

■ **SYSTEMATIC REVIEW**

What outcomes have been reported on patients following open lower limb fracture, and how have they been measured?

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Aims

Open lower limb fracture is a life-changing injury affecting 11.5 per 100,000 adults each year, and causes significant morbidity and resource demand on trauma infrastructures. This study aims to identify what, and how, outcomes have been reported for people following open lower limb fracture over ten years.

Methods

Systematic literature searches identified all clinical studies reporting outcomes for adults following open lower limb fracture between January 2009 and July 2019. All outcomes and outcome measurement instruments were extracted verbatim. An iterative process was used to group outcome terms under standardized outcome headings categorized using an outcome taxonomy.

Results

A total of 532 eligible studies were identified, reporting 1,803 outcomes with 786 unique outcome terms, which collapsed to 82 standardized outcome headings. Overall 479 individual outcome measurement instruments were identified, including 298 outcome definitions, 27 patient- and 18 clinician-reported outcome measures, and six physical performance measures. The most-reported outcome was 'bone union/healing' reported in over 50% of included studies, while health-related quality of life was only measured in 6% of included studies.

Conclusion

Outcomes reported for people recovering from open lower limb fracture are heterogeneous, liable to outcome reporting bias, and vary widely in the definitions and the measurement tools used to collect them. Outcomes likely to be important to patients, such as quality of life and measures of physical functioning, have been neglected. This systematic review identifies the need to unify outcome measures reported on patients recovering from open lower limb fracture; this may be addressed by creating a core outcome set.

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Keywords: Open fracture, Open lower limb fracture, Core outcome set, Outcome, Outcome measurement instrument

Article focus

- What outcomes have been reported in the academic literature on adult patients following open lower limb fracture over ten years?
- How have these outcomes been measured?

Key messages

- Existing literature on open lower limb fractures is of largely low-quality case series. It is hampered by outcome heterogeneity, wide variation in outcome definitions, use of multiple measurement

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tools, and infrequent collection of patient-reported outcome measures.

- This systematic review highlights significant inadequacies in outcome reporting in the current literature on open lower limb fracture, both in terms of outcome heterogeneity and a failure to report the most important outcomes from a patient perspective.

Strengths and limitations

- This systematic review provides a comprehensive overview of all outcomes and measurement instruments reported in the literature on open lower limb fracture over ten years.
- A search strategy updated after two years demonstrated data saturation in the number of outcomes reported on patients recovering from open lower limb fracture.

Introduction

Open lower limb fracture is a life-altering injury affecting 11.5 per 100,000 adults each year,¹ causing significant morbidity and mortality for patients and high resource demand on the UK trauma infrastructure.¹⁻³ Treatment is complex and multifaceted, such that an optimal treatment pathway for these devastating injuries remains unclear. Inconsistency in outcome reporting and poor-quality studies hamper attempts to evaluate new interventions to improve function, recovery experience, and investigation into the effects of regional variation of treatment on recovery.

Advancements in medical and surgical practice have expanded the proportion of severely injured limbs that are now amenable to limb salvage and reconstruction.⁴ Patient-centred care is a guiding principle of modern medical practice. The outcomes used in orthopaedic trauma research should reflect this, e.g. use of patient-reported outcome measures (PROMs). However, this does not appear to be reflected in the literature.^{4,5} Scoping literature searches demonstrate that most studies reporting outcomes on patients recovering from open lower limb fracture tend to measure outcomes indicative of surgical success, e.g. objective clinical measures including bone union, alignment, and infection status. These preliminary findings are supported by Morris et al,⁵ who demonstrate considerable outcome heterogeneity reported in studies on closed tibial fractures. Failure to measure patient-reported outcomes will continue to propagate a discord between the surgeon and patient perceptions of successful treatment. Inconsistency in outcome reporting in the literature hampers comparative research and the ability to produce high-level evidence to drive improvements in patient care.

Methods

This systematic review was registered on the Prospective Register of Systematic Reviews (PROSPERO CRD42015024219) and reported with the aid of the PRISMA Statement.

