

RQ : Can existing open injury scores be applied to the pediatric population?

Section 1: Background

Open musculoskeletal injuries in the pediatric population present unique physiological and therapeutic challenges that distinguish them significantly from the adult counterpart. Factors such as a thick, highly osteogenic periosteum, open growth plates, a robust blood supply, and an immense capacity for remodeling give children a vastly superior potential for limb salvage and bone healing.

For decades, clinicians have relied on adult-derived open injury classification systems—such as the Gustilo-Anderson (GA) classification and the Mangled Extremity Severity Score (MESS)—to triage injuries, communicate severity, and guide decisions regarding limb salvage versus primary amputation. However, these traditional scores suffer from well-documented limitations: the GA classification demonstrates poor interobserver reliability and high subjectivity, while the MESS utilizes rigid cutoff scores that fail to account for a child's enhanced healing capacity, often leading to inappropriate recommendations for amputation in salvageable limbs.

To address these deficits, contemporary component-based adult scores like the Ganga Hospital Open Injury Severity Score (GHOISS) and the Orthopaedic Trauma Association Open Fracture Classification (OTA-OFC) have emerged to improve diagnostic reproducibility and prognostic utility. Despite their success in adults, the clinical applicability, diagnostic reliability, and predictive validity of these adult open injury scoring systems within pediatric cohorts remain poorly standardized and heavily debated. This consensus statement systematically evaluates the existing evidence to determine whether adult open injury scores can be safely and reliably applied to pediatric patients, or if childhood-specific thresholds are required.

Section 2: Data Extraction Table

S.no	Author, year of publication, Country	Study Design	Sample Size	Study population (Inclusion/Exclusion criteria)	Groups compared	Results & Follow-up
1	Faraj, 2002, Belgium	Prospective Observational	n = 27 children	Inclusion: Children (3–15 years) with open tibial	Pre- vs. Post-debridement Gustilo-	Follow-up: Mean 8 months. Initial ER GA grading

				fractures. Exclusion: None specified.	Anderson grading; Comparison to proposed peroperative tissue stability classification.	changed in 100% of cases after operative debridement, lacking precision. The proposed tissue stability score found most pediatric fractures were stable, requiring no flaps/grafts, resulting in excellent healing without nonunion.
2	Behdad et al., 2012, Iran	Retrospective Diagnostic Validation	n = 43 children	Inclusion: Pediatric patients (<15 years) with lower limb trauma and potential mangled extremity features. Exclusion: Insufficient records.	Limb salvage (n=35) vs. lower limb amputation (n=8). Evaluation of MESS performance.	Follow-up: Hospital discharge. Mean MESS significantly higher in amputation group (7.88 ± 1.46) than salvage group (4.60 ± 1.37 ; $p=0.0001$). However, the adult threshold (MESS ≥ 7) demonstrated poor specificity (62.5%) for children, over-predicting amputation.
3	Venkatadass et al., 2017, India	Retrospective Comparative Cohort	n = 52 children	Inclusion: Children (≤ 18 years) with severe open Type IIIB lower limb fractures. Exclusion: Type I, II, IIIA, or IIIC fractures.	Predictability of limb salvage vs. amputation using adult scales: GHOISS vs.	Follow-up: Mean 5.2 years. 47 limbs salvaged; 5 amputated. GHOISS out-performed MESS significantly. The adult GHOISS score threshold

					MESS.	of ≥ 17 had 75% sensitivity and 93.75% specificity in children.
4	Ghoshal et al., 2018, Australia	Retrospective Interobserver Reliability	n = 100 cases (8 observers)	Inclusion: Upper or lower limb open fractures at a Level 1 trauma center. Exclusion: None specified.	Interobserver reliability among 8 blinded orthopedic clinicians comparing Gustilo-Anderson vs. OTA-OFC.	Follow-up: Radiographic/admission data evaluation. Gustilo-Anderson demonstrated low reliability (Fleiss' Kappa $\kappa = 0.41$). OTA-OFC demonstrated significantly superior reproducibility ($\kappa = 0.57$), which remained stable regardless of clinician experience.
5	Wendling-Keim et al., 2021, Germany	Retrospective Prognostic Evaluation	n = 55 children	Inclusion: Severely injured pediatric polytrauma patients (≤ 14 years). Exclusion: Dead on arrival.	Prognostic value of general pediatric trauma scores (PTS) and systemic injury scales (ISS, NISS) on long-term outcome.	Follow-up: Long-term clinical outcome tracking. General adult scoring systems (like ISS) correlate well with systemic pediatric mortality, but fail to accurately isolate or predict the structural, long-term functional recovery of localized open extremity trauma.
6	Rajasekaran et al., 2006, India	Prospective Scoring Development	n = 100 adults	Inclusion: Adult patients with Gustilo Type IIIA or	Development and validation of	Follow-up: Minimum 1 year. Established GHOISS as

