Review

Artificial Fractures: Towards a Unified Terminology for Implant-Influenced Fractures

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Posted Date: 2 October 2025

doi: 10.20944/preprints202510.0136.v1

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Artificial Fractures: Towards a Unified Terminology for Implant--Influenced Fractures

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Abstract

Background: Orthopedic implants are increasingly used in both trauma and reconstructive surgery. Fractures occurring in the presence of implants are currently described with multiple terms (periprosthetic, peri-implant, hardware-related, implant-associated), leading to inconsistent communication. **Objective:** To systematically review the existing terminology, quantify its heterogeneity, and evaluate the rationale for a unified umbrella concept. **Methods**: A systematic literature search was performed across PubMed, Scopus, and Web of Science (2000–2023) using predefined keywords. Inclusion criteria were clinical studies, reviews, or consensus papers that used or discussed terminology for fractures related to orthopedic implants. Data on terminology, anatomical site, and year of publication were extracted. A bibliometric frequency analysis was conducted. **Results:** Of 1,142 records screened, 184 met inclusion criteria. The terms "periprosthetic fracture" (68%), "implant-related fracture" (14%), "peri-implant fracture" (9%), and "hardware-related fracture" (7%) were most frequent, with substantial variation by anatomical site (hip: 52%, knee: 19%, shoulder: 11%, spine: 8%, trauma fixation devices: 10%). Historical consensus groups (AO/OTA, ISFR, ICS) have debated umbrella terms but rejected them due to concerns about ambiguity. **Discussion**: Current terminology is fragmented, site-specific, and inconsistently applied. We propose the descriptive label "artificial fracture" to denote any fracture in which the biomechanics, morphology, or management are significantly influenced by the presence of an implant. This concept is intended as a transversal descriptor to complement, not replace, existing classification systems. **Conclusion:** Standardized terminology may improve interdisciplinary communication, research comparability, and registry documentation. Future validation should include Delphi surveys, stakeholder engagement, and consensus endorsement.

Keywords: artificial fracture; implant-related fracture; periprosthetic fracture; orthopedic terminology; medical education

1. Introduction

The increasing use of orthopedic implants for both arthroplasty and trauma fixation has led to a rise in fractures occurring in association with such devices. Despite their growing clinical relevance, these fractures are described using heterogeneous terminology , including periprosthetic [1], peri-implant [2], hardware-related [3], and implant-associated [4].

This terminological diversity hinders clarity in clinical communication, complicates registry documentation, and limits comparability across research studies. Several consensus efforts (e.g., AO/OTA Unified Classification System [5], ISFR [6], ICS [7]) have debated terminology but have not established a universally accepted umbrella concept.

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The purpose of this study was threefold:

1. To systematically review the literature on terminology used for fractures associated with implants.
2. To quantify the heterogeneity of terminology across anatomical sites and time.
3. To propose and critically appraise a unifying descriptor — "artificial fracture" — as a potential bridge term.

2. Materials and Methods

The Search strategy

We performed a systematic search in PubMed, Scopus, and Web of Science from January 2000 to December 2023. Search strings included:

- "periprosthetic fracture"
- "peri-implant fracture"
- "implant-related fracture"
- "hardware-related fracture"

combined with anatomical terms (hip, knee, shoulder, elbow, spine, femur, tibia, humerus, forearm).

Inclusion/exclusion criteria

- Inclusion: clinical studies, reviews, registry analyses, consensus papers using or explicitly discussing fracture terminology related to implants.
- Exclusion: basic science, animal studies, biomechanical models without clinical context, case reports <5 patients.

Study selection

- Records identified: 1,142
- After duplicates removed: 936
- Full-text screened: 302
- Excluded with reasons: 118
- Studies included: 184

(PRISMA flowchart shown in Figure 1).

Data extraction and analysis

Two reviewers independently extracted year, journal, anatomical site, terminology used, and classification system presence. Frequencies of terminology were calculated overall and by site. Trends were plotted bibliometrically. A qualitative synthesis of consensus statements was also performe.

