CONSENSUS RECOMMENDATION

In severe open tibial fractures, should 72 hours be used as the cut-off between early and delayed soft-tissue coverage?

Section 1: Background

Severe Gustilo-Anderson grade III open tibial fractures require coordinated orthopaedic and plastic surgical care because infection, non-union, flap failure and limb loss are linked to debridement quality, skeletal stability and timely vascularised soft-tissue coverage. The traditional 72-hour target as envisaged by Godina in 1986 derives from early ortho-plastic and microsurgical experience and remains a useful benchmark. However, the literature shows heterogeneity in definitions of "early". Some studies use immediate or same-sitting reconstruction while others use 72 hours, 5 days, 7 days, 10-12 days or continuous delay. Modern negative-pressure wound therapy (NPWT/VAC), staged ortho-plastic protocols and specialist trauma networks have modified the older timing question of 72 hours, but they have not removed the principle that unnecessary delay worsens outcomes. Ganga Hospital guidance supports selective primary closure when the wound is clean, viable and tension-free, but warns against closure in high-energy, contaminated, ischemic, crushed or skin-deficient wounds. Most data are retrospective cohort series which are confounded by injury severity, transfer delay and patient physiology, therefore recommendations need a consensus.

Section 2: Data extraction table

For each included study: author/year, design, sample size, population, intervention/comparator, key outcomes, results and follow-up duration. Follow-up is recorded where available in the consensus source.

S.no	Author, year, country/setting	Study design	Sample size	Study population	Groups/intervention compared	Results / key outcomes
1	Mathews et al., 2015, UK	Retrospective review	73 patients; 74 GA grade III open tibial fractures	Open tibial fractures managed in an orthoplastic centre	Single-stage definitive fixation plus coverage vs staged fixation/coverage; <72h vs >72h	Single-stage surgery had lower deep infection (4.2% vs 34.6%, p<0.001). Completing surgery within 72h showed no infection benefit (20% vs 12.2%, p=0.492). Ortho-plastic process appeared more important than the 72h target.
2	Pincus et al., 2019, North America/TQIP	Large multicentre propensity-matched cohort	672 patients	Open lower-limb fractures requiring flap coverage across trauma centres	Flap coverage <=7 days vs >7 days	Delay >7 days increased complications (16.7% vs 6.2%, p<0.001; NNH=10). Approx. 40% increased risk per additional week
3	Zamorano et al., 2025, Chile	Single-centre retrospective cohort	41 patients	Selected young/healthy GA IIIB patients	Coverage before vs after ROC-derived timing threshold	Optimal cut-off <12 days. No FRI in 10 patients covered within 12 days vs 56.6% beyond 12 days; early coverage still described as gold standard.
4	Hou et al., 2011, USA	Retrospective cohort	32 GA IIIB patients	GA IIIB fractures initially treated with VAC	Coverage <=7 days vs >7 days after VAC bridge	Infection significantly higher with coverage >7 days. VAC reduced flap size/free flap need, but prolonged VAC >1 week increased infection/amputation risk.
5	Shammas et al., 2018, USA	Retrospective database analysis	3,297 patients	Patients undergoing flap coverage after open lower-extremity trauma	Predictors of time to flap	Mean time to flap 230h (~9.6 days). Delays predicted by fixation timing, number of debridements and non-clinical factors including region, insurance, race and age; supports organised ortho-plastic pathways.

