International Consensus Meeting Recommendation: Timing of Surgical Débridement in Low- versus High-Energy Open Injuries

Question

Should the timing of surgical débridement differ between low-energy and high-energy open injuries?

Back ground

The traditional teaching that all open fractures require surgical débridement within six hours originated from military and animal studies that linked bacterial doubling time to infection. Because high-energy injuries (e.g., Gustilo grade IIIB/IIIC tibial fractures) cause extensive soft-tissue stripping, contamination, and ischaemia, they are widely assumed to demand more urgent surgery than low-energy injuries such as simple open finger or distal radius fractures. However, a consistent body of retrospective and prospective evidence now challenges this dogma. Studies of both low-energy upper-extremity fractures and severe high-energy lower-limb fractures have found no significant difference in superficial or deep infection rates when débridement is performed within six hours versus up to 24 hours or beyond, provided that early broad-spectrum antibiotics and meticulous wound care are instituted. Contamination, Gustilo grade, and the quality of débridement—not the hour of first surgery—emerge as the dominant predictors of infection.

Despite these consistent findings, important gaps remain. The existing evidence is entirely observational, and treatment timing was likely influenced by injury severity and physiological status, introducing confounding by indication. No randomised trial has prospectively assigned patients to defined time windows, nor has any study been adequately powered to detect subtle differences in infection rates between low- and high-energy subgroups. The precise safe interval for the most heavily contaminated wounds (e.g., farmyard or marine injuries) remains unknown, and the independent effect of injury energy on the urgency of débridement has never been isolated. Clinically, resolving this question is important because strict adherence to a six-hour rule frequently necessitates out-of-hours operating, with associated risks of surgeon fatigue, incomplete daytime-level resources, and potential delays in medical optimisation. If future studies confirm that modest, controlled delays are safe regardless of injury energy, resource allocation and surgical scheduling could be rationalised without compromising patient outcomes.

Evidence Synthesis

Eight publications were critically appraised, encompassing prospective and retrospective cohort studies, systematic reviews, and a single case report, with a combined sample of over 600 open fractures ranging from low-energy finger injuries to the most severe high-energy tibial defects.

Data extraction table:

S. No	Author, Year of Publication, Country	Study Design	Sample Size	Study Population with Inclusion & Exclusion Criteria	Groups Compared	Results (related to timing of débridement in low- vs high-energy injuries)
1	**M. Barry, S.P.F. Hughes** 1999 United Kingdom	Narrative review	Not applicable	Not applicable – review article	Not applicable	The review emphasises urgent wound excision and lavage for all open fractures regardless of energy level. Contaminated high-energy injuries (farm, marine, war wounds) require repeated aggressive débridement, but no evidence is presented to support different time-to-theatre targets for low- versus high-energy fractures.

2	**Jai Sungaran, Ian Harris, Mohamed Mourad** 2007 Australia	Retrospective cohort study	229 open tibial fractures in 215 patients	**Inclusion:** Skeletally mature patients with open tibial fractures (Gustilo I–IIIC) treated at a single level 1 trauma centre (1995-2002). **Exclusion:** Primary amputation, initial surgery elsewhere, incomplete records.	Early (≤ 6 h) vs. Late (> 6 h) theatre	Infection rate was similar between early (7.9 %) and late (9.6 %) groups; no significant difference in deep infection (2.6 % vs 4.3 %). Increasing Gustilo grade (a surrogate for energy) strongly predicted infection, but timing did **not** influence infection within any grade. **Interpretation:** No need to vary débridement timing between lower-energy (grade I/II) and higher-energy (grade III) open tibial fractures.
3	**Jagwant Singh, Rohit Rambani, Zaid Hashim, Raghu Raman, Hemant Kumar Sharma** 2012 United	Retrospective cohort study	75 Gustilo grade III open fractures in 73 patients	**Inclusion:** Skeletally mature patients with Gustilo III lower-limb fractures (tibia/femur) treated 2005-2010. **Exclusion:** Grade I/II, amputation,	≤ 6 h, 6–12 h, 12–24 h, > 24 h	Overall infection 23 %, deep infection 9.3 %. No significant difference in infection across any time-to-débridement group. Higher Gustilo subtype (IIIB/IIIC) was the only independent risk factor. **Interpretation:** Even for high-energy grade III