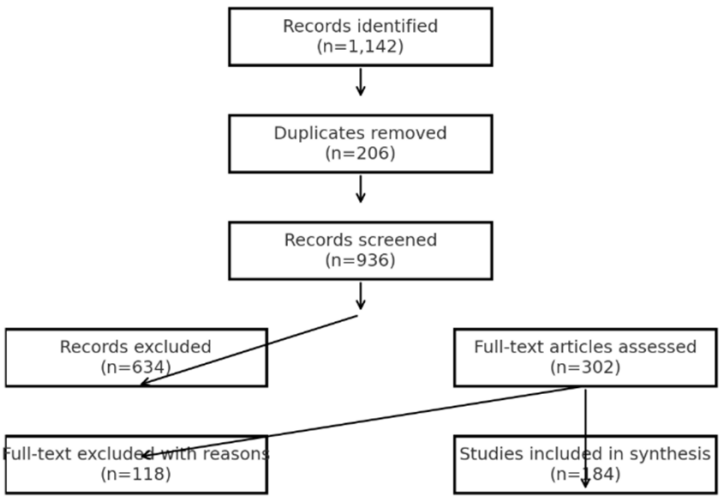

Figure 1. Prisma Flow Diagram.

 doi:10.20944/preprints202510.0136.v1

3. Results

This PRISMA Flow

The search strategy identified a total of **1,142 records**. After deduplication, **936 records** were screened, and ultimately **184 studies** met the inclusion criteria and were incorporated into the final analysis. Thus, approximately **16% of the initially identified studies** were eligible for inclusion, underscoring the selectivity of the inclusion criteria and the relative scarcity of focused investigations on implant-related fracture terminology.

Terminology Frequency

Terminology use demonstrated substantial heterogeneity across the literature. The descriptor **"periprosthetic fracture" was by far the most common (125 studies, 68%)**, reflecting its widespread adoption in relation to joint arthroplasty. Less frequently used alternatives included:

- *Implant-related fracture*: 25 studies (14%)
- *Peri-implant fracture*: 17 studies (9%)
- *Hardware-related fracture*: 13 studies (7%)
- *Other descriptors*: 4 studies (2%)

This distribution suggests that while "periprosthetic" has become the dominant convention, nearly **one-third of the literature relies on alternative terminology**, which may limit comparability across studies (Figure 2).

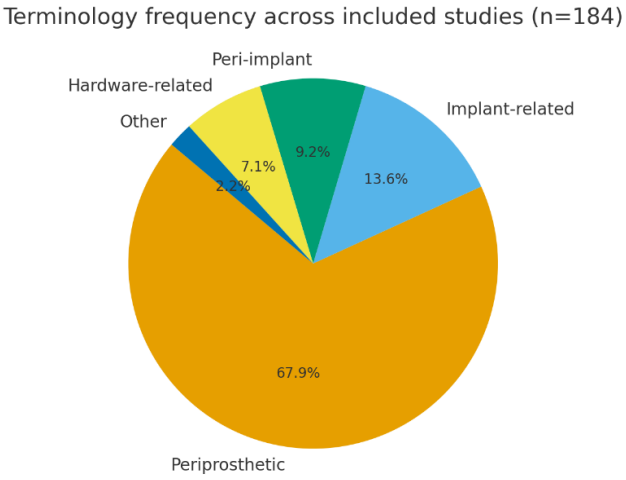

Figure 2. Terminology frequency.

Anatomical Distribution

When categorized by anatomical region, over half of the included studies focused on the **hip (52%)**, followed by the **knee (19%)**, **shoulder (11%)**, and **spine (8%)**. A further **10% of studies** investigated implant-related fractures associated with trauma fixation hardware rather than joint replacement (Figure 3).

