Gupta *et al.*
Journal of Orthopaedic Surgery and Research (2025) 20:247
https://doi.org/10.1186/s13018-025-05609-2

Journal of Orthopaedic Surgery and Research

SYSTEMATIC REVIEW

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Orthopedic frailty risk stratification (OFRS): a systematic review of the frailty indices predicting adverse outcomes in orthopedics

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Abstract

Background With a growing number of elderly patients requiring elective and non-elective procedures, frailty-based preoperative risk stratification is an emerging tool in orthopedic surgery to minimize adverse postoperative outcomes. This paper sought to understand the current literature regarding preoperative Orthopedic Frailty Risk Stratification (OFRS) and describe the disparate frailty indices and their capabilities for discrimination in predicting adverse postoperative outcomes.

Methods A literature search was conducted in Pubmed, Cochrane, and Scopus for articles published during or prior to February 2024 assessing frailty following surgery for orthopedic pathologies. Qualitative variables including study characteristics and application of frailty were collected and synthesized. Quantitative meta-analysis was performed for pooled odds ratio (OR) and area under the curve (AUC) of frailty for mortality and complications. All methods were performed in accordance with PRISMA guidelines.

Results Of the 81 included articles, over half (52%) addressed traumatic orthopedic pathologies with traumatic hip fractures being the most studied in the OFRS (25 studies). Less common categories included oncology, sports, and foot/ankle. Functional status and independence were the most common frailty domain (25, 96.2%) and component across scales (20, 76.9%), respectively. The 5-Item Modified Frailty Index (mFI-5) was the most common frailty index (28 publications). Meta-analysis demonstrated increasing frailty was an independent predictor of mortality (30-day OR: 2.89, 95% CI: 2.00–4.18; 1 year OR: 1.81, 95% CI: 1.48–2.22, $p<0.001$), major complications (OR: 1.63, 95% CI: 1.10–2.41, $p=0.02$), and Clavien-Dindo IV complications (OR: 3.26, 95% CI: 2.18–4.87, $p<0.001$). Frailty had good discriminatory accuracy for predicting mortality at 30-days (AUC: 0.71, 95% CI: 0.68–0.74, $p<0.001$), 3-months (OR: 0.75, 95% CI: 0.65–0.83, $p<0.001$), and 1-year (OR:0.74, 95% CI: 0.73–0.75, $p<0.001$).

Conclusions The orthopedic surgery frailty literature is extremely heterogeneous, with disparate frailty scales implemented to measure varying outcomes across many orthopedic pathologies. Despite no consensus on exact scales or definitions, various frailty indices have predicted adverse outcomes.

Keywords Orthopedic frailty risk stratification (OFRS), Orthopedic surgery, Modified frailty index (mFI), Comorbidity index, Frailty index, And preoperative risk stratification

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Introduction

Over the past decade, the number of orthopedic procedures has risen exponentially, with a 67% increase in Medicare claims from 2000 to 2010 [1]. This trend is largely driven by the expanding elderly population of the United States, with projections showing another doubling of procedures by 2050 [2]. Therefore, the demand for elective and non-elective procedures like total joint arthroplasty (now the most common orthopedic procedure in the United States) has grown [3–6]. Although orthopedic outcomes have improved, the risk of adverse postoperative outcomes has increased significantly in frail patients. The rise in frailty-based risk stratification literature parallels the increase in older surgical patients.

Frailty is a multidimensional concept incorporating disparate factors like comorbidities, functional deficits, nutritional, social, & other domains which contribute to a physiological loss of reserve, resulting in a susceptibility to poor health outcomes with insults of illness and/or surgery [7–15]. Frailty is an independent risk factor for adverse postoperative outcomes, including increased morbidity, mortality, and impaired recovery in various orthopedic procedures [16–21]. Orthopedic surgeons must understand how frailty impacts risk stratification by providing more precise risk–benefit information for preoperative counseling with patients/families. Increased resources may be allocated to high-risk patients, and prehabilitation regimens can be adopted before surgery. These interventions aim to mitigate frailty's impact by reducing adverse outcomes.

Despite their importance, frailty scales may suffer from heterogeneity and lack practical clinical utility. The diversity in frailty assessment tools complicates their application to clinical and research settings, leading to inconsistencies in identifying frail patients with the highest risk of adverse surgical outcomes [7]. This study aims to summarize the current landscape of frailty metrics in orthopedic surgery.

Methods

Search strategy and screening criteria

A literature search using Pubmed, Scopus and Cochrane databases was conducted for articles published on or before February 2024 using the terms "((("orthopedic" OR "orthopaedic") AND (surgery)) AND (frailty OR frail))". Three reviewers (NG, FD, and AB) screened articles using Rayyan Systematic Review Software [22]. Inclusion criteria were: (1) Related to frailty in orthopedic surgery, (2) Used a frailty index to measure patient frailty, (3) Analyzed frailty's effect on orthopedic outcomes, and (4) Published in English language or had an English translation. Examples of articles not meeting inclusion criteria are: (1) Frailty in cardiovascular disease, (2) Use of comorbidity indices such as Charleson Comorbidity Index (CCI), Elixhauser Comorbidity Measure (ECM), or American Society of Anesthesiology score (ASA) to measure frailty, or (3) Use of frailty for population stratification in unrelated variables like race.

Exclusion criteria were: (1) Not primary full-text peer-reviewed articles (letter, review, or conference abstract), (2) Using sarcopenia or single disease as the only frailty measure, (3) Orthopedic pathology not separable from non-orthopedic pathology, (4) Investigating frailty in rheumatoid arthritis, and (5) Examining frailty in spine pathologies or procedures. Spine studies were excluded to focus on pure orthopedic specialties and because a robust body of evidence exists regarding frailty in spine surgery, with contributions from both neurosurgeons and orthopedic surgeons [23–25]. Articles were first subjected to title/abstract screening followed by full-text review.

Variables of interest and data collection

Included studies were subjected to initial data collection (NG, FD, HRC, CS, AB, and MFR) for study characteristics, frailty measures, demographic variables, and outcomes associated with frailty. A secondary review of collected data was performed (NG, CS, and HRC) to ensure accuracy during the initial collection. Study characteristics included study design, data source, and category of procedure/pathology. The type of frailty measure(s) utilized in the study were recorded alongside frailty tiers (as applicable). Demographic variables included cohort size and mean/median age cutoff for inclusion. Finally, outcomes associated with frailty were recorded including predictive value in comparison to other risk factors.