	Kingdom			initial surgery elsewhere, gunshot wounds, pathological fractures.		open fractures, a strict early débridement window is not supported; timing need not be adjusted by fracture energy.
4	**John C. Kurylo, Thomas W. Axelrad, Paul Tornetta III, Andrew Jawa** 2011 USA	Retrospective case series	32 open distal radius fractures in 32 patients	**Inclusion:** Skeletally mature patients with open distal radius fractures (Gustilo I–IIIA) treated with emergent irrigation, débridement and immediate internal fixation (1999-2009). **Exclusion:** Gustilo IIIC, amputation, initial care elsewhere, incomplete records.	Early (≤ 6 h) vs. Delayed (> 6 h)	3 superficial infections (9.4 %), no deep infections. Superficial infections occurred in 1 early and 2 delayed patients ($p > 0.05$). Mean time to débridement was 25 hours. **Interpretation:** In low-energy distal radius fractures, delayed surgical débridement beyond 6 hours is safe, suggesting that for such low-energy upper-extremity injuries, timing can be relaxed.
5	**Tim Ng, Jignesh Unadkat,**	Retrospective cohort study	169 open finger fractures	**Inclusion:** Skeletally mature patients with open	Early (≤ 24 h) vs. Delayed (> 24 h)	Overall infection 5.3 % (9/169). Infection rates were 4.9 % (early) and 6.1 % (delayed) – no

	Richard A. Bilonick, Ronit Wollstein 2014 USA		in 145 patients	finger fractures (index-little, distal to MCP joint) treated with irrigation, débridement and internal fixation. **Exclusion:** Thumb fractures, vascular injury requiring revascularisation, initial care elsewhere, isolated nail-bed injury.		significant difference. Wound size and contamination, not time to surgery, were associated with infection. **Interpretation:** Low-energy open finger fractures can safely undergo delayed operative treatment beyond 24 hours, indicating that extremely early surgery is not mandatory for these injuries.
6	**Susan A. Hendrickson, Rosemary A. Wall, Oliver Manley, William Gibson, Deirde**	Prospective observational multi-centre cohort study	126 severe open tibial fractures (Gustilo IIIB/IIIC) in 126 patients	**Inclusion:** Adults ≥ 16 years with Gustilo IIIB/IIC open tibial fractures requiring flap coverage, treated at four UK	Time-to-débridement as continuous variable and categories (< 12 h, 12–24 h, > 24 h)	Deep infection rate 16.7 %, flap failure 7.9 %. No significant association between time to initial débridement and deep infection or flap failure. Contamination and AO/OTA classification were independent predictors. **Interpret**

	Toher, Katy Wallis, Jayne Ward, David L. Wallace, Michael Lamy, Anna-Victoria Giblin, Thomas C. Wright, Umraz Khan 2019 United Kingdom			major trauma centres (2013-2016). **Exclusion:** Gustilo IIIA, primary amputation, non-operative management/primary closure only.		**ation:** Even in the most severe high-energy open tibial fractures requiring flaps, modest delays in débridement do not increase infection; thus, there is no evidence that débridement timing should be tightened for high-energy injuries.
7	**Chad P. Coles** 2020 Canada	Narrative review	Not applicable	Not applicable – review article	Not applicable	The review recommends early definitive soft-tissue coverage (ideally ≤ 72 h) for high-energy open fractures with substantial soft-tissue loss. It does not prescribe different débridement-timing protocols for low- vs high-energy injuries

						but stresses that a clean, repeatedly débrided wound is the prerequisite for safe coverage rather than an arbitrary time cutoff.
8	**Farzad Vosoughi, Fardis Vosoughi, Seyed Hadi Kalantar** 2022 Iran	Case report	1	Single patient: 34-year-old male with open knee dislocation (Gustilo IIIA), triple intra-articular fractures and patellar tendon rupture – an extreme high-energy injury.	None	With aggressive irrigation, débridement and anatomic fixation performed within 24 hours, the patient had no infection and good functional recovery at 12 months. **Interpretation:** Anecdotal evidence shows that a high-energy contaminated "knee disaster" can be successfully managed with early but not emergent surgery; no comparative data on timing, but the case supports that a modest, medically-optimised delay can still yield an infection-free outcome.

Discussion :

For **low-energy open fractures**, the evidence uniformly demonstrates that delaying surgical débridement does not elevate the infection risk. Kurylo et al. (2011) reported on 32 open distal radius fractures (Gustilo I–IIIA) managed with emergent irrigation, débridement, and immediate internal fixation. Despite a mean time to surgery of 25 hours (range 2–95 hours), no deep infections occurred, and the superficial infection rate was similar in fractures debrided within or after 6 hours. Ng et al. (2014) reviewed 169 operatively treated open finger fractures and found no significant difference in infection between early (≤24 hours, 4.9%) and delayed (>24 hours, 6.1%) surgery. Wound size and contamination, not time to theatre, predicted infection. These data indicate that low-energy upper-extremity injuries safely tolerate a relaxed operative window.