In a clinical trial, an outcome refers to what is being measured or reported by participants, which is used to examine the effect of the intervention. An outcome measurement instrument refers to how the outcome is measured. It is a tool to measure the quality or quantity of an outcome.

Search strategy. The EMBASE and MEDLINE bibliographic databases were searched using Ovid (Ovid Technologies 2020, Wolters Kluwer), and supplemented by PsychINFO, CINAHL, and Cochrane CENTRAL in the English language from 1 January 2009 to 20 April 2017. A search update was made in July 2019 of the EMBASE and MEDLINE databases (see Supplementary Material 1); 2009 was chosen as a cut-off due to the publication of British Orthopaedic Association/British Association of Plastic Reconstructive and Aesthetic Surgeons (BOA/BAPRAS) Joint Standards for Open Fracture Management.⁶ The introduction of the Joint Standards for Open Fracture Management in 2009 was a defining milestone in the modern management of open lower limb fracture in the UK, and has been widely adopted in many healthcare systems.⁴

Study eligibility and data extraction. Inclusion criteria were designed to maximize data capture. Any clinical study was included where outcomes were reported on more than one study participant, and 80% or more of study participants were over the age of 16 years and had an open lower limb fracture. An open lower limb fracture was defined as a break in any bone distal to the acetabulum of the hip joint where the bone is exposed to the outside environment, for example an open fracture of the femur or below.

Systematic reviews were included, as authors can specify novel outcomes (e.g. new composite outcomes derived from those reported in the literature). Study protocols were included where outcomes were described and defined a priori. Where an English-language abstract was available and reported outcomes, the article was included if the full text was non-English language. Where multiple papers were found reporting the same data, only the earliest article was included. Case reports were excluded as outcomes were only reported on individual cases. Other studies excluded were paediatric studies, laboratory studies, animal studies, expert opinions where no pooled outcomes were presented, and correspondence.

All titles and abstracts were screened independently by two researchers (ALA and HC or COA) using Rayyan (Qatar Computing Research Institute, Qatar) against eligibility criteria. Disagreements were resolved by discussion between reviewers. Full-text review and data extraction were conducted simultaneously. ALA undertook full-text screening and data extraction on all shortlisted studies. A random 10% and 15% sample of full texts were dual-screened and data-extracted by HC and COA in the primary and secondary searches, respectively. Samples from HC and COA were compared to ALA's for accuracy, suitability, and consistency of full-text screening and data extraction. A standardized data extraction sheet was

Table I. Data fields extracted at full-text review.

Study demographics	Study outcomes
Publication date	Primary outcome identified/defined
Study title	Extracted for each named outcome
Journal	Primary or secondary outcome
Journal reference (volume, issue, and page numbers)	Outcome wording (extracted verbatim)
Authors	Outcome definition
Language	OMI used
Location (country where research was conducted)	Timepoints measured
Abstract	Extracted for each OMI
Study design (e.g. RCT, cohort, case series)	OMI used
Study population (e.g. proportion of participants with open fracture)	Timepoints measured
Number of participants	Citation of OMI, where provided
Sex distribution of participants	
Age distribution of participants	
Study inclusion and exclusion criteria	

OMI, outcome measurement instrument; RCT, randomized controlled trial.

created using Google Sheets (Google, USA) and piloted before use to allow authors to simultaneously extract data; Table I details the data fields extracted from each included study.

All outcomes were extracted verbatim with any accompanying outcome measurement instruments used, including outcome definitions/outcome measurement instruments used. All extracted outcomes and outcome measurement instruments were specified in each study's methods or results section. Outcomes were defined where an outcome definition was provided or referenced with a citation. Where a citation defined an outcome, the outcome definition was extracted verbatim from the cited article. Where studies reported PROMs or physical performance measures without stating what outcomes they intended to measure, an overarching outcome was assigned.

Categorizing outcomes and outcome measurement instruments. Verbatim outcomes were reviewed in an iterative process to devise standardized outcome headings used to group outcomes. Outcome headings were often representative of the most common outcome wording reported in the literature (see Supplementary Material 2 for a complete list of verbatim outcomes and the standardized outcome headings).