Data synthesis and meta-analysis

Collected data was stratified by qualitative and quantitative analysis. Qualitative analysis was performed using a narrative synthesis to describe the current landscape and state of frailty in orthopedic surgery, summarizing the types of frailty metrics used, their domains, and how they are applied in various subspecialties. We also assessed the prevalence of certain outcomes (mortality vs complications) and compared how different indices captured these events. Variables/components of each frailty tool were stratified by five domains of frailty (physical/comorbidity, social, functional, nutritional, and cognitive) which have been previously validated for the multidimensional measurement of frailty in a surgical population [26].

For quantitative synthesis, odds ratio (OR) and receiver operating characteristic/area under the curve analysis (AUC) were recorded for the outcomes of: mortality (30 day, 3 month, and/or 1 year mortality), major complications (as defined by the respective study), and Clavien-Dindo IV Complications.

In studies with multiple pathologies/surgical procedures and/or multiple frailty tools, data was extracted when there was a clear delineation between populations so each measure could be distinctly reported. For studies which reported OR by frailty tier, results were recorded only what the respective study deemed as frail (ex. excluding prefrail or severely frail). For the predictive value of frailty, pooled odds ratios and 95% confidence intervals were calculated. For calculation of pooled AUC, each studies AUC and 95% confidence interval were used, however, in cases where 95% confidence interval was not reported, this was estimated using the sample size.

Heterogeneity between studies was assessed using Cochrane's I^2 index. A fixed effects model was utilized when $I^2 \leq 50\%$ and a random effects model was used when $I^2 > 50\%$. When outcome definitions differed, we combined effect estimates only if the definitions had appropriate overlap, and if substantial differences were present those results were summarized in the narrative analysis instead of quantitatively pooled. Statistical analysis was conducted using R Studio (4.4.1). All methods were performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

Results

Search results

The initial database query produced 709 articles; 539 records were excluded after title and abstract screening, as the majority were not relevant to frailty/orthopedics (344) or were related to spine (166) (Fig. 1). The remaining 169 articles underwent full text review and 88 were deemed ineligible.

Characteristics of included studies

Most of the remaining 81 articles were retrospective studies (68, 84.0%) (Supplementary Table S1). There were 40 (49.4%) nationwide database studies and 35 (43.2%) single-center studies. The most common nationwide database was the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), utilized in 25 (30.9%) studies. Age cutoffs were used in 59 studies (72.8%), with the most frequent being ≥ 65 years (22 studies, 27.2%). Study cohorts varied greatly in size. The median number of patients for national database studies was 49,738 (IQR: 9,228–179,702 patients), 402 (IQR: 236–855 patients) for single-center studies, and 12,740 (IQR: 4,812–70,225 patients) for multi-center studies. Regarding orthopedic subspecialties, there were 42 traumatology (51.9%), 34 arthroplasty (42.0%), two oncology (2.50%), and one for sports medicine (1.20%), foot/ankle (1.20%), and general orthopedics (1.20%) (Fig. 2).

Frailty scales

There were 26 different frailty metrics utilized in the 81 studies (Supplementary Table S2 and Fig. 3). The modified frailty index (mFI) and its variants were the most common scales used (41, 50.6%), with the modified 5-Item Frailty Index (mFI-5) being the most common individual scale (28, 34.6%). The most common variables used by the frailty metrics were dependence for ADLs / functional independence (20, 76.9%), Congestive Heart Failure (CHF) (15, 57.7%), and Diabetes Mellitus (12, 46.2%) (Supplementary Table S3). The inclusion of the five domains of frailty was as follows: physical/comorbidity (24, 92.3%), functional (25, 96.2%), nutritional (19, 73.1%), cognitive (13, 50.0%), and social (5, 19.0%) (Fig. 4).

Outcomes reported and meta-analysis

The most common reported outcomes in the 81 publications were: increased complications (46, 56.8%), mortality (39, 48.1%), extended length of stay (26, 32.1%), non-home discharge (25, 30.1%), unplanned readmission (24, 29.6%) and unplanned reoperation (18, 22.2%). Less common outcomes included increased medical cost (8, 9.9%) and postoperative delirium (5, 6.2%). Quality-of-life measures, pathology-specific scores, and functional outcomes were also reported (11, 13.6%).

Pooled meta-analysis demonstrated that frailty was a significant predictor of mortality (30 day mortality = OR: 2.89, 95% CI: 2.00–4.18; 1 year mortality = OR: 1.81, 95% CI: 1.48–2.22, $p < 0.001$) (Fig. 5A, B), major complications (OR: 1.63, 95% CI: 1.10–2.41, $p = 0.02$), and CDIV Complications (OR: 3.26, 95% CI: 2.18–4.87, $p < 0.001$) (Fig. 6A, B). Frailty demonstrated good discriminatory accuracy (> 0.70) for mortality at 30 days (AUC: 0.71, 95% CI: 0.68–0.74, $p < 0.001$), 3 months (OR: 0.75, 95% CI: 0.65–0.83, $p < 0.001$), and 1 year (OR:0.74, 95% CI: 0.73–0.75, $p < 0.001$) (Fig. 7A–C). There was not enough data for pooled OR of 3-month mortality or pooled AUC of complications.

Trauma

There were 42 trauma frailty studies (51.9%), and the mFI-5 was the most used index (12, 28.57%). Other variations included the 11-Factor Modified Frailty Index (mFI-11) (5, 11.90%), and age-adjusted Modified Frailty Index (aaMFI) (1, 2.38%). The Orthopedic Frailty Score (OFS) (5, 11.90%) and the Clinical Frailty Scale (CFS) (4, 9.52%) were also used. Lower extremity trauma was the most common subspecialty (31/42), with 25 studies on frailty in patients with traumatic hip and distal femur

