Open Injury Consensus — Evidence Review

RQ: Are mechanical prophylactic measures (e.g. IPC applied to the uninjured limb) sufficient as sole VTE prevention during the acute phase of open fracture management?

Section 1: Background

Venous thromboembolism (VTE) is a recognised and potentially fatal complication of musculoskeletal trauma. In open fractures, prophylaxis poses a specific dilemma due to the soft-tissue wound, contamination, repeated debridements, flap reconstruction and the risk of bleeding into a fresh open wound which can make clinicians reluctant to start pharmacological agents in the acute phase. Mechanical methods such as intermittent pneumatic compression (IPC), foot pumps and graduated compression stockings are therefore preferred because they carry no bleeding risk, and in the open-fracture setting they are sometimes applied only to the uninjured limb because the injured limb is encased in a dressing, external fixator or cast. The clinical question is whether such mechanical measures, used alone, provide sufficient protection during the acute phase, or whether they leave patients exposed until pharmacological prophylaxis can safely begin. This is a question on which open-fracture-specific evidence is strikingly sparse.

Section 2: Data extraction table

S.no	Author, year, country	Study design	N	Study population (incl/excl)	Prophylaxis compared	VTE outcome (DVT/PE)
1	**Zhu Y. et al., 2021, China**	Prospective cohort (risk-factor analysis)	1179	Tibial plateau fractures; preoperative bilateral duplex US screening. Mixed open/closed.	Not a prophylaxis trial – incidence/risk-factor study (prophylaxis not	Preop DVT 16.3% (1.0% proximal, 15.3% distal). DVT in injured limb 86.4%, both 7.3%, uninjured-only 6.3%.

S.no	Author, year, country	Study design	N	Study population (incl/excl)	Prophylaxis compared	VTE outcome (DVT/PE)
					specified in abstract).	OPEN FRACTURE was an independent risk factor for DVT.
2	**Fu Y.-H. et al., 2020, China**	Retrospective observational cohort	femoral neck fx cohort	Femoral neck fractures (closed); pre- and post-op duplex US.	Not a prophylaxis comparison (incidence study).	Preop DVT 32%, postop 56%. DVT on the UNINJURED side = 45% of preop and 43% of postop DVTs; 90% peripheral/distal.
3	**Niikura T. et al., 2015, Japan**	Retrospective two-period comparative cohort (Level III)	39 (23 + 28 fractures)	Complex lower-limb fractures (femoral + tibial) staged ex-fix→internal fixation; INCLUDES open fractures; comparable open-fracture proportion between periods.	MECHANICAL PROPHYLAXIS ONLY – no pharmacological prophylaxis in either group.	VTE rate HIGH: early group 5/17 (3 DVT, 2 PE); later group 10/22 (10 DVT, 4 PE). Several VTEs occurred during the external-fixation (acute) period.
4	**da Cruz Garcia J.V. et al.,**	Retrospective observational (Level II)	99	Proximal femoral fractures, postoperative; institutional protocol.	COMBINED: LMWH + intermittent pneumatic compression +	DVT in only 1/99 (1.01%). Combined protocol judged effective.

S.no	Author, year, country	Study design	N	Study population (incl/excl)	Prophylaxis compared	VTE outcome (DVT/PE)
	2022, Brazil				compression stockings + early gait.	
5	**Yang Shuo et al., 2025, China**	Retrospective cohort (risk-factor analysis)	3311	Patellar fractures, two tertiary centres; Doppler US; DVT prophylaxis applied (type not detailed).	Prophylaxis applied but not characterised as mechanical-only (incidence/risk-factor study).	DVT incidence 30.8%; injured side 96.7%, uninjured side 3.2%. OPEN injury an independent risk factor (OR 1.52); multiple injuries OR 3.62.
6	**Guo et al, 2022, China**	Retrospective cohort	252	Trauma patients with mild craniocerebral injury + clavicular fractures.	PCD (pneumatic compression) + LMWH vs LMWH alone.	DVT 5.6% (PCD+LMWH) vs 15.1% (LMWH alone), $p<0.05$; adding mechanical to pharmacological roughly halved DVT.
7	**Lin et al, 2022, China**	Prospective open RCT	332	Severe traumatic brain injury (not fractures).	IPC vs control (mechanical-only, IPC).	DVT 3.61% (IPC) vs 17.47% (control); IPC raised femoral-vein flow velocity and lowered FIB/HMGB1.

