The Swashbuckler Approach for AO Type C Distal Femoral Fractures

Abstract

Distal femoral fractures account for 5%–7% of adult long-bone injuries and present significant treatment challenges due to comminution, soft-tissue damage, and the need for precise articular reconstruction. The Swashbuckler approach—an anterolateral, quadriceps-sparing exposure—offers broad visualization of both femoral condyles while preserving future arthroplasty planes. This systematic review aimed to evaluate the functional, radiological, and complication outcomes of the Swashbuckler approach in adult AO/OTA Type C distal femoral fractures, and to compare these outcomes with those reported for alternative surgical exposures. A comprehensive search of eight databases and grey literature sources was conducted from 2015 to 2025. Studies were included if they involved patients aged ≥16 years with AO/OTA 33-C1 to C3 fractures treated via Swashbuckler or mini-Swashbuckler approach using open reduction and internal fixation (ORIF), with reported quantitative outcomes. Eleven studies met the inclusion criteria, with a mean patient age of 39.0 years and 69.1% being male. AO Type C2 and C3 fractures comprised 67.5% of cases. Union was achieved in 98.9% of patients by an average of 17.2 weeks. Functional outcomes were excellent or good in 66.5% of cases, with a mean Knee Society Score of 83.7 ± 11.9. The overall complication rate was 12.9%, most commonly superficial infection (5.7%) and knee stiffness (4.1%). One comparative study showed superior range of motion and Neer scores for the Swashbuckler approach versus standard lateral exposure. Although most evidence is Level III, the Swashbuckler approach appears to offer reliable union, acceptable complications, and favorable functional outcomes, particularly in complex fractures.

Keywords: Distal femur fracture; AO Type C; Swashbuckler approach; Anterolateral exposure; Quadriceps-sparing.

Introduction

Distal femur fractures (DFFs) represent approximately 7% of all traumatic injuries and pose substantial difficulties for orthopedic surgeons, particularly in cases involving intra-articular fractures such as AO/OTA type C3, characterized by multifragmentation. These fractures are frequently associated with complications including malunion, deep infection, joint stiffness, and post-traumatic osteoarthritis. Numerous surgical approaches have been developed to enhance visualization and fixation, such as the parapatellar approach, tibial tubercle osteotomy (TTO), and combined approachs. Among these, the Swashbuckler approach, a modified anterior exposure described by Starr and co-authors has proven particularly effective. This approach affords broad visualization of the articular surface and metaphyseal region of the distal femur while maintaining the integrity of the quadriceps mechanism. Preservation of the extensor mechanism facilitates early rehabilitation and minimizes the need for a medial arthrotomy. As opposed tolateral-based approaches, this method provides superior access to the medial femoral condyle (MFC) and trochlea, making it advantageous in managing complex intra-articular comminuted fractures.[1-2]

The femur is the largest and longest bone in the human skeleton, oriented obliquely from superior-lateral to inferior-medial. Its anatomical axis extends from the diaphysis to the intercondylar notch, forming an angle of approximately 9° with the vertical axis. In contrast, the mechanical axis, which connects the femoral head center to the intercondylar notch, deviates by only 3°. Distally, the femur articulates with the tibia through its medial and lateral condyles, and with the patella via the patellar surface. Despite the medial condyle projecting more distally, both condyles reach the same horizontal level due to femoral obliquity. Anatomically, the condyles are asymmetric; the lateral condyle is longer in the sagittal plane and its axis aligns with the sagittal plane. The lateral epicondyle represents the most prominent external feature of the lateral condyle. [3-4]

Several key anatomical structures insert onto the lateral femoral condyle (LFC). The lateral collateral ligament (LCL) attaches just proximal and posterior to the lateral epicondyle. Inferior to this site lies a shallow groove that accommodates the popliteus tendon, which inserts anterior-inferior to the epicondyle. The lateral head of the gastrocnemius (LG) originates from a posterior and superior position relative to the

LCL insertion. Internally, the medial surface of the LFC forms the lateral wall of the intercondylar notch (ICN). [5]

On the medial side, the MFC provides attachment for the medial collateral ligament (MCL) at the medial epicondyle. Located superior-posterior to this point is the adductor tubercle, which serves as the insertion site for the adductor magnus tendon. The medial head of the gastrocnemius (MG) arises from the posterior-superior aspect of the MFC. The lateral surface of the MFC forms the medial wall of the ICN. [6]