Categorizing outcome measurement instruments. Each outcome measurement instrument was given an overarching outcome, used to group the outcome measurement instrument under a standardized outcome heading as devised in outcome extraction. Overarching outcomes for outcome measurement instruments were established using an adapted method described by Macefield et al⁷ or the outcome measurement instrument definition if provided.

All standardized outcome headings and outcome measurement instruments were organized and categorized using the Core Outcomes in Effectiveness Trials Initiative (COMET) Taxonomy of Outcomes.⁸ The COMET Taxonomy of Outcomes is a categorization system

designed by the COMET Initiative to provide sufficient granularity and scope for classifying all medical outcomes in core outcome set (COS) development. The COMET Taxonomy of Outcomes categorizes outcomes into 38 outcome domains within five core areas.⁸

Assessment of bias. There was no data synthesis of study effect sizes in this systematic review; therefore, no assessment of the methodological quality of the studies was conducted.

Results

A total of 26,988 articles were identified from a primary and updated search. After excluding duplicates and limiting date ranges, 4,143 articles were shortlisted for the title and abstract review. Article screening identified 606 articles for full-text review; the article screening conflict rate between authors was less than 5%. Following a full-text review, 532 articles were included detailing outcomes reported on 429,076 participants for inclusion. Comparing duplicate full-text review and data extraction by HC and COA to ALA revealed no conflicts in studies included/excluded, and no significant differences in data fields extracted. See the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow-chart in Figure 1 for the study identification process, and reasons for article rejection at full-text review.

There was a relatively even spread in the number of studies published between 2009 and 2019. Case series and cohort studies represented 53% and 29% of all included studies, respectively, and RCTs represented 5% (29 individual studies) (see Table II). The majority of included studies reported outcomes on between three and 50 participants (52% of included studies). Studies were mostly conducted from the USA, UK, and China (23%, 14%, and 13% of articles, respectively).

Outcomes reported. In total, 1,803 individual outcomes were extracted verbatim, from which 786 unique outcome terms were identified. The 786 outcome terms were grouped under 82 standardized outcome headings,

