RQ: Is there a definitive role for circular/ring external fixators in the acute management of open injuries with bone loss?

Section 1: Background

Open injuries with segmental bone loss are among the most difficult limb injuries to manage because they combine contamination, soft-tissue loss, skeletal instability, vascular compromise, infection risk and reconstructive bone defects [1-8]. Conventional internal fixation may be unsuitable in the acute setting when wounds are grossly contaminated, the soft-tissue envelope is poor, vascular repair is needed or repeated debridement is anticipated [1-4]. Circular or ring external fixators, particularly Ilizarov-based systems, offer stable fixation, biological preservation, access for wound care and flap procedures, early weight-bearing, deformity correction and bone transport or gradual lengthening when bone loss is present [1-8].

Known advantages include minimal periosteal stripping, multiplanar stability, adaptability in contaminated wounds, maintenance or restoration of length and alignment, and the ability to combine fixation with distraction osteogenesis [1-8]. Human case reports and observational studies demonstrate successful use in Gustilo-Anderson IIIB and IIIC injuries, open tibial fractures, open/comminuted femoral fractures and selected cases with segmental bone loss [1,2,4-8].

However, the definitive role of ring fixators in acute management remains uncertain. Current evidence includes case reports, small prospective and retrospective cohorts, and one systematic review dominated by heterogeneous retrospective studies [1-8]. Important gaps remain regarding ideal patient selection, timing of application, whether ring fixation should be temporary or definitive, staged conversion to internal fixation, defect-size thresholds, complication rates, patient tolerance and comparison with alternatives such as monolateral external fixation, staged internal fixation, Masquelet technique, vascularised grafting or amputation [3].

This question is clinically relevant because early fixation strategy directly affects infection control, soft-tissue reconstruction, limb salvage, union, rehabilitation, treatment duration and patient quality of life. Based on current evidence, circular external fixators appear valuable in selected open injuries with bone loss, but stronger comparative evidence is required before recommending them as a universal definitive acute treatment.