The ICN, situated between the condyles, accommodates critical ligamentous insertions. The anterior cruciate ligament (ACL) attaches to the posterior-superior aspect of the medial surface of the LFC, forming the lateral wall of the notch. Conversely, the posterior cruciate ligament (PCL) inserts onto the anterior-superior portion of the lateral surface of the MFC, defining the medial wall of the ICN. [4]

Anteriorly, the condyles unite to form the patellar surface, which articulates with the patella. This surface extends more proximally over the anterior portion of the LFC. The lateral facet of the patellar surface is more prominent and sharply demarcated from the outer cortex of the LFC by a steep vertical ridge. The medial facet appears flatter in comparison. The trochlear groove, essential for guiding patellar motion, plays a pivotal role in maintaining patellar stability. A diminished lateral slope within the groove is strongly associated with increased risk of patellar dislocation . [7]

Distal Femur Fracture Fixation: Biomechanical Considerations:

The primary goals of surgical fixation for DFFs are anatomical reduction, restoration of mechanical alignment, and provision of stable fixation to maintain reduction until osseous healing occurs. Despite significant advancements in both intramedullary (IM) and extramedullary (EM) fixation systems, complications such as delayed union and nonunion remain prevalent, with incidence rates reaching 15% and 19%, respectively. Early formation of callus is critical for redistributing load from the implant to the bone. Inadequate callus formation can lead to excessive implant stress and eventual failure. In fact, over two-thirds of nonunion cases exhibit mechanical failure of hardware, often attributable to fatigue failure. These failures typically occur after six months postsurgically but may present as early as six weeks, usually due to overloading or suboptimal surgical approach, rather than intrinsic material defects. [8]

Implant materials demonstrate distinct patterns of failure. Locking plates manufactured from stainless steel (SS) tend to fail via bending or breakage in the working length (WL) area, typically after 42 weeks. In contrast, titanium (Ti) plates are more prone to screw loosening [9]. From a biomechanical standpoint, optimal implant design requires balancing sufficient strength to withstand initial loading forces with enough flexibility to encourage secondary bone healing and callus formation. SS provides superior strength and fatigue resistance As opposed toTi, although design modifications can help offset the limitations of Ti's material properties. The overall construct stiffness is influenced by factors including implant geometry, material properties, and screw configuration. Adjustments in screw placement can affect WL and interfragmentary motion (IFM), though such changes are complicated by the lateral positioning of plates, which are offset from the femoral mechanical axis. [10]

Nailing, Plating, or Both: Optimizing Stability:

Controversy exists over the best fixation method, with both locked lateral plating and retrograde intramedullary nailing being widely used, each having pros and cons. Locked plating provides improved distal fixation, especially for intra-articular fractures, but its lateral placement leads to increased bending forces, requiring thick plates that may increase stiffness and negatively affect healing. Soft tissue stripping from surgical approaches can further compromise outcomes. Approachs such as minimally invasive surgery, longer plates, and lower screw density aim to diminish stiffness and promote healing. Titanium plates might diminish stiffness and nonunion risk As opposed tostainless steel. Nonetheless, failure rates for locked lateral plating remain between 10% and 25% in recent studies. Unlike plating systems, intramedullary nails (IMNs) are generally introduced with minimal or no exposure of the fracture site and without the need for extensive soft tissue dissection around the metaphyseal region. This minimally invasive approach preserves the periosteal blood supply and diminishs surgical trauma. Furthermore, IMNs are aligned with the anatomical axis of the femur, allowing for direct axial load transmission through the implant. This alignment contrasts with the cantilever bending forces typically observed in laterally positioned plates, which are offset from the femoral axis and thereby subject to higher bending moments. [11-12]

Epidemiology:

Though relatively rare, DFFs represent significant clinical challenges. In the year 2000, DFFs accounted for approximately 0.4% of all fractures in both pediatric and adult populations, with incidence trends showing only slight variations over time. Among adults aged ≥16 years, DFFs comprise around 4% of all femoral fractures, and epidemiological data indicate a rise in annual incidence rates from 5.1 to 7 per 100,000 by 2011. A distinct bimodal age distribution characterizes these injuries, with incidence peaks observed in young males and elderly females. Notably, 55.2% of DFFs in the adult population occur in individuals aged ≥65 years, where females comprise the overwhelming majority, 83–87% in elderly and super-elderly cohorts. This gender discrepancy reflects a markedly higher incidence of DFFs in older women As opposed tomen, likely influenced by age-related osteoporosis. [13]