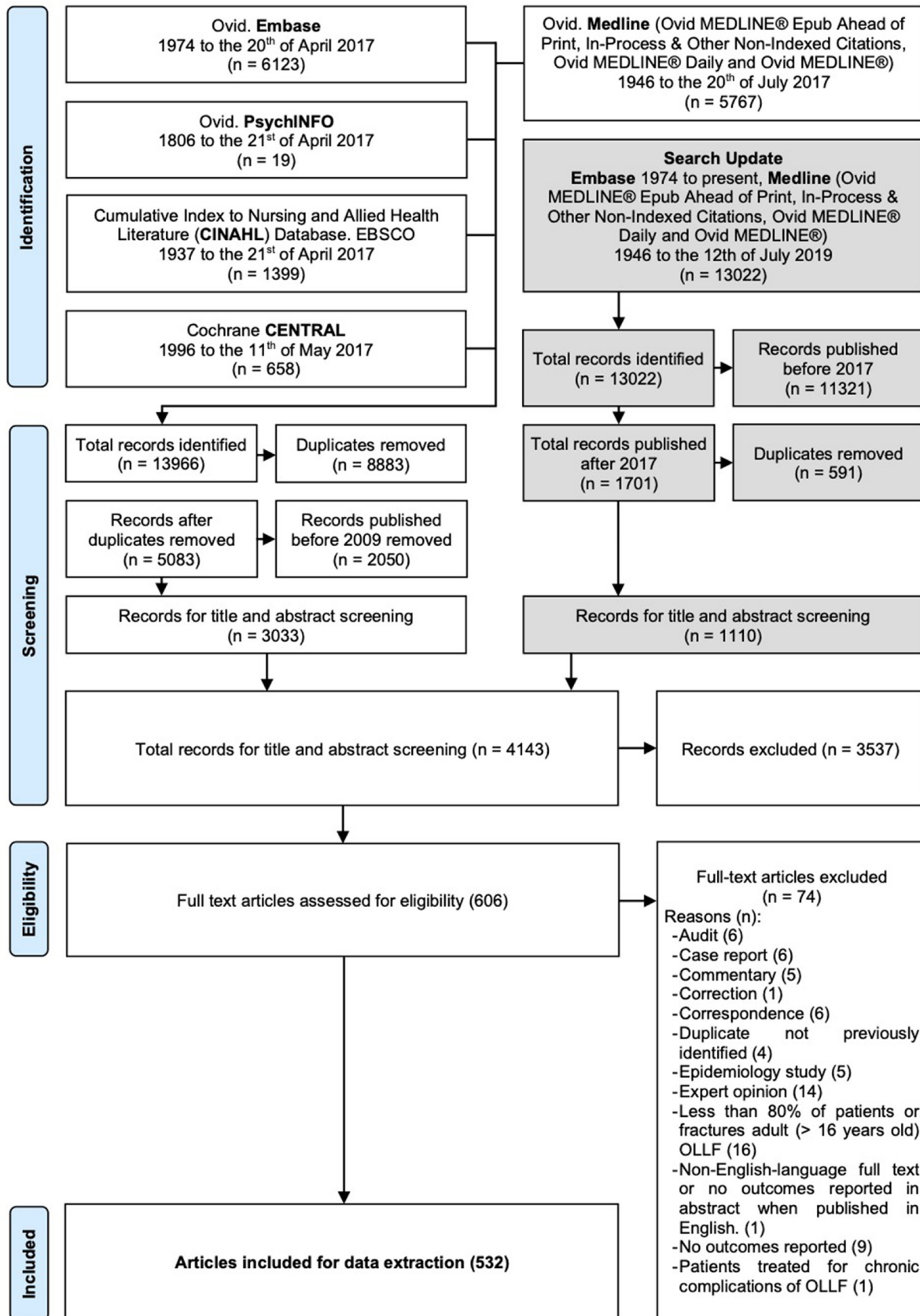


Fig. 1

Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram. OLLF, open lower limb fracture.

Table II. Summary characteristics and demographics of included studies.

Characteristic (number of studies reported)		Summary characteristics and demographics of included studies									
Publication year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Number of studies (%) (n = 532)	27 (5)	42 (8)	51 (9)	48 (9)	47 (8)	51 (9)	58 (11)	51 (9)	53 (10)	57 (11)	47 (9)
Study design	Case series	Retrospective cohort study	Prospective cohort study	Randomized controlled trial	Systematic review	Case-control	Health economic	Qualitative	Cross-sectional	Protocol	Other
Number of studies (%) (n = 523)	275 (53)	115 (22)	38 (7)	26 (5)	23 (4)	20 (4)	8 (2)	7 (1)	4 (1)	4 (1)	3 (1)
Number of participants (total: n = 429,076)	1 to 10	11 to 25	26 to 50	51 to 100	101 to 200	201 to 500	501 to 1,000	Greater than 1,000			
Number of studies (n = 500)	35 (7)	108 (22)	117 (23)	94 (19)	60 (12)	40 (8)	16 (3)	30 (6)			
Top 10 journals of publication	Injury	Journal of Orthopaedic Trauma	International Orthopaedics	The Bone & Joint Journal	China Journal of Orthopaedics and Traumatology	Journal of Reconstructive Microsurgery	Plastic and Reconstructive Surgery	Journal of Bone and Joint Surgery	Chinese Journal of Reparative and Reconstructive Surgery	Indian Journal of Orthopaedics	
Number of studies (n = 532)	56 (11)	17 (3)	16 (3)	12 (2)	11 (2)	11 (2)	11 (2)	10 (2)	9 (2)		
Top 10 countries of origin	USA	UK	China	India	Turkey	Pakistan	Italy	Canada	Germany	Iran	
Number of studies (n = 516)	117 (23)	71 (14)	68 (13)	37 (7)	22 (4)	18 (3)	17 (3)	12 (2)	10 (2)	9 (2)	

Table III. Outcome domains identified how they were reported in 532 studies on adult open lower limb fracture.