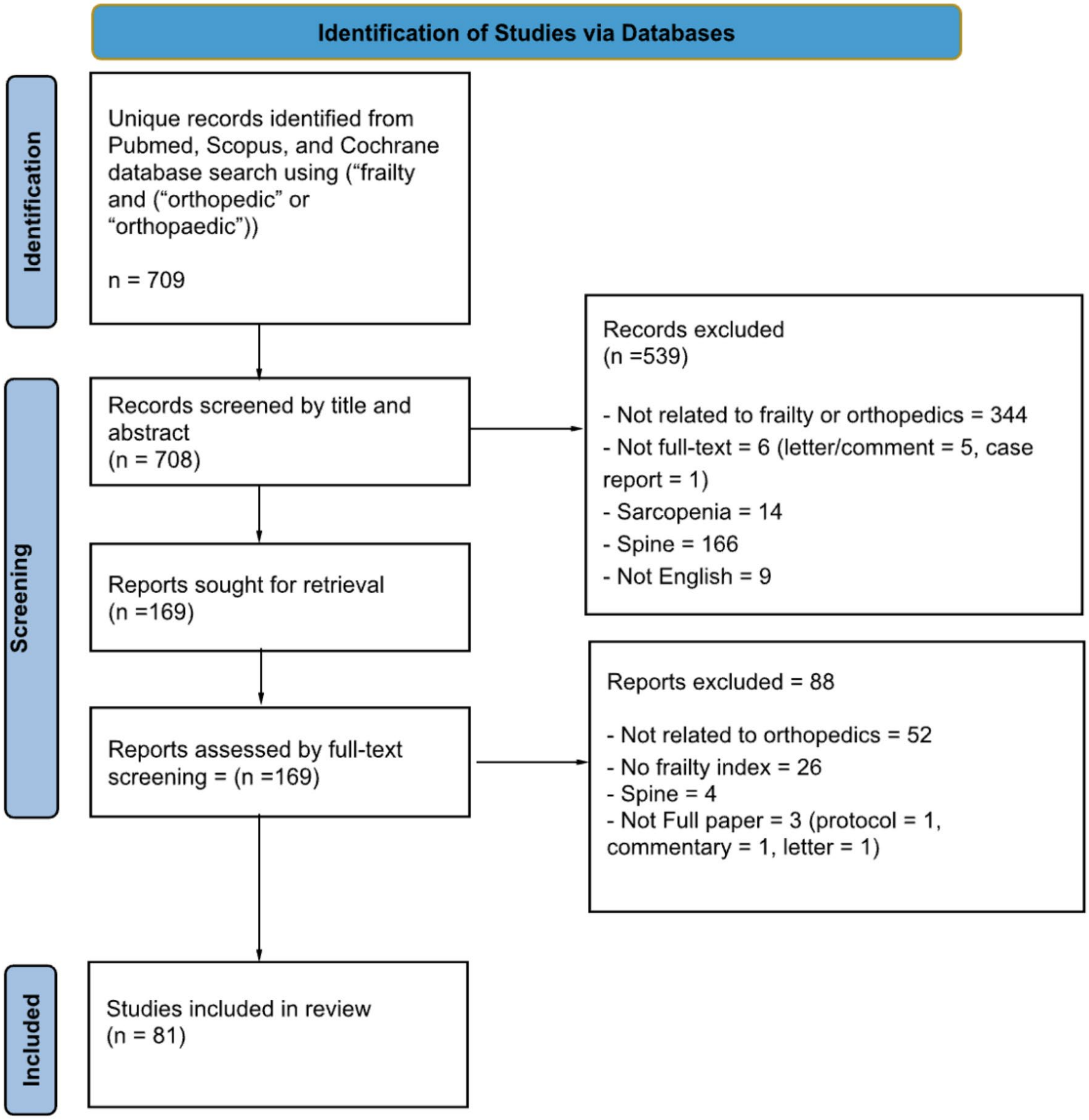


Fig. 1 Flow chart depicting search results, screening strategy, and process for inclusion of articles

fractures. There were four studies each on traumatic upper extremity fractures and upper and lower extremity fractures. The outcomes most associated with frailty included complications (57.14%), mortality (52.38%), non-home discharge (30.95%), and extended LOS (eLOS) (30.95%). There were four studies which found frailty to be associated with decreased functional status or higher functional dependence at discharge. Discriminatory accuracy varied in upper extremity trauma, with Wilson et al. showing mFI-5 superior to age and Yi et al. showing ASA superior to mFI-5 [27, 28]. For lower extremity trauma, hip-MFS, Chart-Derived Frailty Index (CFI), and CFS were shown to be superior to ASA.

Arthroplasty

There were 32 frailty reports on arthroplasty; the majority (20, 62.5%) used mFI-5 (13, 40.62%) or mFI-11 (6, 18.75%). The Hospital Frailty Risk Score (HFRS) was also used (10, 31.25%). Studies included five involving the upper extremity (four TSA and one TEA), 23 involving the lower extremity (16 THA; 16 TKA; one TAA; and one PFR), and six on revision arthroplasty (five TKA and five THA). Common frailty outcomes included increased complications (68.75%), readmission (53.13%), mortality (43.75%), and eLOS (40.63%). Arthroplasty studies reported frailty's association with increased cost more than other pathology subtypes

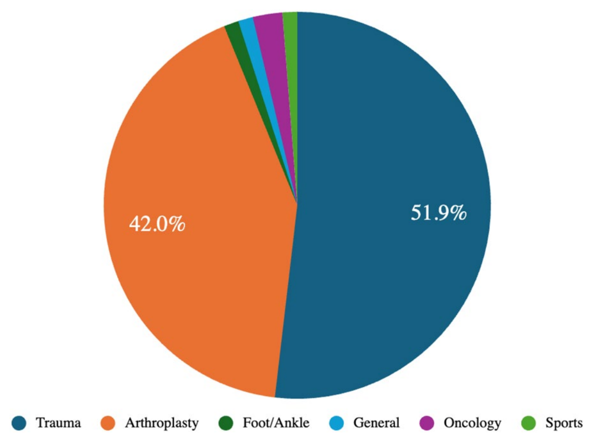


Fig. 2 Distribution of included studies based on orthopedic subcategories

(18.75%). The discriminative thresholds of frailty indices were examined in 9 studies (28.1%). The HFRS demonstrated superior discrimination compared to ASA for predicting mortality and compared to ECM, mFI-5, and CCI for complications [29]. The mFI and mFI-5 demonstrated superior predictive accuracy compared to CCI, a-CCI, ASA, and m-CCI. The novel CARDE-B demonstrated superior discrimination compared to mFI-5.

Oncology

Two orthopedic oncology studies assessed frailty's association with pathologic fractures using the ACS-NSQIP with femur, humerus, or tibia fractures. The Pathologic Fracture Morbidity Index and Pathologic Fracture Mortality Index were compared to the mFI-5. Frailty was associated with increased mortality in both studies, and Vankara et al. demonstrated increased medical morbidity and utilization. The Pathologic Fracture Morbidity and Mortality Indices showed superior discriminatory accuracy compared to ASA and mFI-5.