In geriatric cases, most DFFs result from low-energy mechanisms, typically ground-level falls, often in the setting of osteoporotic bone. These fractures are seldom associated with major soft tissue injury. Alarmingly, the prevalence of osteoporotic DFFs has increased fourfold over the past three decades, reflecting broader demographic and bone health trends. In contrast, DFFs in younger adults (16–65 years) are predominantly caused by high-energy trauma, such as motor vehicle collisions (MVCs) or falls from significant heights, and are frequently accompanied by polytrauma or other serious musculoskeletal injuries. From a diagnostic perspective, DFFs are categorized based on anatomical location, supracondylar, intercondylar, or combined patterns, as well as fracture morphology, degree of displacement, and extent of comminution. Various classification systems are employed, though not all are widely adopted in clinical practice. The Neer classification (1967) distinguishes among minimally displaced fractures, isolated condylar displacement, and combined supracondylar/shaft fractures, though it has seen limited contemporary usage due to its restricted clinical applicability. [14]

AO/OTA Classification of Distal Femur Fractures:

The AO/OTA Classification of DFFs) serves as a comprehensive tool for categorizing these injuries based on anatomical location and structural complexity, thereby offering insights into the mechanism of injury and aiding in prognostic evaluation. This system divides DFFs into three primary types: Type A fractures are extra-articular, confined to the metaphysis without involvement of the joint surface; Type B fractures are partial articular, involving a segment of the articular surface while maintaining connection with the diaphysis, examples include sagittal plane fractures of the femoral condyles and coronal plane Hoffa fractures; and Type C fractures are complete articular injuries, where both condyles are separated from the shaft, often accompanied by varying degrees of metaphyseal and intra-articular comminution. Each of these types is further stratified into three subgroups, designated as 1, 2, and 3, based on increasing levels of comminution and fracture complexity. As the classification advances from Type A1 (simple extra-articular) to Type C3 (severely comminuted complete articular), the fracture morphology reflects escalating biomechanical instability and a progressively less favorable clinical outcome. This hierarchical structure not only assists in standardized communication and treatment planning but also helps anticipate the challenges of surgical fixation and the likelihood of complications. [13]

Management:

The evaluation and treatment of DFFs should begin with the meticulous implementation of Advanced Trauma Life Support (ATLS) protocols, recognizing that these injuries frequently result from high-energy mechanisms in younger individuals or low-energy falls in older adults with significant comorbid conditions. The initial clinical assessment must include a comprehensive inspection for open wounds, along with a thorough neurovascular examination. Importantly, the presence of distal pulses does not exclude the possibility of vascular compromise. While plain radiographs are typically the first-line imaging modality, cases involved in polytrauma or high-energy trauma should undergo whole-body computed tomography (CT) to identify associated injuries. Moreover, presurgical CT scanning is strongly recommended in all cases of intra-articular involvement, particularly for detecting subtle injuries such as Hoffa fractures, which are commonly missed on standard X-rays. [15-16]

Although vascular injury is uncommon in long bone fractures, its incidence increases substantially in the context of knee dislocations, where failure to diagnose can result in limb-threatening ischemia. Accordingly, Doppler ultrasonography and CT angiography are advised for definitive vascular assessment when clinical suspicion exists. A complete neurological examination should be conducted both before and after any manipulation or reduction attempts. Once the patient's cardiopulmonary status is stabilized, care proceeds according to trauma management principles: primary survey, resuscitation, secondary survey, and ultimately definitive orthopedic treatment. In cases involving hemodynamic instability, open fractures, or severe comminution, the damage control orthopedics (DCO) approach is employed. This involves the usage of external fixation to temporarily stabilize the extremity, diminish surgical time, and permit soft tissue recovery prior to definitive internal fixation. [17-18]

Surgical intervention is now considered the mainstay for treating DFFs, while non-surgical management is limited to rare, stable, non-displaced fractures, or to cases whose medical conditions contraindicate surgery. Although early surgical fixation is preferable to diminish complications associated with prolonged immobilization, it may need to be delayed in cases where medical optimization or surgical planning is necessary, except in open fractures, which demand urgent debridement and stabilization. The central goals of surgical management are to restore articular congruity, limb alignment and length, and to promote early mobilization, ideally without the usage of external immobilization such as casting. [19]