Section 2: Data Extraction Table

S. No	Author, year, country	Study design	Sample size	Study population	Intervention / comparison	Key results
1	Nozaka et al., 2023, Japan	Case report	1 patient	68-year-old man with Gustilo-Anderson type IIIC distal tibial open fracture, severe contamination, vascular injury, osteoporosis and 75-mm bone defect.	Acute shortening, vascular repair, Ilizarov fixation, gradual lengthening, low-intensity pulsed ultrasound and teriparatide.	Fixator removed at 12 months; union achieved. At 5 years, full weight-bearing without walking aids, good knee and ankle motion, return to work and AOFAS score 95.
2	Alpharian and Robiady, 2024, Indonesia	Case report and literature review	1 patient	19-year-old man with Gustilo-Anderson type IIIB open tibial fracture and 7-cm bone defect after motorcycle accident.	Debridement, Ilizarov external fixation, segmental resection and bone transport; later conversion to external LCP, internal fixation and bone grafting.	Acceptable bone formation and functional improvement at follow-up without clinical infection; prolonged staged treatment and frame discomfort noted.
3	Fenga et al., 2026, Italy/Spain	Systematic review	8 studies, 303 patients; 6 acute open-fracture cohorts in primary synthesis	Adults with acute traumatic open long-bone fractures managed with circular/ring external fixation, including studies of definitive ring fixation and staged conversion to internal fixation.	Definitive circular fixation versus staged conversion to internal fixation after soft-tissue stabilization; narrative synthesis due to heterogeneity.	Staged conversion may reduce frame-related morbidity in some cohorts, but effects on deep infection and union remained uncertain due to small retrospective studies, inconsistent definitions and confounding. Evidence graded as low-certainty observations.
4	Lovisetti et al., 2019, Italy/India	Retrospective case series	23 patients	Open or comminuted femoral shaft/distal femoral fractures treated definitively with circular external fixators; 13 open fractures including IIIA, IIIB and IIIC; 2 patients had acute femoral bone loss.	Definitive circular/ring external fixation for open or comminuted femoral fractures unsuitable for internal fixation.	22/23 fractures united primarily; mean union time 23.1 weeks; no deep pin-tract infection; superficial pin-tract infection in 12; ASAMI bone results excellent/good/fair/poor in 19/1/1/2 and functional results excellent/good/fair in 16/6/1.
5	Bhosale and Naikwade, 2023, India	Prospective observational study	30 patients	Open tibial fractures managed with Ilizarov ring fixator at an Indian tertiary centre; majority Gustilo IIIA, with IIIB injuries also included.	Ilizarov ring fixator as definitive fixation for open tibial fractures; some initially managed by conventional external fixator and later converted to Ilizarov.	All patients achieved union. Common complications were pin-site infection (36.67%) and delayed union (13.33%). Authors concluded Ilizarov allows early full weight-bearing, high union rates and fewer malunions in open tibial fractures.
6	Wani et al., 2011, India	Prospective hospital-based study	60 patients	Gustilo type II, IIIA and IIIB open tibial diaphyseal fractures presenting within 72 hours; 11 patients had bone loss of 3-7.2 cm.	Emergency debridement and minimal temporary fixation, followed by definitive Ilizarov external fixation after 3-5 days; corticotomy/lengthening used for bone loss.	All fractures united. Mean union time was 21.1 weeks for type II, 21.7 weeks for IIIA and 24.9 weeks for IIIB. Eleven bone-loss cases underwent lengthening with healing index 1.5 months/cm. Final results were excellent in 80%, good in 16.7% and fair in 3.3%; no poor results.
7	Heisnam Singh et al., 2025, India	Prospective observational study	26 patients	Open tibial fractures at JNIMS, Manipur; Gustilo type II (5), IIIA (13) and IIIB (8), managed with Ilizarov fixation; selected bone-loss cases treated with corticotomy/bone transport.	Initial debridement and antibiotics followed by definitive Ilizarov circular external fixation; bone transport/corticotomy/bone grafting and soft-tissue procedures used when required.	Average union time was 20.3 weeks for type II, 23.6 weeks for IIIA, 25.4 weeks for IIIB and 29.8 weeks for bone-loss cases. No deep infection occurred; 2 nonunions were reported. Excellent/good functional outcomes were seen in 88.4%; pin-tract infection was common but mostly manageable.
8	Romeo et al., 2026, India	Prospective observational clinical study	20 patients	Adults aged 18-65 years with Gustilo-Anderson type II, IIIA and IIIB open tibial fractures; 7 patients had bone loss and 6 underwent corticotomy.	Early debridement and Ilizarov circular external fixation; assessment of union, weight-bearing, complications and function using Johner-Wruhs criteria.	All fractures united with mean union time 24.1 +/- 3.4 weeks. Early weight-bearing was achieved by day 2 in all patients; excellent/good outcomes occurred in 90%. Pin-tract infection occurred in 55%, but no deep infection or nonunion was reported.

Section 3: Results Summary

Eight human studies were included after exclusion of the animal-based Rahal et al. report. The included evidence comprised two case reports/case-based reports, one systematic review, one retrospective case series and four prospective observational studies [1-8]. Most studies addressed open tibial fractures, while one retrospective series evaluated open or comminuted femoral fractures [4].

Nozaka et al. described a Gustilo-Anderson type IIIC distal tibial open fracture with severe contamination, vascular injury, osteoporosis and a 75-mm bone defect. Acute shortening enabled vascular repair, followed by Ilizarov fixation and gradual lengthening. Union was achieved, the fixator was removed at 12 months, and at 5-year follow-up the patient was fully weight-bearing without aids, returned to work and had an AOFAS score of 95 [1]. Alpharian and Robiady reported a Gustilo IIIB open tibial fracture with a 7-cm bone defect managed initially by Ilizarov fixation, segmental resection and bone transport, followed by staged conversion and grafting, with acceptable bone formation and no clinical infection [2].

Fenga et al. systematically reviewed staged conversion after circular ring external fixation in adult open long-bone fractures. Eight studies involving 303 patients were included, with six acute trauma cohorts in the primary synthesis. Staged conversion may reduce frame-related morbidity in selected cohorts, but effects on deep infection and union remained uncertain due to small retrospective studies, inconsistent definitions and confounding by indication [3].