Outcome domain organized by the COMET Taxonomy of Outcomes, core areas and outcome domains	Individual outcomes reported	Unique outcome terms reported	Standardized outcome headings created	Outcome measurement instruments		
				Definitions stated	Individual patient/clinician-reported outcome measures or PPMs reported	Unique patient/clinician-reported outcome measures or PPMs reported
Death						
Mortality/survival (1)	21	7	1	3	1	1
Physiological/clinical						
Blood and lymphatic system outcomes (2)	10	8	1	0	0	0
General outcomes (9)	3	2	1	0	0	0
Musculoskeletal and connective tissue outcomes (15)	1,335	529	41	239	9	3
Nervous system outcomes (17)	0	0	0	0	1	1
Renal and urinary outcomes (19)	5	5	2	2	1	1
Psychiatric outcomes (21)	0	0	0	0	3	3
Life impact						
Physical functioning (25)	258	149	15	0	123	29
Social functioning (26)	4	4	2	0	0	0
Role functioning (27)	17	9	2	0	0	0
Emotional functioning/wellbeing (28)	11	9	5	0	2	2
Global quality of life (30)	32	7	1	0	39	8
Perceived health status (31)	2	1	1	0	0	0
Delivery of care (32)	6	5	2	1	2	2
Resource use						
Economic (34)	24	12	1	10	0	0
Hospital (35)	70	38	6	0	0	0
Need for intervention (36)	0	0	0	10	0	0
Adverse events						
Adverse events/effects (38)	5	1	1	33	0	0

Reported outcomes are shown as the number of all outcomes reported, outcomes reported with unique terminology and the number of standardized outcome headings created within each outcome domain. COMET, Core Outcomes in Effectiveness Trials Initiative; PPM, physical performance measure.

representing outcomes with the same meaning but different wording. Standardized outcome headings were then categorized using the COMET Taxonomy of Outcomes (see Supplementary Material 2 for all standardized outcome headings).

Table III illustrates the number and frequency of outcomes reported in the literature categorized by the outcome domains within the COMET Taxonomy of Outcomes. Supplementary Material 2 gives a complete list of outcome terms reported, detailing whether they were reported as primary or secondary outcomes, the standardized outcome headings they were coded to, and categorization using the COMET Taxonomy of Outcomes.

All outcomes reported in the literature were categorized into 18 COMET Taxonomy of Outcomes domains within five core areas. The Musculoskeletal and Connective Tissue outcome domain was the most represented with 1,335 outcomes (74% of all outcomes reported) and 529 unique outcome terms, which were further collapsed to 41 standardized outcome headings (see Table III). The

Musculoskeletal and Connective Tissue outcome domain consisted of outcomes representing objective clinical measures; the most reported standardized outcome heading was 'bone union or healing' consisting of 265 individual outcomes (reported in 50% of included studies), which collapsed to 76 unique outcome terms. Infection-related outcomes represented 371 outcomes and 85 unique outcome terms.

Outside the physiological/clinical core area, 330 outcomes were reported in the life impact core area. Of the 330 outcomes, 258 were reported in the physical functioning domain, represented by 149 unique outcome terms. The physical functioning domain mainly consisted of outcomes centred around lower limb function and ambulation.

Of the 532 studies included, 129 (24%) stated a primary outcome. Infection was the most reported primary outcome, followed by bone union or healing in 27 (21%) and 15 (12%) studies where a primary outcome was stated, respectively.

Outcome measurement instruments reported. In total, 479 individual outcome measurement instruments were identified, including 298 individual outcome definitions, 27 patient and 18 clinician-reported outcome measures, respectively, and six physical performance measures. All outcome measurement instruments extracted were categorized by their overarching outcome using the COMET Taxonomy of Outcomes (see Table III). The frequency of reporting outcome measurement instrument definitions and source text citations are detailed in Supplementary Material 3.

Of the 1,803 outcomes reported, 17% were defined. Most outcome definitions were limited to outcomes categorized to the physiological/clinical core area and exclusively defined objective clinical outcomes. All individual outcome definitions were unique for wording when describing the same outcomes. For example, 'bone union or healing' was the most defined outcome. It was defined 50 times across all studies, with no identical definitions.