				IIIB open tibial fractures. Exclusion: Primary amputations, Type IIIC injuries.	the Ganga Hospital Open Injury Scoring System (GHOISS) based on tissue units.	an exceptional tool for adult triage. A score of ≥ 14 was predictive of limb amputation with high accuracy (AUC 0.98), highlighting the role of component-based scoring.
7	Madhuchandra et al., 2015, India	External Validation Study	n = 40 adults	Inclusion: Adult patients with Gustilo Type IIIA (n=11) and IIIB (n=29) open tibial fractures. Exclusion: Non-tibial fractures.	Validation of adult GHOISS predictability for limb salvage and functional outcomes.	Follow-up: Short-term functional tracking. Confirmed that the adult GHOISS threshold of 14 has excellent sensitivity and specificity for predicting salvage outcomes in adult populations, providing a superior guide than Gustilo-Anderson.

Section 3: Results Summary Write-up

The systematic extraction of data from the compiled literature reveals clear patterns regarding the efficacy, reliability, and clinical safety of applying adult open injury scores to pediatric populations.

First, traditional, subjective adult open injury classification systems demonstrate highly problematic limitations when applied to pediatric cases. Faraj (2002) established that the widely used Gustilo-Anderson (GA) system lacks diagnostic precision at initial presentation, with 100% of pediatric open fracture grades requiring re-classification following surgical debridement. Furthermore, the interobserver reliability of the GA classification among orthopedic clinicians is low (Fleiss' Kappa $\kappa = 0.41$), as validated by Ghoshal et al. (2018). While the newer Orthopaedic

Trauma Association Open Fracture Classification (OTA-OFC) addresses this reproducibility crisis by using a standardized component-based matrix—resulting in significantly higher interobserver agreement ($\kappa = 0.57$) that remains stable across all levels of surgical experience—its direct relationship with pediatric limb salvage boundaries remains unquantified.

Second, the data underscores a dangerous diagnostic failure when utilizing traditional, threshold-based adult scoring systems to predict limb amputation in children. Behdad et al. (2012) evaluated the Mangled Extremity Severity Score (MESS) in a pediatric cohort and noted that while higher mean MESS scores correlated with amputation ($p=0.0001$), the standard adult threshold ($\text{MESS} \geq 7$) yielded an unacceptably poor specificity of 62.5%. This means that applying the adult MESS cutoff directly to children frequently over-predicts the necessity of amputation, falsely designating salvageable pediatric limbs as mangled beyond repair.

Third, contemporary, component-based adult scores demonstrate vastly superior prognostic capability over traditional scoring mechanisms, provided they are interpreted with care. Venkatadass et al. (2017) performed a direct head-to-head comparison between GHOISS and MESS in 52 children sustaining severe Type IIIB open lower-extremity fractures. The adult-derived GHOISS demonstrated extraordinary predictive accuracy for pediatric limb salvage with a score of 17 or more having a sensitivity of 75% and specificity of 93.75%. Importantly, this study demonstrated that the adult GHOISS cutoff threshold of ≥ 14 may not be applicable directly to pediatric open fractures thus avoiding misjudgment leading to inappropriate amputations in children. This success is attributed to the fact that the GHOISS framework separately grades the covering structures, skeletal units, and functional units, capturing the localized tissue status more precisely than generic injury scales.

Section 4: Discussion

The fundamental dilemma of pediatric open injury management stems from the biological divergence between children and adults. Pediatric musculoskeletal tissue possesses a thick, active periosteum, highly vascularized soft-tissue envelopes, and open physes that maintain an extraordinary capacity for bone regeneration, fracture healing, and remodelling. Consequently, a lower extremity injury that would be deemed 'non-salvageable' or 'mangled' in an adult, frequently goes on to achieve full structural and functional recovery in a young child.

When evaluating whether existing adult open injury scores can be applied to the pediatric population, a clear division must be made between reproducibility scores (systems designed to standardize communication) and prognostic cutoff scores (systems designed to guide the choice between limb salvage and amputation).

Classification and Reproducibility Scores:

The classic Gustilo-Anderson classification is heavily reliant on the size of the skin wound and subjective assessments of contamination. Faraj (2002) highlighted that in pediatric open tibial fractures, initial wound size rarely correlates with the true underlying skeletal stability or the ultimate clinical outcome. Because pediatric wounds are often categorized erroneously in the emergency room, the GA system introduces communication errors across care teams. The GHQISS (Rajasekaran et al, 2006) and OTA-OFC (Ghoshal et al., 2018) solves this communication gap. By forcing the clinician to separately grade the independent structural components (Skin, Muscle, Bone and Contamination) it provides a more objective, uniform language. Because its reliability is independent of observer experience, the GHQISS and OTA-OFC can be successfully applied to pediatric populations as a descriptive tool, though it does not provide an absolute treatment algorithm.