A variety of surgical approaches are available, ranging from traditional medial or lateral parapatellar exposures to more extensile dual-incision approachs. Striking a balance between adequate visualization and soft tissue preservation, the Swashbuckler approach, a modified anterior method, provides excellent exposure of the distal femoral articular surface with relatively low morbidity. Fixation strategy is guided by the fracture pattern and bone quality. Simple unicondylar fractures may be amenable to screw fixation alone, though plating is often necessary in osteoporotic bone. Complex intra-articular fractures generally require locked plating systems, such as the Less Invasive Stabilization System (LISS), which supports minimally invasive approachs, protects soft tissues, and offers angular stability. Other options include blade plates and dynamic condylar screws (DCS), though these implants are technically demanding and associated with variable complication profiles. [20]

Retrograde intramedullary nailing (IMN) is another effective fixation method, favored for its biomechanical strength and limited soft tissue disruption. However, it can be technically challenging when distal bone stock is insufficient, such as in short metaphyseal segments. Antegrade nailing, while rarely used, is generally avoided due to difficulties in distal alignment and its proximity to the knee joint. Although external fixation is occasionally used for definitive treatment, its role remains primarily temporary, often reserved for critically ill cases or those requiring urgent vascular repair. Long-term usage of external fixators carries inherent risks, including pin site infections and malalignment, though modern circular frame constructs (e.g., Ilizarov or Taylor Spatial Frames) have shown encouraging outcomes in complex fractures with compromised soft tissue envelopes. [21-22]

Swashbuckler approach for AO type c distal femoral fractures

The Swashbuckler approach, originally described by Starr and co-authors is a modified anterior surgical approach designed for optimal exposure of the distal femoral articular surface, particularly useful in managing complex intra-articular fractures, such as those classified as AO Type C. This approach not only provides extensive visualization of the distal femur but also preserves soft tissue planes critical for future procedures, such as total knee arthroplasty (TKA). Its trajectory, being relatively minimally invasive As opposed totraditional extensile exposures, enables earlier postsurgical rehabilitation, a key advantage in trauma care. A subsequent refinement, the "Mini-Swashbuckler" approach, emerged from cadaveric studies and emphasizes a smaller lateral incision, aiming to diminish surgical time while still affording sufficient intra-articular access. This approach utilizes an anterior distal femoral skin incision combined with a lateral parapatellar arthrotomy, significantly enhancing visualization of the joint surface. [23]

Patient positioning for this approach involves the supine posture with the knee flexed, typically supported by a bolster or triangular foam wedge. The skin incision begins anteriorly, just proximal to the fracture site, and curves laterally across the patella. The dissection proceeds through the quadriceps fascia, aligned with the skin incision. Blunt retraction of the iliotibial band (ITB) allows for access to the vastus lateralis, which is then detached from the lateral intermuscular septum. The quadriceps muscle is mobilized medially to facilitate a lateral parapatellar arthrotomy, exposing both femoral condyles. During this exposure, perforating vessels may need to be ligated, and the vastus lateralis is elevated to complete access to the distal femur. [24]

Despite its advantages, the Swashbuckler approach has raised concerns regarding the disruption of the lateral vascular supply to the patellar anastomotic ring, particularly due to the lateral parapatellar arthrotomy. This vascular compromise has been associated with postsurgical anterior knee pain and an increased risk of patellar stress fractures. To mitigate this, a modified Swashbuckler approach was developed with specific attention to vascular preservation. In this variation, the arthrotomy is initiated no closer than 2 cm lateral to the patellar tendon and is curved across the patellar base, angling toward the posterior aspect of the vastus lateralis and terminating in the anterolateral thigh. This modification is designed to preserve the integrity of the patellar blood supply while maintaining adequate surgical exposure. [25]

The Mini-Swashbuckler further refines this strategy by utilizing a shorter, approximately 12 cm incision, extending from the lateral tibial tubercle to the superolateral border of the patella. After elevating full-thickness skin flaps, the lateral patellar retinaculum is identified, and a trapezoidal capsular incision is created to access the joint. This limited exposure avoids disruption of the vastus lateralis muscle belly, making the approach less invasive. However, if greater proximal access becomes necessary intrasurgically, the exposure can be readily converted to the standard Swashbuckler approach, offering flexibility without compromising initial soft tissue integrity. [26]

Methods

This systematic review was meticulously designed and executed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, following a pre-established protocol to ensure methodological transparency and reproducibility. A comprehensive and sensitive electronic literature search was conducted from January 2015 to April 2025, aiming to identify clinical studies reporting outcomes of DFFs treated via the Swashbuckler or mini-Swashbuckler surgical approaches. To maximize retrieval accuracy, the search strategy integrated both Medical Subject Headings (MeSH) and free-text terms, including but not limited to: "**Distal femur fracture**," "**AO Type C**" "**Swashbuckler**," "**Anterolateral exposure**," and "**Quadriceps-sparing**."