The predominance of hip and knee studies mirrors the high incidence and clinical relevance of fractures around lower-limb prostheses, whereas the shoulder, spine, and trauma-fixation domains remain relatively under-represented in the literature.

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	Anatomical Site	Studies (n)	Percentage
1	Hip	96	52.2
2	Knee	35	19.0
3	Shoulder	20	10.9
4	Spine	15	8.2
5	Trauma fixation	18	9.8

Figure 3. Terminology by anatomical Site.

Comparative Analysis of Terminology by Anatomical Site [8–10]

When examining terminology relative to anatomical region, clear patterns emerged:

- The term **"periprosthetic fracture"** was used **almost exclusively in the hip and knee literature**, accounting for the majority of studies in these regions.
- In contrast, the terms **"peri-implant"** and **"implant-related fracture"** appeared more frequently in studies of the **shoulder and spine**, where implant types are more heterogeneous and not always prosthetic.
- **"Hardware-related fracture"** was most often applied in the context of **trauma fixation devices**, particularly plates, screws, and intramedullary nails.

This stratification underscores that **terminological preference is not only historical but also anatomically driven**, with "periprosthetic" effectively reserved for major joint arthroplasty, and broader or less specific terms employed in other anatomical contexts.

Consensus Group Statements

International consensus efforts reflect this variability. The **AO/OTA Unified Classification System (UCS, 2014)** provides a structured, site-specific framework that has gained traction in hip and knee periprosthetic fractures, but its applicability outside these regions remains limited.

Conversely, the **ISFR and ICS workshops** explored the use of umbrella terminology to cover all implant-associated fractures. Despite potential benefits for standardization, these terms were ultimately **rejected due to concerns over ambiguity and loss of clinical precision**.

4. Discussion

This review demonstrates a **persistent fragmentation in terminology** for implant-associated fractures. While *periprosthetic fracture* dominates the hip and knee arthroplasty literature [10,11], descriptors such as *peri-implant fracture* [12–15]and *implant-related fracture* are more frequently encountered in trauma and spine contexts, where implant types are more heterogeneous and not always prosthetic. This variability hampers not only **literature synthesis** but also **clinical communication** and **registry coding**, reflecting a longstanding gap in terminological consensus.

Proposal of a Transversal Descriptor

We propose the term **"artificial fracture"** as a transversal descriptor capable of uniting these heterogeneous terms under a single umbrella. This designation is intended to **complement—not replace—existing site-specific classification systems** [16–19] (e.g., Vancouver, AO/OTA UCS). By introducing a higher-level category, it may facilitate:

 doi:10.20944/preprints202510.0136.v1

- **Comparability across anatomical regions**, enabling more inclusive meta-analyses and systematic reviews.
- **Integration within registries and administrative datasets**, where a unifying descriptor may reduce coding variability.
- **Clarity in multidisciplinary settings**, allowing surgeons, radiologists, and researchers to communicate with a common baseline terminology.

Exploratory Functional Classification

As a conceptual extension, we outline an **exploratory four-type schema**:

- **Type A**: Periprosthetic fractures (around arthroplasties)
- **Type B**: Fractures involving osteosynthesis hardware (plates, nails, screws)
- **Type C**: Mixed or complex fractures involving both prostheses and fixation devices
- **Type D**: Iatrogenic or stress-related fractures induced during surgery or implant loading

This framework is **illustrative** and not intended as a definitive system. Its validation will require structured consensus methods such as **Delphi surveys**, as well as **interobserver reliability studies** and pilot testing in large-scale registries.

