ICM on Open Injuries - Submission of the consensus recommendation

RQ: Does photodynamic disinfection (light-activated antimicrobial therapy) represent a promising adjunct for decontamination of devitalised tissue?

Section 1: Background (<300 words):

Meticulous surgical debridement remains the cornerstone of open-injury care because devitalised tissue, foreign material and bacterial contamination are major drivers of wound infection and delayed reconstruction. Photodynamic disinfection, also called antimicrobial photodynamic therapy, is proposed as an adjunctive decontamination method rather than a replacement for excision of non-viable tissue. It involves applying a photosensitiser to the wound, allowing an incubation period, and then irradiating the photosensitised tissue with light of an appropriate wavelength. The activated photosensitiser generates reactive oxygen species, including singlet oxygen, which can damage microbial cell walls, membranes and intracellular structures [1].

The technique is attractive because its antimicrobial effect is local, does not depend on conventional antibiotic susceptibility, and may be useful in contaminated wounds with resistant organisms [1]. However, the current clinical evidence in open injuries is extremely limited. The single included human study reported experience in combat-related extremity wounds with major vascular injury and infectious wound complications, using staged negative-pressure wound therapy, phototherapy/photodynamic therapy and subsequent closure with cellular/fibroblast matrix methods [1]. This makes the evidence relevant to complex traumatic wounds, but indirect for routine open fracture debridement.

The key clinical uncertainty is whether photodynamic disinfection meaningfully improves decontamination of devitalised tissue beyond standard debridement, antibiotics, lavage, temporary stabilisation and staged soft-tissue reconstruction. Because no comparative open-fracture trial exists, any recommendation must be cautious and should frame photodynamic disinfection as a promising adjunct for selected wounds, not as standard-of-care replacement therapy.

Section 2: Data extraction table

S.no	Author, year of publication, Country	Study Design	Sample Size	Study population (Inclusion and exclusion criteria)	Groups compared / Intervention	Results	Follow-up duration
1	Ivanova et al., 2023, Ukraine [1]	Observational clinical case series / retrospective report of a 10-year institutional experience. No randomized or comparative control group.	36 patients with mine-blast, shrapnel and gunshot extremity wounds with great-vessel injury. The article reports 9 patients treated in 2014-2015 and 27 patients treated in 2022-2023; 34 men aged 14-52 years were described.	Combat trauma victims with extremity wounds, great-vessel injury and infectious wound complications treated in a specialist vascular/emergency surgery department. Inclusion criteria were not formally stated beyond the described population. Exclusion criteria were not reported.	No control group. All patients underwent staged wound management. Initial treatment used negative-pressure wound therapy at -75 to -115 mm Hg for 4-5 days. PDT was then applied using either dimeguin photosensitiser in 2014-2015 or 6% 5-aminolevulinic acid phosphate gel in 2022-2023, followed by red-light irradiation (660 nm Barva-Flex matrices or 635 nm pulsed LED lamp). Some patients subsequently received dermotension, suturing, autodermoplasty, xenotransplantation, autologous mesenchymal stem cell suspension or fibroblast matrix closure.	Before treatment, high bacterial contamination was reported. In the 2014-2015 group, only 20% achieved complete microflora eradication by days 1-2; after repeat PDT, 100% eradication was recorded by days 4-5. In the 2022-2023 group, microbial associations were reported in 25 patients with high contamination. After one PDT session, gram-negative flora were decontaminated; four residual Staphylococcus aureus / Enterococcus cultures remained below the critical level and required a second session. Wound decontamination after pulsed irradiation reportedly occurred after the first session. Wounds healed by secondary tension in 7-18 days. The authors concluded that combined NPWT and PDT improved wound healing in a short time.	Short-term wound healing only. No long-term functional, fracture union, reoperation, recurrence of infection, amputation or comparative follow-up was reported.

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

Only one eligible human study was identified for this question. Ivanova et al. reported 36 combat-trauma patients with mine-blast, shrapnel or gunshot extremity wounds and major-vessel injuries treated with a staged wound protocol that included negative-pressure wound therapy, phototherapy/photodynamic therapy and later plastic or cellular wound closure methods [1]. The study was not designed specifically for open long-bone fractures and did not isolate devitalised tissue decontamination as an independent outcome.

The intervention was multimodal. Initial local treatment used negative-pressure wound therapy at -75 to -115 mm Hg for 4-5 days. In 2014-2015, dimeguin photosensitiser was applied to wounds with 20 minutes of exposure before irradiation; in 2022-2023, 6% 5-aminolevulinic acid phosphate gel was applied under occlusion for 2 hours before red-light irradiation using 660 nm matrices or a 635 nm pulsed LED lamp [1].