Sports

One single-center sports study on arthroscopic rotator cuff repair found frailty was associated with worse outcomes by the following scores: Oxford Shoulder Score (OSS), Constant Shoulder Score (CSS), UCLA Shoulder Score, and Visual Analog Scale (VAS).

Foot and ankle

One single-center study on foot/ankle pathologies (hallux valgus) reported that frailty, measured by mFI-5, was associated with worse postoperative American Orthopedic Foot and Ankle (AOFAS) scores.

General orthopedics

Frailty was associated with increased mortality in a single-center study, with CFS demonstrating superior

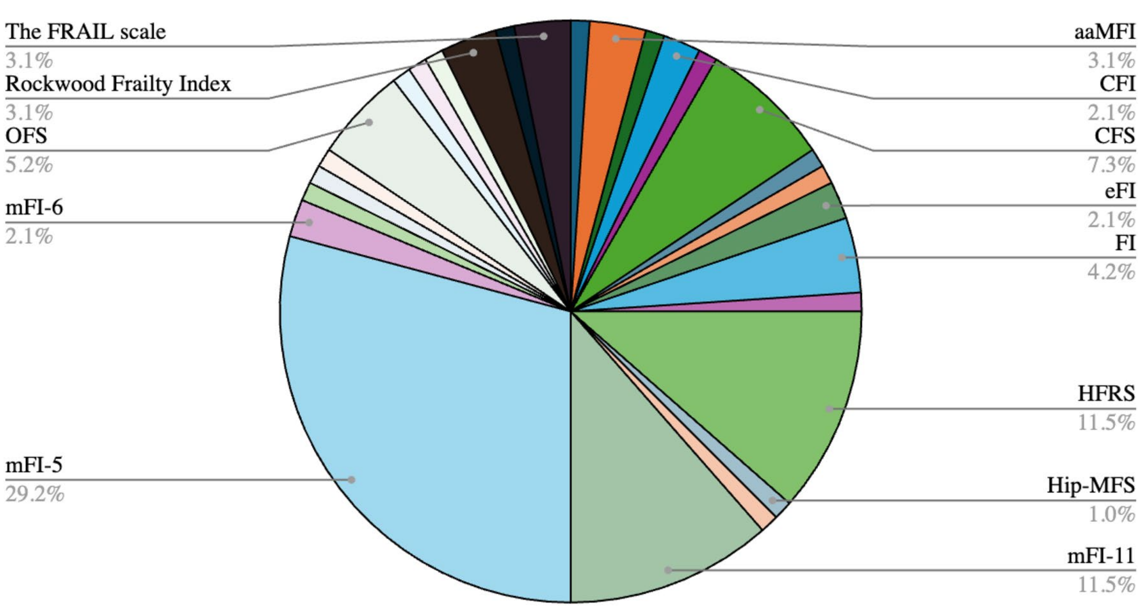


Fig. 3 Graphical representation of unique orthopedic frailty indices reported in the literature. (aaMFI = Age-Adjusted Modified Frailty Index, CFI = Chart Derived Frailty Index, CFS = Clinical Frailty Scale, eFI = Electronic Frailty Index, FI = Frailty Deficit Index, HFRS = Hospital Frailty Risk Score, mFI-11, mFI-5 = Modified 5-Item Frailty Index, mFI-6 = Six-Item Modified Frailty Index, OFS = Orthopedic Frailty Score)