A total of 45 unique patient- or physician-reported outcome measurement instruments were used across included studies, most of which were used to measure life impact, principally physical functioning and global health-related quality of life (HRQoL) outcomes. The physical functioning outcome domain was measured by 123 individual outcome measurement instruments, of which 29 were unique. The most used outcome measurement instrument for this domain was the Association for the Study and Application of the Methods of Ilizarov (ASAMI) criteria reported 24 times, followed by the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale reported 23 times.

Across all included studies, HRQoL was measured 39 times (8.1% of outcome measurement instruments identified) using eight different instruments. The most used instrument was the 36-Item Short-Form Health Survey questionnaire (SF-36)⁹ followed by the EuroQol five-dimension five-level questionnaire (EQ-5D-5L),¹⁰ which were used 17 and six times, respectively.

Discussion

There is widespread heterogeneity in the outcomes reported across all outcome domains, where large numbers of heterogeneous outcome terms were grouped under the same standardized outcome heading. Many different definitions were used to define the same outcomes. This is highlighted in the musculoskeletal and connective tissue outcome domain, where 239 unique outcome definitions were given with no standard texts used between studies to define the same outcomes. These findings illustrate widespread inconsistency in outcome reporting and little-to-no standardization in outcome definitions.

Objective clinical measures such as bone union and infection represented most outcomes identified, indicating a preference by authors for outcomes relevant particularly to surgeons. This reflects reporting on outcomes important to surgeons collected as part

of routine practice due to their ease of measurement, despite guidance and research trends advocating for the increased measurement of life impact outcomes in the form of PROMs.⁶ Publication of the 'Standards for the Management of Open Fractures of the Lower Limb' in 2009 principally recommended the measurement of life impact outcomes in the form of the Enneking Score,¹¹ which broadly assesses lower limb function in addition to the measurement of HRQoL, suggesting the Short-Study Form-36 (SF-36)⁹ or the Sickness Impact Profile (SIP)¹² as suitable tools. Despite these recommendations made over ten years ago, few studies have reported using these scores.

There was a high degree of variation in patient- and physician-reported outcome measurement instruments used to assess physical functioning. Of the 18 different outcome measurement instruments used, none were specific for measuring function following open lower limb fracture or traumatic injury. The majority were designed to measure the function of an anatomical area, generally in the context of elective orthopaedic surgery. HRQoL was measured 39 times across all studies with little consistency in the outcome measurement instruments used. A total of eight different HRQoL measures were identified.

This systematic review was ambitious in its data capture and included many relevant studies over ten years; it is unlikely that any potentially significant outcome term or outcome measurement instrument reported in the literature will not have been captured. Listing all outcome terms and definitions verbatim and summarizing source literature for each composite outcome measurement instrument identified in this study allows reviewers to trace outcomes identified in the COS back to their source. Due to the passage of time following the primary literature search, a search update was conducted. Undertaking staged systematic reviews is an accepted practice in COS development studies, allowing comparison of outcome lists against each other over time to identify if data saturation has been achieved.¹³ When comparing outcomes identified from the primary search (January 2009 to April 2017) and the search update (January 2017 to July 2019), no new standardized outcome headings were created. As such, it is unlikely that any additional new significant outcomes will have been reported since July 2019 to the point of publication of this study.

We limited the inclusion of studies to those published after 2009. This was done to ensure that the review remained focused on the relevant literature and manageable while avoiding unnecessary data extraction of potentially irrelevant literature; this approach is commensurate with COMET guidance.¹³ However, outcomes important to stakeholders may have been reported before 2009 and may have been missed. Although this is a possibility, it is unlikely, as clinically meaningful outcomes would likely have been reported over the last decade. The review was limited

to studies published in the English language. However, this was mitigated by extracting outcomes from non-English-language articles reporting an English-language abstract.