The reported outcomes were microbiological decontamination and wound healing. In the earlier group, complete microflora eradication was achieved in 20% by days 1-2; after a second PDT session, eradication was reported in 100% by days 4-5. In the later group, microbial associations were present in 25 patients. After the first PDT session, gram-negative organisms were reportedly decontaminated, while four residual Staphylococcus aureus / Enterococcus cultures persisted below the critical level and required repeat PDT. Wounds subsequently healed by secondary tension within 7-18 days [1].

The study did not report a standard-care comparator, infection recurrence rate, requirement for repeat surgical debridement, fracture union, functional outcomes, amputation rate, mortality attributable to wound infection, or cost. Therefore, the available result is descriptive and hypothesis-generating: photodynamic disinfection appeared feasible and was associated with short-term microbiological improvement in complex infected combat wounds, but its independent benefit over standard debridement and negative-pressure therapy cannot be determined.

Section 4: Discussion (<1000 words)

The single included study suggests that photodynamic disinfection may be a promising adjunct in heavily contaminated or infected traumatic extremity wounds, particularly where resistant microbial flora are a concern. However, the study does not prove efficacy because there was no control group and the treatment package included several simultaneous interventions: negative-pressure wound therapy, antimicrobial care, PDT, phototherapy, vascular procedures and advanced wound closure with cellular or fibroblast matrix techniques [1].

Biologically, the concept is plausible. After a photosensitiser accumulates in damaged or microbial cells, irradiation with an appropriate light wavelength generates reactive oxygen species. These cause local photochemical injury to microorganisms and may reduce bacterial burden. Unlike antibiotics, photodynamic injury is not dependent on conventional antibiotic sensitivity patterns, and resistance development is considered less likely [1]. These features are particularly attractive in devitalised traumatic wounds, where bacterial contamination, tissue hypoxia and biofilm formation may compromise healing.

Nevertheless, decontamination of devitalised tissue begins with surgical excision. Photodynamic therapy cannot substitute for removing dead tissue, foreign material and gross contamination. Its logical role is after adequate debridement and lavage, when the remaining wound bed requires additional reduction of microbial burden before staged closure. The Ivanova study used PDT after negative-pressure wound therapy when oedema had reduced, the wound surface had cleaned and granulation/marginal epithelialisation had appeared [1]. This supports an adjunctive rather than primary role.

The evidence is substantially limited. The sample size was small (36 patients), the population was combat-trauma patients with vascular injury rather than a clearly defined open-fracture cohort, and inclusion/exclusion criteria were not formalised. The outcome assessment was mainly microbiological and short-term. No comparator group was available, so the contribution of PDT cannot be separated from negative-pressure therapy, repeated wound care, systemic antibiotics, vascular reconstruction or cellular wound closure. The study also did not provide long-term outcomes such as recurrent infection, fracture union, limb salvage, reoperation, functional recovery or adverse events related to photosensitiser use.

For clinical practice, photodynamic disinfection should therefore be viewed as a potentially useful adjunct in selected complex wounds, not a routine recommendation for all open injuries. It may be considered in specialised centres for infected or persistently contaminated wounds after adequate debridement,

particularly when multidrug-resistant organisms or delayed closure are concerns. Future prospective comparative studies should evaluate standard debridement and antibiotics with versus without photodynamic disinfection, stratify by open-fracture severity and contamination, and report deep infection, repeat debridement, flap success, union, amputation, functional outcomes and safety.

Section 5: Risk of bias of included studies

Risk of bias was assessed using the JBI Critical Appraisal Checklist for Case Series and visualised using ROBVIS. Ivanova et al. (2023) was judged as an uncontrolled clinical case series, not a cohort study, because all included patients received the same multimodal intervention without a comparator group. Eight of ten applicable JBI domains were rated Yes/Low, while two domains were Unclear: consecutive inclusion and complete inclusion of participants. No domain was rated No/High risk.

JBI score: 8/10 = 80.0%. By the prespecified numerical rule, this is Low risk of bias. However, because the evidence consists of a single uncontrolled case series with multimodal treatment, the ROBVIS overall judgement is best interpreted as some concerns/unclear for comparative effectiveness. The study supports feasibility and short-term microbiological decontamination, but it cannot prove that photodynamic therapy alone improves clinical outcomes.