S.no	Author, year, country/setting	Study design	Sample size	Study population	Groups/intervention compared	Results / key outcomes
6	Steiert et al., 2009, Germany	Retrospective series	43 open extremity fractures; mostly IIIB	Late-referred extremity fractures reconstructed beyond 72h	VAC bridge and delayed free flap reconstruction	Mean definitive closure 28 days. Free flap failure 1/38 (2.6%). Authors argued delayed reconstruction can be acceptable with modern VAC and damage-control orthopaedics.
7	Lee et al., 2021, Korea	Retrospective cohort with ROC analysis	46 GA IIIB/IIIC patients	Patients managed with NPWT before free flap	Timing thresholds for complications	ROC cut-offs varied by outcome: revision ~10 days, flap complications 33 days, bony complications/osteomyelitis 91 days. Suggests outcome-dependent thresholds with NPWT.
8	Kamath et al., 2012, India	Retrospective/clinical series	151 GA type IIIB cases	Open tibial type IIIB wounds treated with local/regional flaps	Coverage <10 days vs 10 days-6 weeks vs >6 weeks	Deep infection: 16.5% (<10d), 55.3% (10d-6w), 41% (>6w). Authors recommended flap coverage ideally within first 5 days.
9	Rajasekaran et al., 2014, India	Review/validated scoring framework	Not applicable; based on GHOIS experience	GA IIIB injuries stratified by skin, bone and musculotendinous injury	GHOIS-guided salvage, reconstruction timing and closure criteria	Skin score 1-2/no skin loss may allow primary closure if bleeding margins appose without tension and total score is low; skin score >=3 needs flap. GHOIS guides salvage vs amputation.
10	Gopal et al., 2004, UK	Functional outcome follow-up	33 patients; 34 GA IIIB-IIIC fractures	Severe open tibial fractures treated by fix-and-flap	Early muscle flap coverage; timing categories <24h, 24-72h, >72h	Mean union 41 weeks; deep infection 6.1%; all limbs salvaged. Earlier flaps had faster union and fewer infections in internal breakdown.
11	Nambi et al., 2017, India	Prospective/clinical series	22 GA IIIA/B fractures	Non-degloving open fractures	Single-stage reamed IM nail plus ipsilateral fasciocutaneous flap within 8-14h	Mean union 16 weeks; infection requiring secondary procedure 9%; 100% limb salvage.
12	Nishida et al., 2024, Japan/Korea	Small retrospective series	10 GA IIIB cases	Severe open fractures where immediate fix-and-flap was impractical	Definitive fixation followed by staged ALT free flap; median flap 7.5 days from injury	All flaps survived; no deep infection; all fractures united. Supports planned staged care in selected/polytrauma patients.
13	Chua et al., 2014, Singapore	Retrospective comparative study	89 GA IIIB/IIIC fractures	Severe open tibial fractures	Flap coverage <=72h (n=30) vs >72h (n=59)	Early coverage reduced stay (31 vs 56 days), deep infection (23% vs 54%) and operations; no difference in union time, amputation or secondary union procedures. Late group had more associated injuries.
14	Wagels et al., 2015, Australia	Retrospective series	251 flaps in 235 patients	Lower-limb trauma reconstructions	Timing, NPD use, contamination, flap type	Outcomes improved despite fewer reconstructions within one week as NPD use rose. Poor outcome predicted by contaminated distal fracture, longer delay and complete flap failure; delay likely confounded by severity/logistics.
15	Small & Mollan, 1992, UK	15-year retrospective series	168 fractures	Open tibial fractures over historical treatment eras	Historical late coverage vs earlier free muscle flaps	Shift from mean 2.8-month coverage to 4-day coverage. Free-flap failures concentrated in chronic/late wounds; authors favoured muscle flaps and rejected skin grafting as primary cover.