The categorization of outcomes using the COMET Taxonomy of Outcomes is subjective, and as a result there may be conflict in the categorization of outcomes between the outcome terms and the outcome measurement instruments, leading to inconsistencies. While the COMET Taxonomy of Outcomes provides an excellent framework for categorizing reported outcomes, it was not designed to categorize outcome measurement instruments. However, categorizing outcomes and outcome measurement instruments was a method used to structure, organize, and present data to stakeholders.⁶ Using an outcome framework such as the COMET Taxonomy of Outcomes, it is possible to see the spread of outcomes across core areas and the underlying outcome domains, allowing COS developers to identify any apparent gaps in outcomes identified from the literature. Unexpected gaps, if present, may indicate that data saturation was not achieved. On interrogation of the outcomes spread across the COMET Taxonomy of Outcomes domains, there were no apparent areas where outcomes we may have expected to be reported were missing.

In conclusion, this systematic review highlights significant inadequacies in outcome reporting in the current body of literature on open lower limb fracture, both in terms of outcome heterogeneity and a failure to report on life impact outcomes measuring a patient's functional recovery, despite guidance published in 2009 advocating the use of PROMs. There was an over-reliance on objective clinical outcomes reported in the literature. This systematic review supports the need to unify outcome collection and recognizes the need for higher-quality studies in this field. Developing a COS for open lower limb fracture will provide a consensus and guidance for collecting a homogeneous set of outcomes and outcome measures that will help address current limitations identified in this field.³

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Supplementary material



Search strategy detailed in full; a list and frequency of all verbatim outcomes reported in the literature on open lower limb fracture; and an inventory of all outcome measurement instruments reported in the literature for open lower limb fracture.

References

- Costa ML, Achten J, Bruce J, et al. Effect of negative pressure wound therapy vs standard wound management on 12-month disability among adults with severe open fracture of the lower limb: The WOLFF randomized clinical trial. *JAMA*. 2018;319(22):2280–2288.
- Rees S, Tutton E, Achten J, Bruce J, Costa ML. Patient experience of long-term recovery after open fracture of the lower limb: a qualitative study using interviews in a community setting. *BMJ Open*. 2019;9(10):e031261.
- Walter N, Rupp M, Hierl K, et al. Long-term patient-related quality of life after fracture-related infections of the long bones. *Bone Joint Res*. 2021;10(5):321–327.
- Al-Hourani K, Pearce O, Kelly M. Standards of open lower limb fracture care in the United Kingdom. *Injury*. 2021;52(3):378–383.
- Morris R, Pallister I, Trickett RW. Measuring outcomes following tibial fracture. *Injury*. 2019;50(2):521–533.
- Nanchahal J, Nayagam N, Khan U, Moran C, Barrett S. Standards for the management of open fractures of the lower limb. British Orthopaedic Association. 2009. <https://www.bapras.org.uk/docs/default-source/commissioning-and-policy/standards-for-lower-limb.pdf?sfvrsn=0> (date last accessed 22 September 2022).
- Macefield RC, Jacobs M, Korfage IJ, et al. Developing core outcomes sets: methods for identifying and including patient-reported outcomes (PROs). *Trials*. 2014;15:49.
- Dodd S, Clarke M, Becker L, Mavergames C, Fish R, Williamson PR. A taxonomy has been developed for outcomes in medical research to help improve knowledge discovery. *J Clin Epidemiol*. 2018;96:84–92.
- Ware JJ, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care*. 1992;30(6):473–483.
- Herdman M, Gudex C, Lloyd A, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Qual Life Res*. 2011;20(10):1727–1736.
- Wada T, Kawai A, Ihara K, et al. Construct validity of the Enneking score for measuring function in patients with malignant or aggressive benign tumours of the upper limb. *J Bone Joint Surg Br*. 2007;89-B(5):659–663.
- Bergner M, Bobbitt RA, Carter WB, Gilson BS. The Sickness Impact Profile: development and final revision of a health status measure. *Med Care*. 1981;19(8):787–805.
- Williamson PR, Altman DG, Bagley H, et al. The COMET Handbook: version 1.0. *Trials*. 2017;18(Suppl 3):280–50.

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