of 69% versus 21% for pre-debridement specimens. D'Souza et al. found pre-debridement cultures were more sensitive (83%, OR 12.5) while post-debridement cultures were more specific (87%, OR 4.7). Al Kindi et al., in a pooled analysis of 640 Gustilo II/III fractures, found only 9.2% positivity in post-debridement screening; however, when positive cultures were treated with targeted antibiotics and further debridement, only 4/59 (6.8%) went on to develop deep infection with the same organism. In contrast, 72 of 581 fractures with negative post-debridement screening (12.4%) still developed infection — demonstrating that a negative screen does not exclude subsequent nosocomial infection. Lenarz et al.'s protocol of

repeated debridement with closure deferred until consecutive negative post-debridement cultures yielded an overall infection rate of 4.3% (IIIA 1.8%, IIIB 10.6%, IIIC 20%).

Cultures at established infection: Polmear et al. (PREP-IT, n=484 SSI cases) found deep/organ-space cultures positive in 96.7% of cases, with open fractures significantly more likely to be polymicrobial (47.8% vs 36.8%, p=0.029) and Gram-negative (50.4% vs 37.4%, p=0.011) than closed fractures. Palmer et al. identified a fundamental limitation of conventional culture: in 34 patients with long-bone nonunions, routine culture detected bacteria in only 23.5% of specimens versus 88% by molecular (Ibis PCR-MS) diagnostics confirmed by fluorescence in situ hybridisation (FISH), implying that biofilm-associated organisms are substantially missed by standard culture at any stage.

Section 4: Discussion (<1000 words)

Taken across these 11 studies, the evidence does not support routine cultures at every stage of reconstruction as a universal policy — but it does not dismiss a role for cultures altogether. The picture is more nuanced, and the key is understanding what different cultures at different timepoints actually tell us.

It is perhaps not surprising that pre-debridement swabs have generally failed to predict the eventual infecting organism in most series. Open fracture wounds, by the time they reach a theatre in a tertiary centre, have often already been irrigated, dressed, and exposed to prophylactic antibiotics. The bacteria identified on early swabs are therefore frequently contaminants — organisms present on the surface of a wound at a snapshot in time — not the pathogens that will later establish deep infection. The evidence from Lingaraj et al. (no predictive association, p=0.523), Hao & Peng (3.3% concordance), and Mangala et al. (sensitivity 21%) makes this point clearly. Where pre-debridement cultures do appear to have value — as in the series by Ojo et al. (predictive value ~91%) — the context is very different: late-presenting patients with heavily contaminated, unprotected wounds, in a resource-limited setting where the initial flora has had time to establish rather than being disrupted by early intervention. Even this, however, is not reproduced consistently — Sitati et al., working in comparable circumstances, found only 5.7% concordance.

The picture shifts when we look at cultures taken at the time of debridement and beyond. Here, cultures are being taken not to screen for what might happen, but to understand what is already happening in the wound environment. Mangala et al. and D'Souza et al. both demonstrate improved sensitivity and specificity at this stage compared with pre-debridement swabs. More importantly, Lenarz et al. and Al Kindi et al. suggest that post-debridement cultures,

when positive, serve a practical purpose: they can guide antibiotic selection, prompt further debridement, and inform the decision on when it is safe to close. In Al Kindi et al.'s pooled cohort, targeted management of culture-positive wounds resulted in deep infection in only 6.8% — a meaningful benefit in a condition where infections carry enormous morbidity.

The PREP-IT data (Polmear et al.) underline a separate but important point: deep-tissue cultures obtained once infection is clinically suspected are highly informative (96.7% positivity), and their results directly affect treatment. Open fractures, in particular, are disproportionately associated with polymicrobial and Gram-negative infections, with Gram-negative SSIs presenting earlier and behaving more aggressively. The argument for obtaining cultures at this stage is unambiguous.

Finally, the work of Palmer et al. introduces a sobering limitation: even with optimal culture technique, conventional microbiology misses a substantial proportion of bacteria, particularly those growing in biofilm. In their series, molecular diagnostics identified bacteria in 88% of specimens that were negative on routine culture. This does not invalidate culturing, but it does counsel against over-interpreting a negative result at any stage of reconstruction.

In summary, the evidence supports a tiered, indication-driven approach to cultures in open fracture reconstruction, rather than blanket culturing at every stage. Cultures at or after debridement, when combined with appropriate clinical judgement and targeted management of positive results, appear to offer genuine benefit. Deep-tissue cultures at clinical suspicion of SSI are essential. Routine pre-debridement screening, on the other hand, should be reserved for settings with substantially delayed presentation and limited pre-hospital intervention.

A point that perhaps deserves more emphasis in clinical discussions about culturing is that a positive culture is not, in itself, the problem. The organisms cultured from a wound do not cause infection by themselves. Infection develops when contamination is allowed to persist in a biologically compromised environment. The surgeon's task is therefore not merely to identify bacteria and initiate appropriate antibiotics, but to repeat debridement and convert a contaminated wound into a healthy, vascularised, mechanically stable environment. Culture results, at their best, inform this process — they do not replace it.

Section 5: Risk of bias of included studies

MODERATE to HIGH overall. Nine of eleven studies are single-centre prospective or retrospective cohorts or pilot studies with small sample sizes (n=32–108), with significant heterogeneity in culture technique (superficial swab vs deep tissue biopsy vs intraoperative swab), culture timing, and definitions of infection. Two studies are retrospective (Hao & Peng; Al Kindi et al. institutional cohort). Palmer et al., though methodologically innovative, is limited by a small nonunion cohort (n=34) with limited applicability to the acute open fracture setting. The PREP-IT analysis (Polmear et al.) is the most methodologically robust — multicentre, RCT-derived, n=484, with predefined CDC SSI criteria — and is judged LOW-to-MODERATE risk of bias; however, it specifically addresses cultures at established infection rather than staged surveillance, and therefore does not directly answer the primary question.

Section 5: Response/Recommendation

Routine cultures prior to every stage of reconstruction are not recommended as a blanket policy. The available evidence does not support pre-debridement swabs as a reliable predictor of subsequent infection in settings with

early patient presentation. Cultures obtained at or after debridement carry clinical value when positive, as they can guide antibiotic selection, direct further surgical debridement, and inform the timing of wound closure, and should be considered — particularly in Gustilo III injuries. Deep-tissue cultures must always be obtained when infection is clinically suspected. In resource-limited settings with substantially delayed presentation and absent pre-hospital wound care, initial cultures may carry additional predictive value and are reasonable to obtain.

Section 6: Level/strength of Evidence:

LOW.

The evidence base comprises predominantly Level III–IV observational studies (prospective and retrospective cohorts, pilot studies, one diagnostic comparative study), with small sample sizes in most series (n=32–108), substantial heterogeneity in culture timing, sampling technique, and infection definitions, and directly conflicting findings regarding the predictive value of early cultures even within similar resource settings (Ojo et al. vs Sitati et al.). The one larger multicentre analysis (Polmear et al., PREP-IT, n=484) addresses a related but distinct question — cultures at

established infection — and raises the overall rating to LOW rather than VERY LOW, but does not resolve the central question of staged surveillance culturing during reconstruction.

References

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