

RQ - Should techniques such as laser fluorescence or indocyanine green angiography be routinely used to assess soft tissue viability during debridement ?

Section 1: Background:

Open fracture management is based on principles of adequate debridement and appropriate stabilisation. The debridement is subjective largely based on the surgeons experience and judgement often a debate between how much to preserve and what all to sacrifice. Inadequate debridement leads to prolonged treatment, increased hospital stay, increased number of procedures and increased cost. The use of ICG fluorescence can provide an objective visualisation of ischemic zones in such cases.

Section 2: Data extraction table

S.no	Author, year of publication, Country	Study Design	Sample Size	Study population, methods	Groups compared	Results
1	Gary Fenn et al	Case report	1	Single crush injury to hand injury debridement using ICG fluorescence.	None	ICG fluorescence based debridement led to accurate marking of the ischemic zone and helped in single stage appropriate repair.

2	Emily Blumenthal, Lt Col Steven Jeffery, 2018	Case report	2	2 burn cases, debridement done and persistent bacterial load evaluated using MolecuLight i:X Imaging Device with direct bacterial fluorescence without use of dye	None	In both the cases hand held device could intraoperatively visualise bacterial persistence and debridement was done accordingly to eradicate the bacterial load.
3	Eline Anna Breuking et al, 2025	Systematic review	13 studies, mostly non randomised and retrospective	ICG fluorescence in trauma surgery with full English or dutch texts available	None	No adverse effects from ICG infusion. The dose and timing of visualisation was different in different studies, sample sizes were small. Finally change in intraoperative decision in many studies, with a range of 28.5% to 78.9%. I
4	Jonathan Thomas Elliott et al, 2022	Case series	3 cases	ICG fluorescence to assess extent of bone debridement in non unions	None	3 cases where ICG infusion helped in intra op visualisation of avascular bone ends thus helping in debridement

5	Seijiro Koshimune et al, 2016	Retrospective comparative groups	23 cases(13 LA ICG used, 10 LA ICG free)	Open lower limb fractures managed with LA ICG visualisation to define dead soft tissues	LA-ICG–used and LA-ICG–free groups	Deeper areas more than 2 cm cannot be visualised, dead bone cannot be differentiated. Bordering zone between healthy and dead tissues was the area with intermediate intensity seen at equilibrium phase of perfusion
6	Pierre P. Zaharia et al 2020	Case series	5 cases of low velocity ankle fractures, selected between 2013 -2018.	When the transverse medial wound was too cephalad for direct fracture visualization and management, LA-ICGA was considered to plan wound extension for assistance with exposure, visualization, and implant placement where appropriate.	None	All 5 cases healed well. 1 had minor wound issues. The process is technically demanding and the cost of use of expensive lasers has not been calculated.

7	Eufemia Cetan et al	prospective, single-center case series	patients with Gustilo–Anderson type III B,C open fractures and/or severe degloving injuries who underwent bone and soft-tissue reconstruction between March 2024 and July 2025	In 8 patients clinical assessment of dead margins and tissues were assessed followed by ICG guided tissue assessment.	6 ICG based debridement, 2 non ICG based debridement	Among 8 cases it was seen ICG based debridement had better results. Intra operatively there was on an average 114% more ischemic area detected by ICG as compared to clinical assessment.and 166.7% increased wound margin detected in ICG based debridement
8	Tim Pruimboom et al , 2018	Single case report	Open gustillo type III B both bone leg case	Debridement was initially done and exfix for stabilisation. After 6 ICG based debridement	None	Single case report no comparison

Section 3: Results summary write-up-

Critical Technical Observations

- **The Bordering/Transition Zone:** The boundary between healthy and necrotic tissue was characterised by an **intermediate fluorescence intensity** observed specifically during the *equilibrium phase* of perfusion.
- **Standardisation Gaps:** Across the reviewed studies, sample sizes were small, and there was a lack of uniformity regarding both ICG dosing and the optimal timing for fluorescence visualisation.

Technical & Practical Limitations

- **Depth Constraints:** Near-infrared (NIR) visualisation is limited to superficial tissues; pathology deeper than **2 cm** cannot be visualised.
- **Diagnostic Specificity:** While ICG identifies a lack of perfusion, it cannot definitively differentiate between structurally dead bone (sequestrum) and severely ischemic but viable bone.
- **Resource Hurdles:** The workflow is technically demanding, requires a specialized learning curve, and the cost-effectiveness of utilizing expensive laser equipment has not yet been quantified.

Section 4: Discussion-

The papers reviewed are largely case based series with small number of patients studied. one paper is a systematic review (1) one prospective single centre case series (2) and one retrospective comparative study (3). The results of all the papers are promising but lack strong validation statistically and methodologically. This needs further detailed research keeping in mind the cost of the equipment, standardised methodology and technical issues. If the technology is promising as it sounds and has the potential to quantify the surgical debridement as a procedure it has the potential to change the narrative of open injury management.

Section 5: Risk of bias of included studies

High

Section 5: Response/Recommendation

The technique is promising but lacks scientific backing and standardisation. Justification: Although ICG fluorescence angiography demonstrates potential to improve intraoperative assessment of tissue viability and may influence debridement decisions, the current evidence is limited to small observational studies with methodological heterogeneity, lack of standardized protocols, and no robust comparative trials. Therefore, routine use cannot currently be recommended.

Section 6: Level/ strength of Evidence:

LOW- *mostly single centre case studies with Very few cases. No strong Controll group. The systematic review was also not strongly structured .*

References-

- 1- Eline Anna Breuking et al, *Current applications of indocyanine green fluorescence angiography in trauma patien and its potential impact: a systematic review*, BMJ Open 2025;**15**:e099755. doi:10.1136/ bmjopen-2025-099755
- 2- Eufemia Cetani et al, *Effectiveness of indocyanine green in assessing tissue perfusion in lower limb open fractures: A prospective pilot study*, Injury 57 (2026) 113259

3-Seijiro Koshimune et al, *Laser-Assisted Indocyanine Green Angiography Aids in the Reconstruction of Gustilo Grade IIIB Open Lower-Limb Fractures* , DOI [http://dx.doi.org/ 10.1055/s-0036-1593807](http://dx.doi.org/10.1055/s-0036-1593807). ISSN 0743-684X.