S.no	Author, year, country	Study design	N	Study population (incl/excl)	Prophylaxis compared	VTE outcome (DVT/PE)
8	**Niu et al ,2021, China**	Retrospective cohort (risk-factor analysis)	980	Elderly femoral neck fractures (closed); duplex US.	Not a prophylaxis comparison (incidence study).	Preop DVT 6.8%. UNINJURED extremity 14.9%; injured-only 76.1%; both 9.0%.
9	**Ma et al, 2020, China**	Retrospective cohort (Level III)	537	CLOSED foot fractures (calcaneus excluded); duplex US.	Not a prophylaxis comparison (incidence study).	Preop DVT 5.2%. Injured limb 85.7%, uninjured 10.7%, bilateral 3.5%. Concomitant other fractures raised DVT (12.6% vs 2.9%).
10	**Wang et al, 2020, China**	Retrospective cohort	494	Lower-extremity fractures; DVT in the UNINJURED limb specifically examined; anticoagulants used for prevention/treatment.	Anticoagulant prophylaxis used (not mechanical-only); study isolates uninjured-limb DVT.	DVT in the uninjured limb 19.84% during admission, 18.83% at 1 month; uninjured-limb-only DVT 4.04% then 6.48%, DESPITE anticoagulation.
11	**Wang et al, 2019, China**	Prospective cohort	110	Pelvic and acetabular fractures; duplex US.	COMBINED mechanical + chemical thromboprophylaxis in ALL patients.	DVT 29.09% (21 proximal, 3 PE) DESPITE combined prophylaxis; acetabular > pelvic;

S.no	Author, year, country	Study design	N	Study population (incl/excl)	Prophylaxis compared	VTE outcome (DVT/PE)
						complex acetabular more proximal DVT.
12	**Flevas et al, 2018, (review)**	Narrative review / update	n/a	Orthopaedic VTE prophylaxis overview (mechanical vs pharmacological).	Reviews mechanical (mobilisation, GCS, IPC, foot pumps) and pharmacological agents.	Without prophylaxis VTE 40–60% in major ortho surgery; with prophylaxis symptomatic VTE 1.3–10%. LMWH most efficient overall; scepticism re aspirin as sole agent; explicit CONTROVERSY over VTE prophylaxis in lower-leg injuries.
13	**Brathwaite et al, 2016, New Zealand**	Prospective open-label feasibility study	7 (of 142 eligible)	Isolated lower-limb injury needing ≥4 wks below-knee CAST immobilisation.	Within-cast IPC device (Jet Impulse Technology) – mechanical-only.	FEASIBILITY FAILED: only 7/142 (5%) eligible/enrolled; NO participant had adequate adherence; device used mean 4.1 h/day.
14	**Keehan et al,**	Retrospective controlled	24 (12 IPF vs 12	Ankle fractures requiring ORIF (closed).	Intermittent pneumatic FOOT pump pre-op (anti-	Outcome was swelling/delay, NOT VTE efficacy: 50% reduction

S.no	Author, year, country	Study design	N	Study population (incl/excl)	Prophylaxis compared	VTE outcome (DVT/PE)
	2013, UK	before-after study	controls)		embolic device used to reduce swelling).	in time-to-surgery (p=0.024); shorter stay; cost saving. VTE not the endpoint.
15	**Niikura et al, 2012, Japan**	Retrospective cohort	109	Fractures around and below the knee, surgically treated.	PHYSICAL (mechanical) prophylaxis in ALL patients.	VTE 25.7%, PE 4.6% (all asymptomatic) DESPITE physical prophylaxis; higher with accompanying injuries and with routine screening.
16	**Sutwoska et al, 2012, Japan**	Retrospective cohort	46	Pelvic and acetabular fractures (Japanese population).	PHYSICAL (mechanical) prophylaxis in ALL patients.	VTE 41.3%, PTE 21.7% (all asymptomatic) DESPITE physical prophylaxis; significantly higher than trauma patients without pelvic/acetabular fracture.