Lovisetti et al. reported 23 open or comminuted femoral fractures treated definitively with circular fixators, including 13 open fractures and two cases with acute femoral bone loss. Twenty-two fractures united primarily, mean union time was 23.1 weeks, no deep pin-tract infection occurred, and most ASAMI bone and functional results were excellent or good [4].

Prospective tibial fracture studies from India consistently reported high union rates with Ilizarov fixation. Bhosale and Naikwade reported union in all 30 open tibial fractures, with pin-site infection in 36.67% and delayed union in 13.33% [5]. Wani et al. reported union in all 60 type II/IIIA/IIIB open tibial fractures, including 11 patients with 3-7.2 cm bone loss treated by lengthening; final outcomes were excellent or good in most cases [6]. Heisnam Singh et al. reported 26 open tibial fractures with average union times of 20.3-25.4 weeks by Gustilo grade and 29.8 weeks in bone-loss cases; no deep infection occurred, but two nonunions were reported [7]. Romeo et al. reported 20 open tibial fractures with 100% union, early weight-bearing by day 2 in all patients and excellent/good outcomes in 90%, though pin-tract infection occurred in 55% [8].

Overall, the evidence supports circular/ring external fixation as a valuable option in selected open injuries with bone loss or severe soft-tissue compromise, particularly when internal fixation is unsafe or when bone transport/lengthening is anticipated. However, the evidence does not establish a definitive universal role because most studies are small, observational and heterogeneous, and comparative evidence remains limited [3-8].

Section 4: Discussion

The role of circular or ring external fixators in acute open injuries with bone loss is clinically important but remains incompletely defined. The included studies show that Ilizarov-based circular fixation can provide stable fixation, preserve biology, allow wound access, facilitate early weight-bearing and enable bone transport or gradual lengthening when bone loss is present [1-8]. These advantages are particularly relevant in Gustilo-Anderson type IIIB and IIIC injuries, contaminated wounds, poor soft-tissue envelopes, vascular repair settings and segmental defects where acute internal fixation may be unsafe [1,2,6-8].

The strongest direct evidence for open injuries with large bone defects comes from case-based reports and observational series. Nozaka et al. demonstrated that acute shortening combined with Ilizarov fixation and later lengthening can salvage a Gustilo IIIC tibial injury with a 75-mm defect and vascular injury [1]. Alpharian and Robiady similarly showed that Ilizarov bone transport can be incorporated into a staged pathway for a Gustilo IIIB tibial injury with a 7-cm defect [2]. Wani et al. provided larger prospective evidence in open tibial fractures, including 11 patients with bone loss of 3-7.2 cm, all of whom achieved union with a healing index of 1.5 months/cm after lengthening [6]. Heisnam Singh et al. also reported a longer union time in bone-loss cases than in uncomplicated type II/IIIA/IIIB fractures, supporting the clinical reality that segmental defects require prolonged treatment even when Ilizarov fixation is effective [7].

Observational evidence also supports definitive ring fixation in selected high-energy open or comminuted fractures. Lovisetti et al. reported reliable union and good functional outcomes in open or comminuted femoral fractures treated definitively with circular fixators, including cases with acute femoral bone loss [4]. Bhosale and Naikwade, Heisnam Singh et al. and Romeo et al. reported favourable outcomes in open tibial fractures, including high union rates, early mobilisation and mostly manageable pin-tract complications [5,7,8]. These studies suggest that circular fixation can be used not only as a temporary damage-control method but also as a definitive reconstructive strategy when applied by experienced teams with appropriate follow-up and rehabilitation.

Nevertheless, the 2026 systematic review by Fenga et al. highlights the uncertainty around staged conversion after circular fixation [3]. Although conversion to internal fixation may reduce frame-related morbidity in selected patients, its effects on deep infection and union remain uncertain. This uncertainty reflects inconsistent infection definitions, small sample sizes, heterogeneous fracture patterns, variable soft-tissue protocols and confounding by indication [3]. Therefore, the decision to retain the frame until union or convert to internal fixation should be individualized according to soft-tissue stability, infection risk, pin-tract status, patient tolerance, defect reconstruction strategy and surgeon expertise.