At the opposite end of the severity spectrum, three independent cohorts of **high-energy open tibial fractures** reached the same conclusion. Sungaran et al. (2007) studied 229 open tibial fractures and observed no difference in overall (7.9% vs 9.6%) or deep infection (2.6% vs 4.3%) between débridement within or after 6 hours; within each Gustilo grade, timing did not influence infection. Singh et al. (2012) limited their analysis to 75 Gustilo grade III fractures and demonstrated no association between any time-to-débridement subgroup (≤6, 6–12, 12–24, >24 hours) and infection. Only increasing Gustilo subtype independently predicted higher infection rates. The highest level of evidence comes from the prospective multi-centre TIDE study (Hendrickson et al., 2019), which enrolled 126 Gustilo IIIB/IIIC fractures requiring flap coverage. Deep infection occurred in 16.7% and flap failure in 7.9%; time to initial débridement—analysed as a continuous and categorical variable—was not significantly associated with either complication. Wound contamination and fracture classification were the sole independent predictors.

Supporting narrative reviews (Barry & Hughes, 1999; Coles, 2020) emphasise that the thoroughness of débridement, early broad-spectrum antibiotics, and timely definitive soft-tissue coverage (within 72 hours for severe injuries) are far more critical than an arbitrary hour-based target. Even an extreme high-energy knee dislocation with triple intra-articular fractures (Vosoughi et al., 2022) healed without infection after débridement within 24 hours.

Clinical Implications

The traditional six-hour rule is not evidence-supported for any injury energy level. Wound contamination and tissue viability are the primary determinants of infection, and they are independent of injury mechanism. The consensus allows trauma systems to shift towards daytime, physiologically optimised surgery, avoiding fatigued teams and out-of-hours resource limitations, without compromising outcomes. Urgent antibiotic administration (within one hour of presentation) remains mandatory for all open fractures. Grossly contaminated wounds or those with vascular compromise still require emergent surgery. For all other open fractures, the panel concluded that a modest, medically planned delay is safe,

provided antibiotics have been started and the wound is adequately dressed and stabilised. No differential timing protocol based solely on injury energy is warranted.

Risk of bias:

All eight studies are observational—none employed randomisation—so **confounding by indication** is the dominant and pervasive bias: fractures with the worst contamination or physiological compromise were likely expedited to theatre, while cleaner, more stable wounds safely tolerated delay, potentially masking a true protective effect of early surgery. Retrospective chart-based designs (Sungaran, Singh, Kurylo, Ng) introduce **information bias** through inconsistent recording of injury times, surgical timing, and infection diagnoses, while every study carries **selection bias** by excluding cases with missing data, prior amputation, initial treatment elsewhere, or early death, thereby removing the most severe outcomes. Small samples and low infection rates—particularly in Kurylo, Ng, and Vosoughi—yield **inadequate statistical power** to detect modest but clinically meaningful differences. Even the prospective TIDE study could not escape confounding by indication, and its use of broad, arbitrary time windows (≤6 h, 6–12 h, etc.) creates **non-differential misclassification** that dilutes any real association. The two narrative reviews (Barry, Coles) lack systematic search methods and formal bias appraisal, introducing **selection and confirmation bias**, while the single case report (Vosoughi) suffers from extreme **publication bias**, describing only a successful outcome. Critically, key confounders—antibiotic timing, contamination grade, and quality of débridement—are inconsistently controlled across studies, leaving **residual confounding**. Consequently, the uniformly null results may arise not from a true absence of a timing effect, but from systematic biases that obscure a genuine benefit of earlier débridement in high-risk open injuries.

Recommendation:

Based on consistent observational evidence across low- and high-energy open injuries, the timing of surgical débridement does not need to differ by injury energy, as infection risk is driven primarily by wound contamination rather than the time to first surgery.

Level of Evidence: MODERATE

Justification:
The body of evidence consists of eight studies: one prospective multi-centre cohort (Hendrickson et al., n=126), three retrospective cohort studies (Sungaran et al., n=229; Singh et al., n=75; Ng et al., n=169), one retrospective case series (Kurylo et al., n=32), two narrative reviews, and one case report. Collectively, over 600 open fractures were analysed across the entire spectrum of injury energy, from low-energy finger fractures to severe Gustilo IIIB/IIIC tibial fractures requiring flap coverage. All primary studies used observational designs; no randomised trials exist, and every study carries a significant risk of confounding by indication, as well as selection and information biases. Despite these methodological limitations, the findings are remarkably consistent: no study detected a significant difference in infection rates based on time to débridement, and no evidence supports different timing thresholds for low- versus high-energy injuries. The inclusion of a prospective multi-centre investigation with predefined data collection strengthens the evidence base. However, the absence of randomisation, persistent risk of residual confounding, and limited power in subgroups prevent a rating of HIGH. The consistent signal across diverse study designs, populations, and injury severities elevates the rating from LOW to MODERATE.