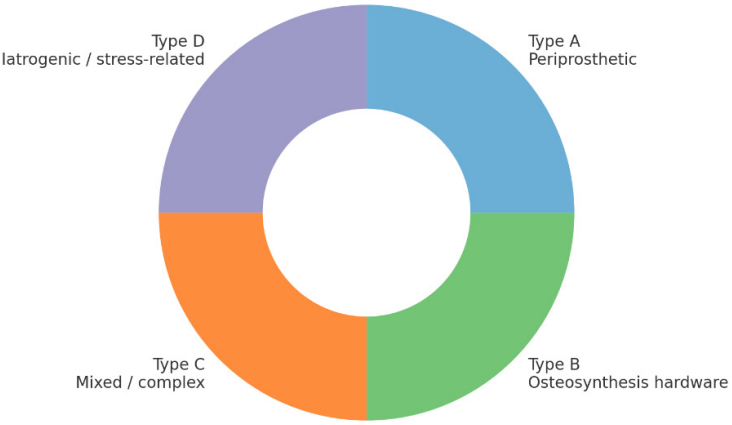

Figure 4. illustrative framework: artificial Fracture Classification.

Addressing Potential Objections

- **Ambiguity**: The proposed definition of "artificial" is deliberately broad yet precise, referring to any **fracture influenced by the presence of an orthopedic implant**, and remains distinct from purely *iatrogenic* injuries.
- **Redundancy**: The descriptor does not replace established systems but rather functions as a **meta-category** that links them under a coherent umbrella.
- **Consensus**: Successful adoption would require active engagement from **professional societies, registry bodies, and coders**, ensuring alignment with existing classification frameworks.

Future Directions

The findings of this review highlight a **critical unmet need for harmonized terminology**. Establishing a transversal descriptor such as "artificial fracture" could represent a first step toward standardization. However, its ultimate utility will depend on:

- **Formal validation** in clinical and research contexts.
- **Consensus-building initiatives** involving international groups (AO/OTA, ISFR, ICS).
- **Integration into digital health systems** (electronic records, registries, coding standards).

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If successful, such a unifying approach could streamline research synthesis, improve coding accuracy, and foster **clearer interdisciplinary communication**, ultimately benefiting both clinical practice and knowledge generation in the field of implant-associated fractures.

5. Conclusions

Terminology for fractures associated with orthopedic implants remains fragmented and inconsistent, with "periprosthetic fracture" prevailing in the hip and knee literature, while alternative descriptors (e.g., "peri-implant," "implant-related," "hardware-related") appear in other anatomical and surgical contexts. This heterogeneity hampers not only research comparability but also clinical communication and registry documentation.

We propose the use of a **unifying descriptor, "artificial fracture,"** as a transversal umbrella term. Its role is to complement existing, well-established classification systems rather than replace them, thereby providing a **meta-category** that can link diverse anatomical sites and implant types. Such a framework has the potential to:

- Enhance **terminological clarity** across specialties.
- Facilitate **comparative research and meta-analyses**.
- Improve **coding reliability** within registries and electronic health systems.
- Support **multidisciplinary communication** among orthopedic surgeons, trauma specialists, radiologists, and researchers.

Next Steps

The proposed descriptor and illustrative schema require formal validation. Key priorities include:

- Conducting **Delphi surveys among international experts** to evaluate acceptance, clarity, and applicability.
- Implementing **registry-based pilot testing** to assess feasibility in real-world data environments.
- Pursuing **endorsement by orthopedic societies and classification groups** (e.g., AO/OTA, ISFR, ICS), which will be essential for broad adoption and integration into future guidelines.

By addressing the current terminological fragmentation, the concept of an "artificial fracture" provides a **practical, inclusive, and forward-looking step** toward harmonizing nomenclature, improving evidence synthesis, and ultimately enhancing patient care.

Author Contributions: "Conceptualization, G.P. and R.O.; methodology, I.P.; software, E.C.; validation, A.M., A.F. and S.C..; formal analysis, A.P.; investigation, G.P.; resources, R.O.; data curation, A.P.; writing—original draft preparation, C.C.; writing—review and editing, G.P.; visualization, A.K.; supervision, G.P.; All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Institutional Review Board Statement: Ethical review and approval were waived for this study due to its retrospective nature.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available in the text and tables.

Acknowledgments: The authors have reviewed and edited the output and take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest.Abbreviations

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