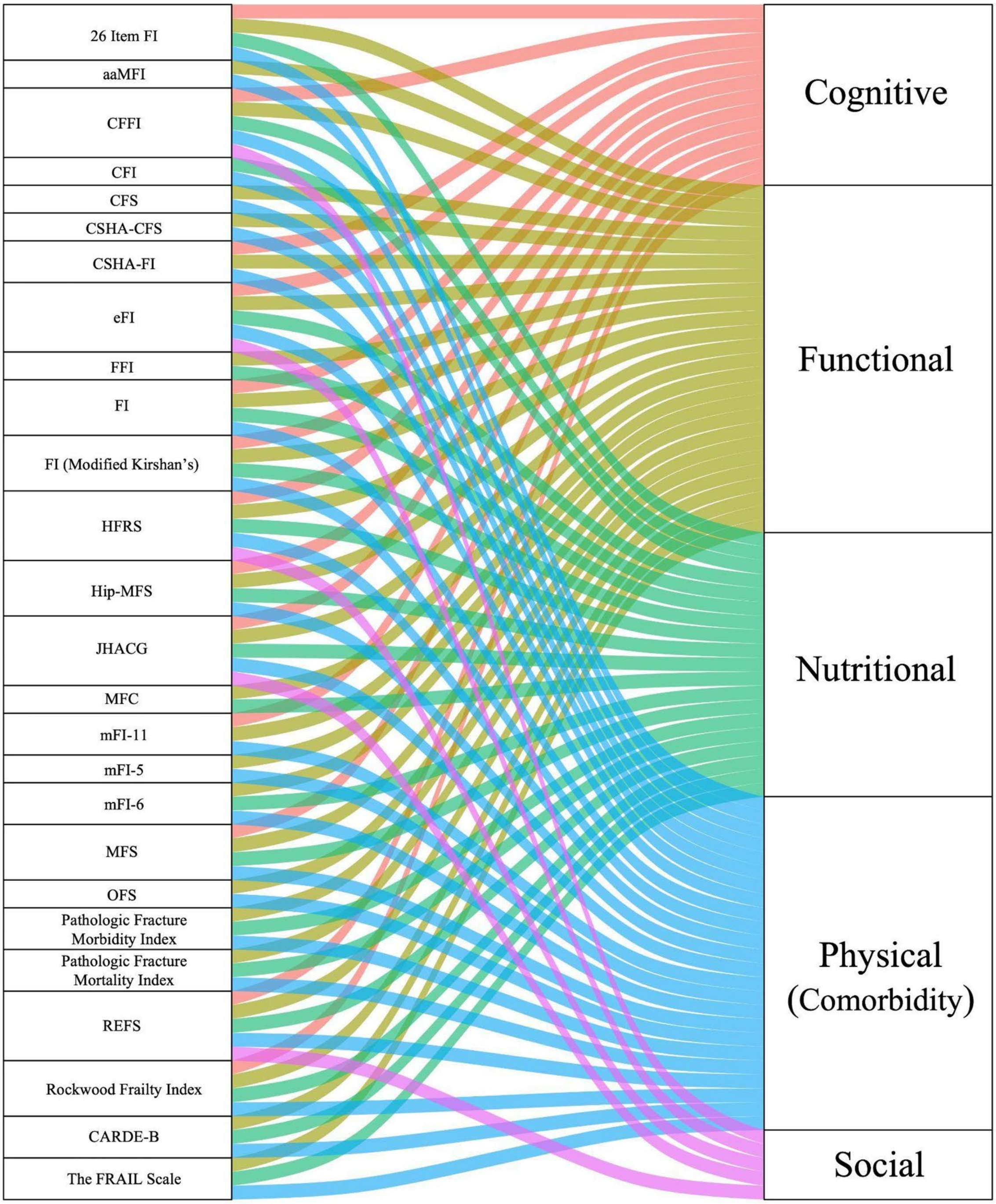


Fig. 4 Alluvial plot demonstrating composition of frailty tools stratified by the inclusion of five domains of frailty: physical (comorbidity), cognitive, function, nutritional, and social

discrimination in predicting mortality compared to CCI, age, and BMI.

Discussion

This systematic review describes the current literature regarding frailty as a predictive tool for preoperative risk stratification in orthopedic surgery. Over 25 unique frailty metrics are utilized in OFRS literature,

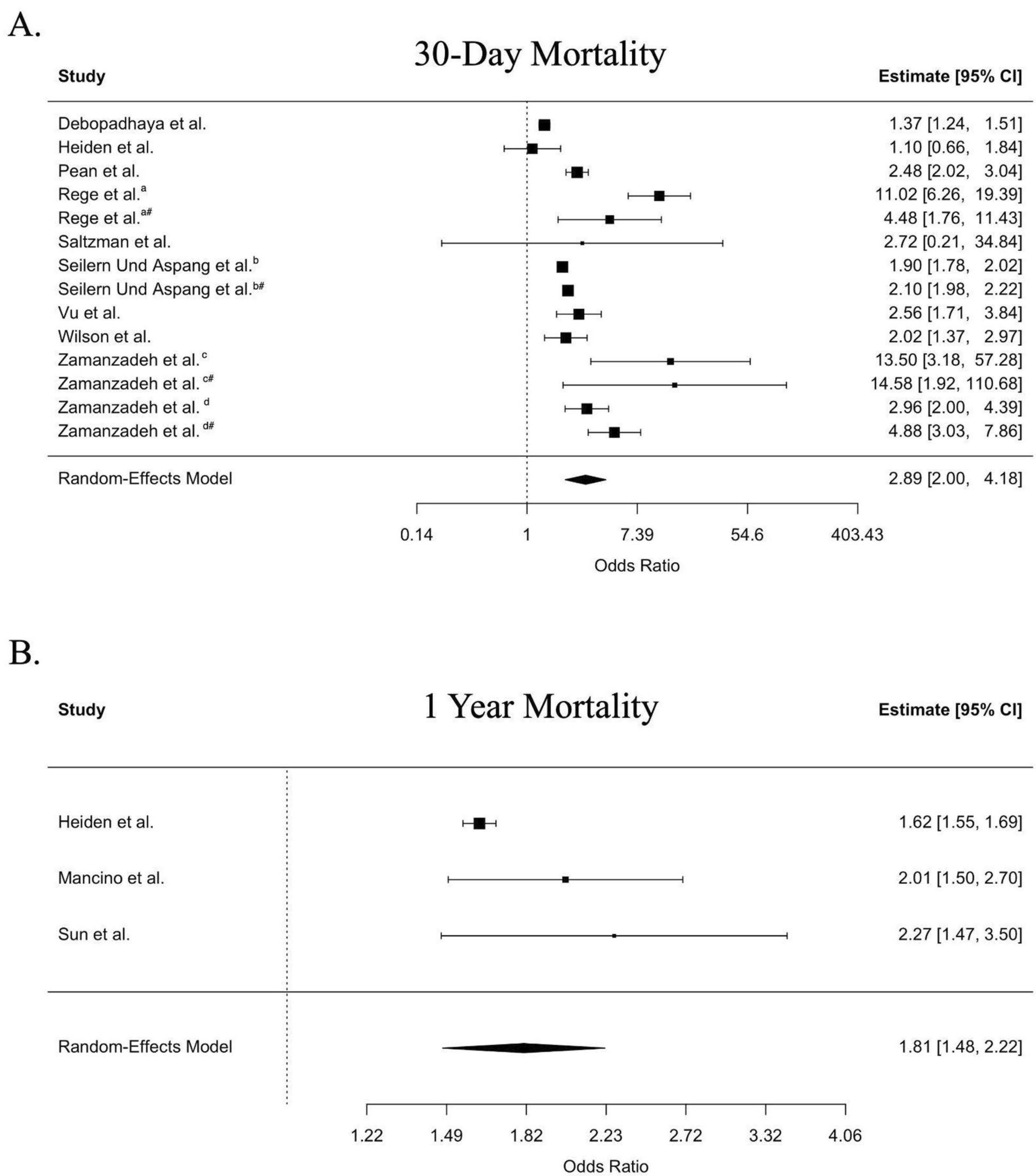


Fig. 5 Forest plots demonstrating pooled odds ratio (estimate) and 95% confidence interval (95% CI) for frailty as a predictor of 30-day mortality (**A**.) and 1-year mortality (**B**.). (a. Rege et al. young cohort; a#. Rege et al. old cohort; b. Seilern Und Aspang et al. mFI scoring; b#. Seilern Und Aspang et al. aaMFI scoring; c. Zamanzadeh et al. (2024) rTHA cohort; c#. Zamanzadeh et al. (2024) rTKA cohort; d. Zamanzadeh et al. (2023) mFI cohort; d#. Zamanzadeh et al. (2023) aaMFI cohort)

demonstrating the need for selecting which metrics demonstrate superior discrimination for predicting adverse orthopedic outcomes. The most common adverse outcomes associated with frailty were major complications (such as renal failure, myocardial infarction, or septic episodes), mortality, and extended length of stay.