S.no	Author, year, country/setting	Study design	Sample size	Study population	Groups/intervention compared	Results / key outcomes
16	Moda et al., 1994, India	Prospective protocol series	60 type III tibial fractures	Open type III tibial fractures	External fixation, second look at 48-72h and flap at 5-7 days	Union 23.6 weeks; stay 3.5 weeks; 100% salvage; no major complications. Supports planned 5-7 day coverage after repeat debridement.
17	Webb et al., 2007/LEAP, USA	Prospective subgroup analysis	156 limb-threatening type-III tibial fractures	LEAP limb salvage/amputation cohort	Timing of debridement/coverage/bone grafting and fixation choices	Timing of debridement (<6h vs 6-24h), coverage (<=3d vs >3d) and grafting had no measurable outcome effect; fixation method and injury severity were more important. Follow-up 2-7 years.
18	Rajasekaran, 2007, India	Prospective	510 type III injuries; 173 primary closures	Selected type III open injuries without skin loss	Primary closure under strict criteria	~91% uneventful recovery; 9.1% infection. Criteria include debridement <12h, no skin loss, tension-free approximation, no severe contamination, satisfactory debridement, no vascular insufficiency.
19	Choudry et al., 2008, USA	Retrospective 15-year series	65 GA IIIB midshaft tibia fractures	GA IIIB midshaft tibial fractures	Soleus vs free flap; acute <1 week vs delayed >1 week	Delayed coverage associated with higher nonunion (42% within 1 week vs 74% beyond). Flap type made little difference when early; bony injury severity was important.
20	Hertel et al., 1999, Switzerland	Comparative cohort	29 grade 3B/3C lower-leg fractures	Severe open lower-leg fractures	Immediate day-0 reconstruction vs delayed mean 4.4 days	Immediate coverage had lower infection fewer operations, faster union (5.6 vs 11.6 months) and faster weight-bearing.
21	Liu et al., 2012, UK/trauma centre	Retrospective cohort	103 patients; 105 free flaps	Open lower-limb fractures requiring free flap	Coverage <3d, 4-7d, >7d; metalware exposure duration	Coverage within 3 days and immediate coverage of exposed metalware optimised outcomes. Delay >7d sharply increased flap take-back, deep metal infection and osteomyelitis. NPWT was bridge only.
22	Gopal et al., 2000, UK	Retrospective	84 GA IIIB/IIIC fractures	Severe open tibial fractures	Radical debridement, fixation and early muscle flap; immediate/early/late	95% limb salvage; 3.5% flap failure. Deep infection rose from 6% immediate to 10% <72h and 30% >72h; favoured internal fixation.
23	Karanas et al., 2008, USA	retrospective	14 reconstructions	Delayed severe lower-extremity wounds	Aggressive debridement, VAC, CT angiography, anastomosis outside injury zone	Average time to flap 22 days; no flap losses; one late osteomyelitis. Supports selected safe delayed microsurgery with modern adjuncts.
24	Byrd et al., 1981, USA	Prospective protocol/historical comparison	20 type III/IIIa fractures	Type III open tibial fractures	External pin fixation plus muscle/musculocutaneous flap within 5 days	5% complication rate vs historical 30%; established early conversion of open injury to closed vascularised wound.
25	Olesen et al., 2015, Denmark	Retrospective	45 open tibial fractures	Open tibial fractures requiring free flap	Coverage <=7 days vs >7 days	Infection rose from 27% to 60% when coverage delayed beyond 7 days; smoking and high-energy trauma also predicted complications.
26	Hammer et al., 1992, Sweden	Prospective	37 type III tibial fractures	Type III tibial injuries	Early 1-3d cover for exposed neurovascular/joint structures; otherwise 4-7d	Emphasised simultaneous microvascular and orthopaedic assessment and transfer to reconstructive centres within a week.

S.no	Author, year, country/setting	Study design	Sample size	Study population	Groups/intervention compared	Results / key outcomes
27	Koltenyuk et al., 2026, USA	Nationwide database study	1,970 patients, 2015-2019	Open tibia/fibula/femur fractures requiring flap	Delay from admission/fixation to flap as continuous variable	Each extra day increased inpatient FRI odds by ~10.7% from admission and ~9.1% from fixation; argues against arbitrary early/late cut-offs.
28	Cao et al., 2022, China	Retrospective series	394 GA IIIB free-flap reconstructions	GA IIIB fractures requiring free flap	Early reconstruction (<=2 debridements, mean 6.15d) vs delayed (>2 debridements, mean 16.46d)	Early group had fewer flap complications/necrosis, shorter stay, faster wound and bone healing and better function.
29	Al-Hourani et al., 2019, UK/Bristol	Retrospective	45 GA IIIB diaphyseal fractures	GA IIIB tibial shaft fractures	Temporary internal fixation, then definitive fix-and-flap	Mean debridement 19h and definitive reconstruction 65h; timing not significantly associated with deep infection, flap failure or nonunion; underpowered/narrow early timing range.
30	Franken et al., 2010, Netherlands/Europe	Retrospective series	52 lower-leg soft-tissue defects	Acute traumatic defects and chronic osteomyelitis	Local vs free; fasciocutaneous vs musculocutaneous; <72h vs >72h	No significant difference between early and late using 72h cut-off; late group confounded by sicker patients. Musculocutaneous flaps outperformed fasciocutaneous.