Section 3: Results summary

The single most direct study (Niikura 2015) followed complex lower-limb fractures including open fractures managed with mechanical prophylaxis only, and found a high VTE rate (5 of 17 and 10 of 22 across two periods), with several events occurring during the acute external-fixation phase. This is the closest available article and it argues against the sufficiency of mechanical-only prophylaxis. Studies of mechanical prophylaxis in adjacent fracture populations reinforce this such as pelvic and acetabular fracture cohorts using physical prophylaxis reported VTE of 29–41% (Japanese pelvic/acetabular cohort 41.3%, with 21.7% pulmonary thromboembolism), and fractures around the knee with physical prophylaxis reached 25.7%. Where mechanical prophylaxis was added to pharmacological prophylaxis pneumatic compression plus LMWH halved DVT versus LMWH alone, 5.6% vs 15.1%), and IPC alone outperformed no prophylaxis in a non-fracture TBI RCT (3.6% vs 17.5%) but neither addresses mechanical-only sufficiency in open fractures. A within-cast IPC feasibility study failed outright: only 5% of eligible patients enrolled, no patient achieved adequate adherence, and 3 of 7 had adverse events including one DVT and two skin ulcers highlighting that the practical delivery of mechanical prophylaxis around an injured limb is itself problematic. The uninjured-limb studies add a crucial part to the specific strategy of compressing only the uninjured limb: although a substantial minority of clots do occur in the uninjured limb (6–45% across femoral-neck, tibial-plateau, patellar and foot-fracture cohorts, and 19.8% in a dedicated uninjured-limb study despite anticoagulation), the majority of DVTs (76–97%) form in the injured limb the very limb that mechanical compression typically cannot cover. Open fracture itself emerged as an independent risk factor for DVT in two large cohorts (tibial plateau, patellar). No included study demonstrated that mechanical prophylaxis alone is sufficient in open fractures.

Here's a summary table for the Results section:

Study Type/Population	Intervention	VTE/DVT Rate	Key Finding	
Complex lower-limb fractures (Niikura 2015)	Mechanical prophylaxis only	29% (5/17) and 45% (10/22)	High VTE rate; events during acute external-fixation phase	
Pelvic/acetabular fractures (Japanese cohort)	Physical prophylaxis only	41.3% VTE (21.7% PE)	Reinforces insufficiency of mechanical-only approach	

Fractures around the knee	Physical prophylaxis only	25.70%	High VTE rate with mechanical prophylaxis alone	
Pneumatic compression + LMWH	Combined therapy	5.6% DVT	50% reduction vs LMWH alone	
LMWH alone	Pharmacological only	15.1% DVT	Less effective than combination	
IPC alone (non-fracture TBI)	Mechanical only	3.60%	Better than no prophylaxis (17.5%)	
Within-cast IPC study	Mechanical prophylaxis	Failed study	5% enrollment, poor adherence, 43% adverse events	
Various fracture cohorts	Uninjured limb compression	6-45% clots in uninjured limb	76-97% of DVTs occur in injured limb (cannot be compressed)	
Open fractures (tibial plateau/patellar)	Various	Not specified	Open fracture = independent DVT risk factor	

Section 4: Discussion

The defining feature of this question is the near-absence of direct evidence. Despite a targeted search, not one study was designed to test whether mechanical prophylaxis alone is sufficient as the sole VTE-prevention strategy in acute open fracture management. Any recommendation must therefore be reasoned from indirect evidence, and the strength of that reasoning depends on how closely each study approximates the clinical scenario.

The closest study is Niikura (2015), in which complex lower-limb fractures explicitly including open fractures were managed with mechanical prophylaxis only, no pharmacological agent. The VTE rate was high in both study periods, and importantly several events occurred during the acute external-fixation phase, which is precisely the window this question concerns. Although small and retrospective, it is the most directly

applicable evidence available, and it points away from mechanical-only sufficiency. This direction is echoed across higher-risk fracture cohorts using physical prophylaxis pelvic and acetabular series reported VTE of 29–41% with pulmonary thromboembolism in up to a fifth, and peri-knee fractures reached 25.7% all despite mechanical measures. While these are not open-fracture studies, they share the relevant feature of high baseline thrombotic risk and reliance on mechanical methods, and they consistently show substantial residual VTE.