Complications remain clinically important. Pin-tract infection was common in tibial fracture series, ranging from 36.67% to 55% in recent prospective studies, although most infections were superficial and controlled with local care and antibiotics [5,7,8]. Frame discomfort, joint stiffness, prolonged treatment duration, docking-site problems, delayed union, nonunion and need for secondary procedures are relevant disadvantages [2,5-8]. These limitations are important because success with ring fixators depends not only on surgical technique but also on patient compliance, access to regular follow-up, physiotherapy and limb reconstruction expertise.

The evidence base remains limited. There are no high-quality randomised trials specifically evaluating circular fixators versus monolateral external fixation, internal fixation, Masquelet technique, vascularised fibular grafting or early amputation in acute open injuries with bone loss. Most studies are observational and focus on tibial fractures; femoral data are limited, and evidence for other long bones is scarce [3-8]. Outcome measures are also heterogeneous, including ASAMI, Tucker, Johner-Wruhs and descriptive union/complication reporting [4-8].

Overall, circular/ring external fixators should be considered a selective, versatile tool rather than a universal standard. They are especially useful when contamination, soft-tissue compromise, bone loss or vascular injury makes internal fixation unsuitable, or when bone transport and gradual lengthening are anticipated. Current evidence supports feasibility and favourable outcomes in selected patients, but stronger prospective comparative studies are needed to define indications, timing, defect-size thresholds, complication rates, functional outcomes and cost-effectiveness.

Section 5: Risk of Bias of Included Studies

Overall Risk of Bias: MODERATE TO HIGH

The overall risk of bias is moderate to high. The evidence includes two case reports/case-based reports, retrospective and prospective observational series, and one systematic review of predominantly small retrospective studies [1-8]. Although the number of human studies has increased to eight, most are non-randomised, single-centre and subject to selection bias.

The main sources of bias include small sample sizes, absence of control groups in most studies, confounding by injury severity, heterogeneity of fracture sites and Gustilo grades, variable soft-tissue management, inconsistent definitions of infection and union, and differing outcome measures [1-8]. Several studies included selected patients suitable for Ilizarov fixation, which may overestimate success compared with an unselected open-injury population.

The systematic review improves evidence mapping, but it also concluded that current data are low-certainty because studies were methodologically heterogeneous and dominated by small retrospective cohorts [3]. Recent prospective studies support favourable union and function, but their lack of comparison groups limits causal inference [5-8]. Therefore, the evidence supports feasibility and selected clinical utility, but does not prove superiority over alternative reconstruction strategies.

Section 6: Response / Recommendation

Circular/ring external fixators have a useful role in selected acute open injuries with segmental bone loss, particularly when contamination, soft-tissue compromise, infection risk, vascular injury or anticipated bone transport makes internal fixation unsuitable [1-8].

However, current evidence is insufficient to recommend them as a definitive standard for all open injuries with bone loss; their use should be individualized and preferably undertaken by an experienced limb reconstruction/orthoplastic team [3-8].

Section 7: Level / Strength of Evidence

Level / Strength of Evidence: LOW

The strength of evidence remains low. Although eight human studies were included, the evidence base consists mainly of case reports, small observational cohorts and one systematic review that itself concluded that the available comparative evidence is low certainty [1-8]. Most studies report favourable outcomes such as union, infection control, limb salvage, early weight-bearing and functional recovery, but these outcomes are derived from non-randomised and heterogeneous populations.

The recommendation could not be graded as moderate or high because of small sample sizes, lack of randomised or robust comparative studies, variable inclusion criteria, inconsistent outcome definitions and limited adjustment for confounding factors such as Gustilo grade, bone loss, contamination, soft-tissue cover and patient physiology [3-8].

Therefore, current evidence supports a low-strength recommendation for selective use of circular/ring external fixators in carefully chosen acute open injuries with bone loss, especially where bone transport, staged reconstruction or soft-tissue access is required.

References

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