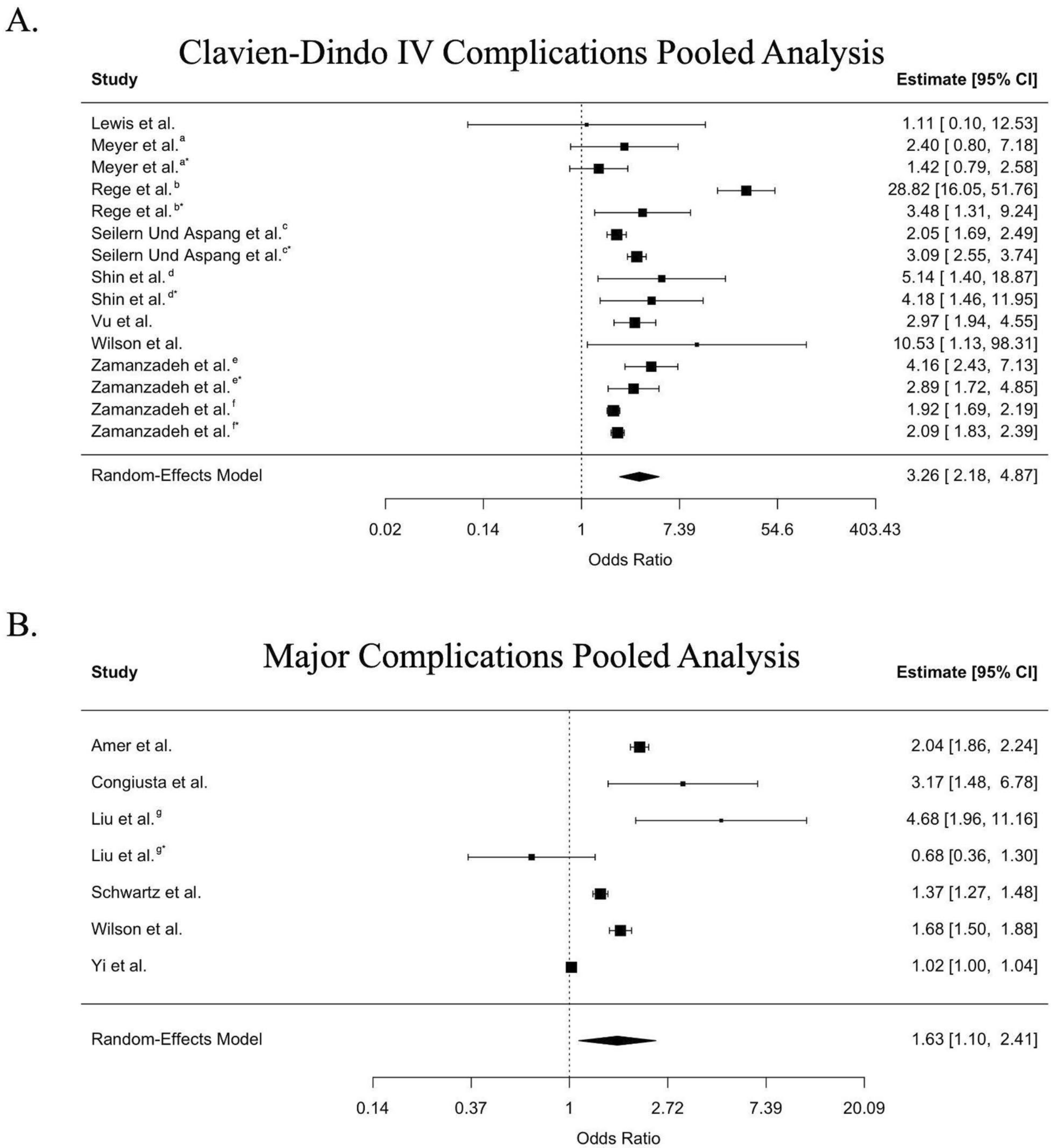


Fig. 6 Forest plots demonstrating pooled odds ratio (estimate) and 95% confidence interval (95% CI) for frailty as a predictor of Clavien-Dindo IV complications (**A**.) and major complications (**B**.) (major complications as defined by the respective paper). (a. Meyer et al. (2020) primary total hip and knee arthroplasty; a*. Meyer et al. (2021) revision total hip and knee arthroplasty; b. Rege et al. old cohort; b*. Rege et al. young cohort; c. Seilern Und Aspang et al. mFI scoring; c*. Seilern Und Aspang et al. aamFI scoring; d. Shin et al. TKA cohort; d*. Shin et al. THA cohort; e. Zamanzadeh et al. (2024) rTHA cohort; e*. Zamanzadeh et al. (2024) rTKA cohort; f. Zamanzadeh et al. (2023) mFI cohort; f*. Zamanzadeh et al. (2023) aaMFI cohort; g. Liu et al. CFS scoring; g*. Liu et al. MFI scoring)

Meta-analysis demonstrated that frailty was a significant predictor of mortality and complications. The most common pathologic subtypes were trauma (e.g. hip fractures) and arthroplasty. This is primarily because hip fractures and joint arthroplasty are common in older, more frail patients. Therefore, this trend in the literature will continue in prevalence due to the nature of the patient population.