Section 3: Results summary write-up

The evidence supports early definitive soft-tissue coverage but does not support 72 hours as a rigid cut-off. Classic fix-and-flap series such as Gopal, Hertel, Chua and Liu report lower infection, fewer operations, shorter stay or faster union when coverage is immediate or within 72 hours. However, several recent studies weaken the stricter 72-hour rule. Mathews found that single-stage ortho-plastic fixation and coverage, rather than the 72-hour threshold itself, was associated with lower infection. Pincus, Hou, Olesen, Choudry and Liu show the most consistent deterioration beyond approximately 7 days. Koltenyuk further reframes timing as a continuous risk. Each additional day increases infection odds rather than risk suddenly changing at one threshold. Some selected cohorts, including Zamorano, Nishida, Karanas, Steiert and Lee, report acceptable outcomes beyond 72 hours when debridement is radical, NPWT is used as a temporary bridge, fixation is stable and reconstruction is delivered by experienced ortho-plastic teams. Overall, 72 hours remains a valuable target and standard, but delay beyond 7 days is the more clinically concerning threshold unless explained by patient physiology, contamination control, transfer logistics or staged reconstruction planning.

For primary closure, the most direct evidence comes from Rajasekaran and the Ganga Hospital Open Injury Score framework. Primary closure is acceptable in selected type III injuries without skin loss after satisfactory debridement, provided wound edges are bleeding and can be approximated without tension, contamination is limited, perfusion is intact and skeletal fixation is stable. The evidence does not support a blanket prohibition on closure; instead, it supports early conversion of a clean, closable open wound into a closed wound. However, closure is unsafe when there is true skin loss, questionable viability, high-energy crush/degloving, gross organic/farmyard/sewage contamination, vascular insufficiency, severe host risk or unstable fixation.

Section 4: Discussion

Literature shows why the 72-hour question remains controversial. The early ortho-plastic literature established the principle that rapid debridement, stable fixation and vascularised soft-tissue coverage reduce the complications of severe open tibial fractures. Gopal and Hertel strongly support immediate or very early reconstruction, and Chua and Liu demonstrate measurable benefits when coverage occurs within 72 hours or before one week. These findings justify preserving 72 hours as an aspirational target, especially for exposed metalware, vascularised flap planning and trauma-network audit.

However, several factors prevent 72 hours from being a universal dividing line. First, studies define “early” differently, ranging from same-day to 12 days. Second, late cohorts are often clinically different as they include more polytrauma, contamination, transfer delay, multiple debridements and higher injury severity. Wagels, Franken, Webb and Al-Hourani illustrate how timing can become a marker of case complexity rather than an independent causal factor. Third, modern NPWT/VAC can protect the wound temporarily, although Hou and Liu caution that it must remain a bridge and cannot justify prolonged avoidable delay. Fourth, the outcome being measured matters as Lee found different thresholds for revision, flap complications and osteomyelitis, while Koltenyuk suggests a continuous dose-response rather than a discrete threshold.

A pragmatic analysis is therefore required to describe coverage timing as a continuum. Same-sitting fix-and-flap is preferred where the patient is physiologically stable and orthoplastic capacity is available. Coverage within 72 hours remains the ideal target. Coverage within 7 days is a defensible practical ceiling supported by multiple contemporary cohort studies . Beyond 7 days, risk of infection, non-union, repeated surgery and flap complications rises and the delay should be justified and actively managed. Selected cases may do well beyond 72 hours, but those studies should not be interpreted as permission for system-related delay.

The primary-closure question is conceptually separate from flap timing. Most flap studies concern wounds with soft-tissue loss, whereas primary closure applies to wounds that remain closable after debridement. Rajasekaran’s criteria are the clearest operational guide: no primary or secondary skin loss, bleeding viable margins, tension-free approximation, limited contamination, intact perfusion, stable fixation and low overall injury severity. This fits the broader timing literature because leaving a clean, closable wound open may increase nosocomial colonisation and secondary tissue loss. Conversely, forced closure over devitalised, contaminated or tensioned tissue risks necrosis, dehiscence, deep infection and later flap requirement.

The overall consensus is process-based by early specialist ortho-plastic assessment, radical debridement, repeated review where needed, stable fixation, early definitive closure/coverage and careful selection for primary closure. Timing matters, but the quality of the pathway matters at least as much as the clock.