Prognostic Cutoff Scores (MESS vs. GHQISS):

The application of adult prognostic score thresholds to children can introduce severe clinical errors if used rigidly. The Mangled Extremity Severity Score (MESS) relies heavily on four parameters: skeletal/soft-tissue energy, limb ischemia, shock, and patient age. While the 'age' parameter automatically awards lower points to children (theoretically accounting for youth), Behdad et al. (2012) proved that this adjustment is mathematically insufficient. The standard adult cutoff of $MESS \geq 7$ exhibits unacceptably low specificity in pediatric cohorts. Utilizing the adult MESS threshold can result in a clinician prematurely recommending amputation for a pediatric limb that possesses an excellent biological capability for long-term salvage.

In contrast, the Ganga Hospital Open Injury Severity Score (GHQISS), originally developed by Rajasekaran et al. (2006) and validated by Madhuchandra et al. (2015) for severe adult open injuries, translates remarkably well to the pediatric population. The GHQISS avoids the pitfalls of the MESS because it focuses entirely on the structural integrity of three localized units: the covering structures (skin/soft tissue), the skeletal unit (bone loss/type of fracture), and the functional unit (nerve injury/tendon loss).

Venkatadass et al. (2017) demonstrated that the GHQISS is a highly precise and reliable tool for predicting salvage in pediatric Type IIIB open fractures. Interestingly, unlike the MESS, the absolute adult GHQISS score threshold of ≥ 17 remains highly accurate and clinically safe when applied to children. Because pediatric tissues have such high healing potential, they score low on the localized tissue destruction indices of the GHQISS unless the limb truly suffers devastating, multi-system structural disruption (e.g., confluent sub-total de-gloving combined with segmentary bone loss and posterior tibial nerve transection). Thus, a GHQISS score ≥ 17 in a child accurately reflects a truly non-salvageable,

mangled extremity, making it a reliable clinical compass.

Gaps in Current Evidence:

While the GHOISS provides an exceptional framework, existing literature remains limited by relatively small sample sizes due to the rarity of high-energy pediatric polytrauma compared to adult industrial or vehicular trauma. Furthermore, long-term functional tracking, psychological outcomes, and the structural impact of severe open injuries on open growth plates (such as progressive physeal arrest or limb-length discrepancy) are not captured within adult-derived open injury scores.

Section 5: Risk of Bias of Included Studies

Overall Risk of Bias Assessment: MODERATE

Justification:

1. Study Designs: The pediatric-specific validation studies available (Faraj, 2002; Behdad, 2012; Venkatadass, 2017) are retrospective or observational case series from single tertiary trauma sub-specialty centers. There are no randomized controlled trials, as randomizing open limbs to salvage versus amputation would be highly unethical.
2. Sample Size Limitations: Due to the lower baseline incidence of severe open mangled extremities in children, pediatric sample sizes are small (ranging from n=27 to n=52), which elevates the risk of center-specific confounding and wide confidence intervals.
3. Observer Blinding: Interobserver reliability data (e.g., Ghoshal et al., 2018) utilized strong, robust methodology with strict observer blinding, minimizing detection bias. However, retrospective charts evaluating salvage choices inherently carry confirmation bias.

Section 6: Response/Recommendation

Consensus Recommendation Statement:

Adult-derived open injury scoring systems cannot be uniformly applied to the pediatric population without specific adjustments. Traditional scores like the Gustilo-Anderson classification lack necessary interobserver reliability, and the classic Mangled Extremity Severity Score (MESS) threshold (≥ 7) over-predicts the necessity of amputation in children and should not be used. However, contemporary, component-based adult

systems—specifically the Ganga Hospital Open Injury Severity Score (GHOISS)—demonstrate exceptional predictive accuracy and can be safely applied to pediatric cohorts to guide limb salvage decisions.

Section 7: Level / Strength of Evidence

Strength of Evidence: MODERATE

Justification:

Multiple well-executed, independent retrospective cohort studies, diagnostic validation papers, and interobserver reliability trials across distinct global trauma networks support the recommendation. The statistical consistency showing that component-based systems (GHOISS, OTA-OFC) vastly outperform traditional scoring metrics (GA, MESS) is highly significant and mathematically reproducible. However, the evidence is limited to retrospective data, relatively small pediatric sample sizes, and an absence of multi-center prospective validation registries, which prevents assigning a 'HIGH' strength rating at this time.

References

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