The studies that examined mechanical prophylaxis more favourably do not actually support mechanical-only use in open fractures. Adding pneumatic compression to LMWH halved DVT compared with LMWH alone, and IPC outperformed no prophylaxis in a traumatic brain injury RCT but both describe mechanical methods as an adjunct to, or a substitute in the absence of, pharmacology, not as a sufficient sole strategy in open fractures. A practical thread runs through the mechanical-device studies delivering mechanical prophylaxis around an injured limb is difficult. The within-cast IPC feasibility study failed on enrolment and adherence, and produced harms – skin ulceration and maceration, and a DVT despite the device. This matters for open fractures specifically, where dressings, external fixators and flaps frequently make it impossible to apply a device to the injured limb at all. That is exactly why the question specifies application to the UNINJURED limb and this is where the uninjured-limb evidence becomes decisive. Across femoral-neck, tibial-plateau, patellar and foot-fracture cohorts, the large majority of DVTs (76–97%) formed in the INJURED limb, with only a minority (commonly 3–15%, though as high as 45% in one femoral-neck series) in the uninjured limb; a dedicated study found 19.8% uninjured-limb DVT even under anticoagulation. Compressing only the uninjured limb therefore addresses, at best, the minority of clots, leaving the higher-risk injured limb unprotected. This is a mechanistic argument against the specific strategy named in the question, and it is consistent across studies.

Two honest counterweights belong in the record. First, the outcome in almost all of these studies is screen-detected, frequently asymptomatic, distal DVT; its clinical significance is uncertain, and high screen-detected rates do not equate to high rates of clinically important VTE. Second, open fracture was an independent risk factor for DVT in two large cohorts, which raises baseline risk but does not, by itself, tell us which prophylaxis strategy is best. Taken together, the evidence does not prove mechanical-only prophylaxis is inadequate in

open fractures – no study can, because none was done – but every relevant indirect line points the same way, and none supports sufficiency. The defensible consensus position is that mechanical measures are a valuable adjunct and a temporising option when bleeding or wound risk precludes pharmacology, not a sufficient sole strategy, and that open-fracture-specific trials are needed.

Section 5: Risk of bias of included studies

Risk of bias is high to very high across the included evidence. The designs are predominantly retrospective cohorts and incidence/risk-factor studies; only two are randomised (one a protocol without results, one in a non-fracture TBI population), and one is a narrative review. Major bias domains are: (1) indirectness – most populations are closed fractures, mixed trauma, immobilised-but-not-open injuries, or non-fracture conditions, so applicability to acute open fractures is limited; (2) outcome-measurement bias – routine duplex/CT screening detects asymptomatic distal DVT and inflates event rates, with screening intensity differing between studies and even between periods within the same study; (3) confounding and selection bias – prophylaxis was non-randomised and often incompletely described, and high-risk patients may have received different prophylaxis; (4) imprecision – several studies are very small (the direct study has 17 and 22 patients per period; the feasibility study only 7). The single off-topic exclusion list is provided for transparency. No formal meta-analysis is appropriate given this heterogeneity.

Section 6: Response / Recommendation

> WIth the available evidence, the Consensus cannot recommend mechanical prophylactic measures (including IPC applied to the uninjured limb) as SUFFICIENT sole VTE prevention during the acute phase of open fracture management. Direct evidence is essentially absent, and the closest and most relevant indirect evidence is mechanical-only prophylaxis in complex lower-limb fractures, and physical prophylaxis in high-risk pelvic/acetabular and peri-articular fractures which consistently shows high residual VTE rates, while most clots occur in the injured limb that mechanical devices cannot cover. Mechanical methods should be regarded as an ADJUNCT when pharmacological prophylaxis is contraindicated by bleeding or wound concerns, with pharmacological prophylaxis added as soon as it is judged safe.

Section 7: Level / strength of evidence

The certainty of evidence is VERY LOW. There is no randomised or even prospective comparative evidence isolating mechanical-only prophylaxis as a sole strategy in an open-fracture population during the acute phase. The body of evidence is dominated by retrospective cohorts and risk-factor/incidence studies, most using asymptomatic screen-detected DVT as the outcome (which inflates event rates and limits clinical interpretability), with heterogeneous prophylaxis definitions, small samples, and populations that are only indirectly applicable (closed fractures, mixed trauma, immobilised but not open injuries, or non-fracture conditions). The one mechanical-only fracture study that includes open fractures (Niikura 2015) is small and non-randomised. Two relevant trials are either a protocol without results (IPC in cast immobilisation) or conducted outside fractures (IPC in TBI). By GRADE reasoning, the indirectness, risk of bias and imprecision all lower certainty substantially. The consistent DIRECTION of the indirect evidence high residual VTE under mechanical/physical prophylaxis and a predominance of injured-limb clots supports a cautious recommendation against relying on mechanical measures alone, but high-quality, open-fracture-specific studies are required before any firm conclusion can be drawn.