Section 5: Risk of bias of included studies

Overall risk of bias: MODERATE to HIGH.

Justification: The evidence base is dominated by retrospective cohorts, database studies, single-centre case series and historical comparisons. There is substantial confounding by injury severity, transfer pathway, contamination, patient physiology, fixation method, NPWT use and surgeon/team expertise. Sample sizes vary widely, outcomes are inconsistently defined, and “early” is not standardised. Stronger evidence includes large multicentre/database analyses (Pincus, Shammas, Koltenyuk) and prospective cohorts/subgroup analyses (LEAP/Webb), but even these have limitations in residual confounding and outcome capture. Primary-closure evidence is clinically persuasive but mainly observational and criteria-dependent.

Section 6: Response/Recommendation

Recommendation 1: Do not use 72 hours as an absolute cut-off between early and delayed coverage. Treat it as an ideal benchmark and aim for coverage as soon as safely possible, preferably within 72 hours and generally within 7 days, unless delay is justified by physiology, contamination control, transfer or planned staged ortho-plastic management.

Section 7: Level/strength of evidence

Level/strength of evidence: LOW to MODERATE for a strict 72-hour cut-off

Justification: Multiple observational studies consistently support early coverage and show deterioration with increasing delay, particularly beyond 7 days. However, the specific 72-hour boundary is inconsistent across studies and is confounded by injury severity and health-system factors. Selective primary closure is supported by Rajasekaran/Ganga criteria and observational outcomes, but depends heavily on debridement quality and wound selection rather than randomised evidence.

References

1. Mathews et al. (2015). Single-stage ortho-plastic reconstruction, North Bristol.
2. Pincus et al. (2019). Multicentre North American trauma centre/TQIP cohort on flap timing.
3. Zamorano et al. (2025). Timing of coverage in selected young healthy GA IIIB patients.
4. Hou et al. (2011). VAC/delayed coverage in GA IIIB fractures.
5. Shammas et al. (2018). National Trauma Databank predictors of time to flap.
6. Steiert et al. (2009). Delayed flaps after VAC in open extremity fractures.
7. Lee et al. (2021). NPWT and ROC-derived timing thresholds for free-flap outcomes.
8. Kamath et al. (2012). Timing of non-microvascular flaps in GA IIIB injuries.
9. Rajasekaran et al. (2014). Ganga Hospital Open Injury Score and reconstruction guidance.
10. Gopal et al. (2000, 2004). Fix-and-flap ortho-plastic series and functional follow-up.
11. Nambi et al. (2017). Single-stage nailing and fasciocutaneous flap coverage.
12. Nishida et al. (2024). Fix followed by flap staged reconstruction.
13. Chua et al. (2014). Flap coverage within versus after 72 hours.
14. Wagels et al. (2015). Lower-limb flap series, timing, NPD and outcome predictors.
15. Small & Mollan (1992). Historical open tibial fracture coverage series.
16. Moda et al. (1994). Type III tibial fracture protocol with second look and 5-7 day coverage.
17. Webb et al. (2007). LEAP subgroup analysis of timing and fixation.
18. Rajasekaran (2007). Primary closure in selected type III open injuries.
19. Choudry et al. (2008). Flap timing and non-union in GA IIIB midshaft tibia fractures.
20. Hertel et al. (1999). Immediate versus delayed reconstruction in grade 3B/3C lower-leg fractures.
21. Liu et al. (2012). Free-flap timing, metalware exposure and complications.
22. Karanas et al. (2008). Delayed microsurgical reconstruction with VAC and aggressive debridement.
23. Byrd et al. (1981). Early muscle/musculocutaneous flap protocol.
24. Olesen et al. (2015). Infection after free-flap timing beyond 7 days.
25. Hammer et al. (1992). Team approach to type III tibial injuries.
26. Koltenyuk et al. (2026). Nationwide database study of delay and inpatient FRI odds.
27. Cao et al. (2022). Early versus delayed GA IIIB free-flap reconstruction.
28. Al-Hourani et al. (2019). Two-stage ortho-plastic protocol for GA IIIB diaphyseal fractures.
29. Franken et al. (2010). Lower-leg flap timing and flap-type outcomes.