Current state of frailty in orthopedics

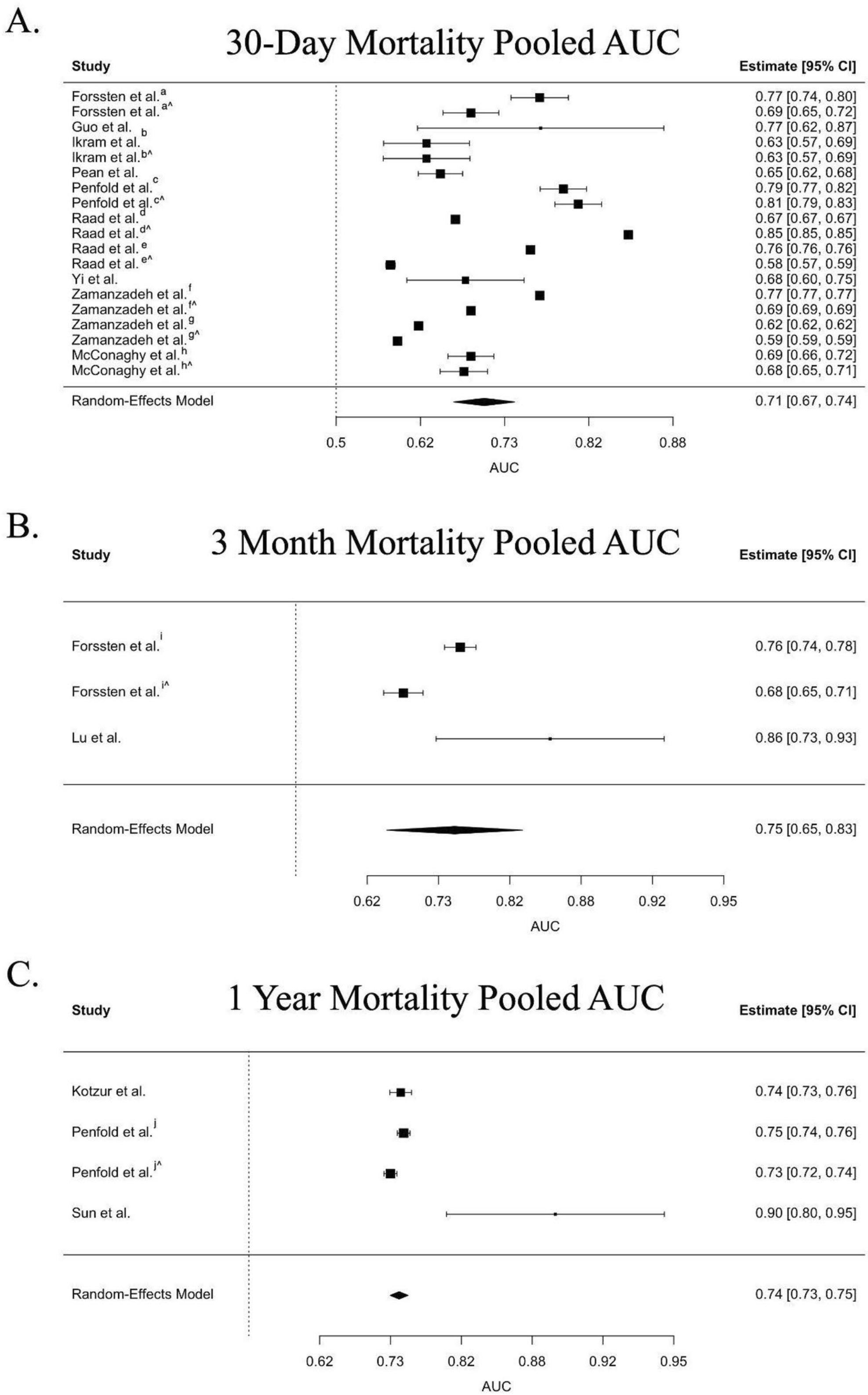
OFRS is rapidly expanding with the aging population, as older patients increasingly require orthopedic treatment. Common OFRS frailty indices include the mFI (with its variations) and the HFRS. Both indices have predicted adverse postoperative outcomes in multiple orthopedic settings [30, 31]. Currently, there is no consensus regarding the best OFRS metric. A systematic review by Lemos et al. showed mFI was the most used frailty index [16]. They reported 38% mFI-11 use and 24% mFI-5 use. The mFI-5 and mFI-11 have been extensively applied to spinal pathologies, showing good discrimination in predicting adverse outcomes. Although classically used, it is important to consider that frailty encompasses multiple domains, whereas comorbidities only measure a single domain [32]. Evidence shows the Risk Analysis Index (RAI) has superior discriminatory accuracy, encompassing five domains of frailty (physical [comorbidity], functional, social, nutritional and cognitive), compared to mFI's two domains [26, 33]. Alongside criticisms of the mFI for measuring comorbidity rather than frailty, Owodunni et al. illustrate their point of mFI's limitation as a frailty tool by illustrating a hypothetical case of a patient with full dependency for activities, in need of social support, with multiple comorbidities, and decreased appetite [34, 35]. Although this patient would presumably do poorly postoperatively, she only has an mFI-5 score of 1 (normal) compared to her RAI score of 55 (very frail). This example demonstrates mFI's limitations in assessing frailty well, as it only measures 4 comorbidities and a binary independence question.

Similar to mFI, the HFRS has been widely used in orthopedics according to our study. Since frailty measures physiologic reserve, using HFRS, which combines comorbidities and awards 'frailty' points based on the severity of acute illness or traumatic injury, begs the question of whether HFRS assesses frailty or multimorbidity and serious injuries [36, 37]. HFRS uses International Classification of Disease 10th Revision codes to measure patient conditions and assigns points based upon current symptoms and physical examination findings [36]. Points in this index relate to acute conditions and do not take the patient's physiological baseline status into account [36]. In addition, the HFRS index has never been validated for any patient under 75 years or in nonacute care settings [36]. Further consideration must be taken for the use of HFRS as this tool may not be useful for patients without a previous admission and does not take into consideration functional status [38]. For example, a 21-year-old Olympic athlete in perfect health, who is the opposite of frail, would have a significantly elevated HFRS if they presented to the hospital with polytraumatic injuries and an associated arterial injury following a motor vehicle accident. This demonstrates the poor predictability of an individual's frailty status with HFRS. HFRS has been shown to be superior within orthopedics when compared to mFI, however, the majority of studies utilizing HFRS did not determine discriminatory accuracy when compared to other models [29, 39–41]. These results suggest the need to further delineate between the effects of frailty versus multimorbidity on orthopedic surgical outcomes, as the two main indexes used may be geared towards multimorbidity rather than frailty.

As previously stated, the use of frailty scales in orthopedic surgery was found to be remarkably heterogeneous. Outside of mFI and HFRS, another commonly used scale was the CFS. The CFS consists of 9 total points and grades patients from very fit to terminally ill based upon medical conditions and symptoms of active disease [7]. Of note, it is important that CFS be applied prior to the trauma or recent issue at hand. For example, if someone breaks their hip while riding a bicycle, their current frailty score by CFS, or any metric, is how they were that morning while riding the bike, not a measure of their current state in bed, unable to walk and in significant pain. Increased CFS scores have been associated with poor outcomes in patients including increased

(See figure on next page.)