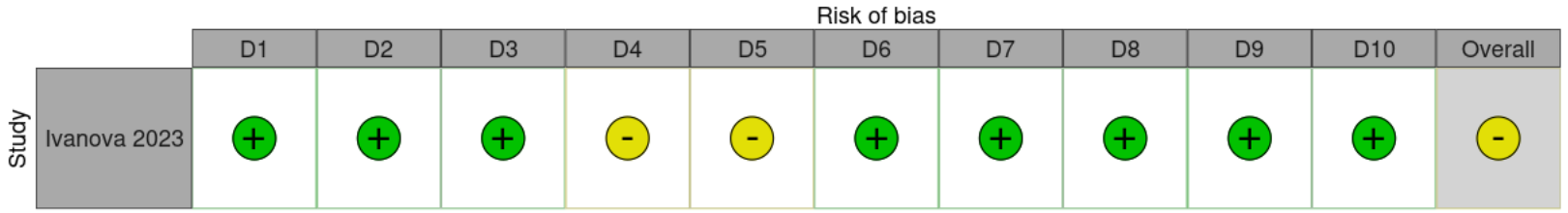

Figure 1. ROBVIS risk-of-bias visualisation for Ivanova et al. (2023) using mapped JBI Case Series domains.

Domain key: D1 clear inclusion criteria; D2 condition measured in a standard/reliable way; D3 valid methods for identifying the condition; D4 consecutive inclusion; D5 complete inclusion; D6 demographics clearly reported; D7 clinical information clearly reported; D8 outcomes/follow-up clearly reported; D9 presenting site/clinic information clearly reported; D10 appropriate statistical analysis.

ROBVIS / JBI percentage summary

Judgement	Number of domains	Percentage	Interpretation
Low / Yes	8/10	80.0%	Most checklist domains were adequately reported.
Unclear	2/10	20.0%	Consecutive and complete inclusion were not clearly stated.
High / No	0/10	0%	No checklist item was rated No/High risk.
Overall	1 study	Some concerns / unclear	Single uncontrolled case series; PDT effect cannot be separated from NPWT, surgery, antibiotics and cellular wound closure.

Overall risk assessment

Study	JBI score	Risk category	Main sources of bias / impact on recommendation
Ivanova et al., 2023 [1]	8/10 = 80.0%	Low by JBI score; ROBVIS overall some concerns/unclear	Uncontrolled single-centre case series; unclear consecutive/complete inclusion; no control group; multimodal intervention (NPWT, antibiotics, PDT, surgery and wound closure) prevents attribution of effect to PDT alone; outcomes are mainly short-term microbiological/wound-healing endpoints.

Section 6: Response / Recommendation

Response: Photodynamic disinfection appears promising as an adjunct for short-term decontamination of complex infected combat-related extremity wounds, but the evidence is insufficient to recommend it as routine standard care for decontamination of devitalised tissue in open injuries.

Recommendation: Photodynamic disinfection may be considered selectively as an adjunct after adequate surgical debridement, lavage, antibiotics and standard wound management in specialised centres or research protocols. It should not replace meticulous surgical debridement and should not be considered mandatory for routine open-fracture care based on current evidence.

Section 7: Level / strength of evidence

LOW. The recommendation is based on a single human observational case series of 36 combat-trauma patients. The study is relevant to complex infected extremity wounds but indirect for routine open fractures and devitalised-tissue decontamination. There was no comparator group, no randomisation, no blinding, no standardized control intervention, and no long-term outcomes. The evidence supports feasibility and a possible adjunctive effect, but not definitive efficacy.

Key consensus messages

- Photodynamic disinfection is an adjunctive wound-decontamination technique; it is not a substitute for surgical debridement.
- The only included human open-injury-related study is a small uncontrolled case series in combat extremity wounds with infectious complications.
- Reported findings suggest rapid microbiological improvement and short-term wound healing, but the independent effect of PDT cannot be separated from NPWT, antibiotics, staged surgery and cellular wound closure.
- There is no comparative evidence showing that PDT reduces deep infection, repeat debridement, nonunion, amputation or poor functional outcome in open fractures.
- Current evidence supports cautious selective use in specialised centres or research settings, not routine use in all open injuries.

References

1. Ivanova YuV, Gramatyuk SM, Kryvoruchko IA, Prasol VO, Myasoedov KV. Advances in the treatment of combat trauma to the extremities: photodynamic therapy and methods of plastic wound closure. The Ukrainian Journal of Clinical Surgery. 2023;90(4):25-30. doi:10.26779/2786-832X.2023.4.25.