Fig. 7 Forest plots demonstrating pooled AUC values (estimate) and 95% confidence interval (95% CI) for the discriminatory accuracy of frailty for predicting 30-day mortality (**A**.), 3 month mortality (**B**.), and 1 year mortality (**C**.). (a. Forssten et al. OFS scoring; a^. Forssten et al. MFI scoring; b. Ikram et al. CFS scoring; b^. Ikram et al. NHFS scoring; c. Penfold et al. TKA cohort c^. Penfold et al. THA cohort; d. Raad et al. (2021) mFI-5 scoring; d^. Raad et al. (2021) CARDE-B scoring; e. Raad et al. (2021) PFMI scoring; e^. Raad et al. (2021) mFI-5 scoring; f. Zamanzadeh et al. (2024) rTHA cohort; f^. Zamanzadeh et al. (2024) rTKA cohort; g. Zamanzadeh et al. (2023) mFI cohort; g^. Zamanzadeh et al. (2023) aaMFI cohort; h. McConaghy et al. THA cohort, h^. McConaghy et al. TKA cohort; i. Forssten et al. OFS scoring; i^. Forssten et al. MFI scoring; j. Penfold et al. TKA cohort; j^. Penfold et al. THA cohort)



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rates of mortality, length of stay, and risk of postoperative complications [7]. A cross-sectional study by Ou et al., assessed elderly patients undergoing lower extremity fracture fixation and found an increased risk of postoperative pneumonia amongst patients with an increased CFS score preoperatively [42]. In their study, a total of 65 (11.4%) patients developed postoperative pneumonia. Similar to the HFRS, the CFS was deemed superior to mFI for adverse postoperative outcomes following TKA on multivariable analysis [43]. Conversely, Moorthy et al. reported the mFI to be superior to the CFS for functional outcomes following arthroscopic rotator cuff repair [44]. Taken together, these results suggest that although the mFI has commonly been used as a measure of frailty, the results are inconclusive regarding which frailty scale within orthopedics provides superior risk stratification.

Implications

As the aging process alongside comorbid conditions intrinsically results in a reduced physiologic reserve, the role of frailty in preoperative risk stratification for orthopedic procedures is an important tool [45]. This is further emphasized by the growing number of elderly patients requiring elective and non-elective orthopedic care [46]. Although, there is an abundance of literature regarding the value of frailty indexes for predicting adverse outcomes following orthopedic surgery, our findings suggest a vast heterogeneity of tools for preoperative risk stratification. These claims are consistent with previous studies which support the lack of coherent utilized metrics; nonetheless, this hinders the ability to clinically translate these findings to practice [16]. This heterogeneity may be due to the lack of an unclear delineation between frailty and comorbidity in the orthopedic literature, important as although these concepts are related — they are not the same. Furthermore, the practical implications must be considered as the accuracy of these tools must be balanced with the ease of use by clinicians.

Limitations

The use of national databases may limit the generalizability of these frailty indexes, as data for minority/underrepresented groups may be lacking. An additional limitation is the unclear delineation within the literature regarding frailty versus comorbidity. Our study focused on the use of frailty specific indexes, however, there were multiple studies which sought to evaluate frailty using comorbidity indexes. Although frailty and comorbidity share characteristics, they are two distinct entities [47]. Therefore, further studies should seek to understand whether comorbidity indices are truly a measure of frailty in orthopedic surgery. Finally, the vast heterogeneity in measurement within these different models limits the strength of association and level of evidence these studies carry.

Conclusion

OFRS provides significant discrimination in predicting adverse orthopedic postoperative outcomes for some pathology subtypes. These indexes have the potential to provide orthopedic surgeons with an accurate method for preoperative risk stratification to reduce adverse postoperative outcomes. Currently, there remains no gold standard for frailty measurement in orthopedics. Many currently used systems may measure multimorbidity rather than true frailty. Thus, future research should delineate frailty from multimorbidity, and their individual effects on postoperative outcomes. In doing so, novel frailty indices can be developed to accurately measure decreased physiological reserve in patients prior to orthopedic surgery.

Abbreviations

OFRS	Orthopedic Frailty Risk Stratification
mFI	Modified frailty index
mFI-5	5-Item Modified Frailty Index
CCI	Charleson Comorbidity Index
m-CCI	Modified Charleson Comorbidity Index
a-CCI	Age-adjusted Charleson Comorbidity Index
ECM	Elixhauser Comorbidity Measure
ASA	American Society of Anesthesiology score
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
ACS-NSQIP	American College of Surgeons National Surgical Quality Improvement Program
IQR	Interquartile range
mFI-11	11-Factor Modified Frailty Index
aaMFI	Age-adjusted Modified Frailty Index
OFS	Orthopedic Frailty Score
CFS	Clinical Frailty Scale
eLOS	Extended LOS
LOS	Length of stay
Hip-MFS	Hip-Multidimensional Frailty Score
CFI	Chart-Derived Frailty Index
HFRS	Hospital Frailty Risk Score
TSA	Total shoulder arthroplasty
TEA	Total elbow arthroplasty
THA	Total hip arthroplasty
TKA	Total knee arthroplasty
TAA	Total ankle replacement
PFR	Patellofemoral replacement
OSS	Oxford Shoulder Score
CSS	Constant Shoulder Score
VAS	Visual Analog Scale
AOFAS	American Orthopedic Foot and Ankle
BMI	Body mass index
RAI	Risk Analysis Index
CARDE-B	Cardiac Rehabilitation, Diabetes, and Exercise Barcelona

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-025-05609-2.

Supplementary file 1.

Acknowledgements
None

Authors' contributions
NG and CB contributed to manuscript conception and design. NKG, FD, HRC, CS, AB, and MFR contributed to acquisition or analysis of data. NKG, TM, MT, TKW, JWW, BCT, and CB contributed to interpretation of data. NKG, HRC, CS, TM, MT, TKW, and CB contributed to drafting of the article. JWW, BCT, and CB contributed to critical revision of article. All authors have read and approved the final submitted manuscript.

Funding
The American Osteopathic Foundation and the American Osteopathic Academy of Orthopedics Foundation helped fund this project.

Availability of data and materials
All data presented in this manuscript are derived from the included articles published in the Supplementary Information Files. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request. This systematic review has not been registered prospectively.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
Dr. BCT is a consultant for/lecturer bureau for ZimmerBiomet; consultant for Stryker; consultant for Atricure; royalties from Innomed; editorial board for Orthobullets.com. NKG, FD, HRC, CS, AB, MFR, Dr. TM, Dr. MT, Dr. TKW, Dr. JWW, and Dr. CB report no financial or non-financial competing interests.

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Received: 2 September 2024 Accepted: 14 February 2025
Published online: 06 March 2025

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