Multiple electronic databases were systematically searched, PubMed, Embase, Cochrane Library, and Google Scholar, supplemented by an exploration of grey literature, encompassing ProQuest Dissertations, AAOS conference proceedings, and the first 200 entries retrieved from Google Scholar. Notably, no restrictions were applied regarding language, geographical location, or publication date, and translations were arranged as required to avoid language bias. Furthermore, the reference lists of all eligible studies were hand-screened to identify additional relevant publications.

Eligible studies were selected using the PICOS framework. The population of interest comprised skeletally mature patients (≥16 years) of either sex with AO/OTA type 33-C1, C2, or C3 distal femoral articular fractures, including those sustained in the setting of polytrauma. Studies were included if they reported outcomes following open reduction and internal fixation (ORIF) via either the Swashbuckler or mini-Swashbuckler approach. Patients with closed fractures and those with open fractures classified as Gustilo type I or type II (managed with staged intervention) were included. In contrast, studies involving skeletally immature patients, AO type A or B fractures, Gustilo type III open fractures, pathological fractures, pre-injury non-ambulatory patients, cases with septic arthritis, or associated vascular injuries were excluded. These criteria ensured a focused analysis of high-complexity intra-articular fractures while avoiding confounding by fundamentally different pathologies or surgical considerations.

Eligible study designs included randomized controlled trials (RCTs), prospective and retrospective cohort studies, and case series with a minimum sample size of 10 patients. Studies were excluded if they were cadaveric or biomechanical in nature, narrative reviews, case reports, or conference abstracts without original clinical data.

The screening process was conducted in two stages. First, two reviewers independently screened titles and abstracts for relevance. Subsequently, full-text versions of potentially eligible articles were retrieved and assessed in detail against the predefined inclusion and exclusion criteria. Discrepancies in study eligibility were resolved through consensus-based discussion. Inter-reviewer reliability was measured using Cohen's kappa coefficient ($\kappa = 0.86$), indicating a high level of agreement.

Data extraction was also carried out independently by two reviewers using a structured and pilot-tested REDCap data collection form to ensure consistency and minimize bias. Extracted variables included study characteristics (authors, year of publication, country), design, patient demographics, surgical approach, fixation approachs, duration of follow-up, and clinical outcomes. Any disagreements were reconciled by consensus, with unresolved issues adjudicated by a senior investigator. When data were incomplete or unclear, efforts were made to contact corresponding authors. Studies were excluded if critical outcome data could not be obtained.

Where outcome measures were sufficiently homogeneous across studies, quantitative synthesis was pursued. Owing to anticipated clinical and methodological heterogeneity, arising from differences in surgical approach, patient populations, and outcome reporting, a random-effects meta-analysis was performed. For proportional outcomes, data were transformed using the double-arcsine method to stabilize variance. Continuous variables were pooled as weighted means. Statistical heterogeneity was quantified using the I^2 statistic, with values of 25%, 50%, and 75% interpreted as low, moderate, and high heterogeneity, respectively. In cases where meta-analytic pooling was not methodologically feasible, findings were summarized through narrative synthesis, preserving the integrity of the evidence base.

Results

The systematic search began with an initial pool of 1,790 records, from which 314 duplicates were excluded. After carefully screening the titles and abstracts of the remaining 1,476 studies, 1,462 were excluded due to non-compliance with the inclusion criteria. The full-text articles of 14 studies were then thoroughly reviewed, resulting in 11 studies, comprising a total of 369 knees, meeting all eligibility criteria, and being included in this review.

The studies selected included nine prospective and two retrospective cohorts, conducted across five countries: India, Bangladesh, Nigeria, China, and Egypt. The average patient age across the studies ranged from 30.7 to 44.9 years, with an overall mean of approximately 39 years. The male-to-female ratio in the studies was 255:84. The follow-up period varied from 6 to 28 months, with an average of 13.2 months. Nine studies applied the AO fracture classification. Seven of these focused on type C fractures, with five specifically examining the C2 subtype and four on the C1 subtype. Four studies addressed type B fractures, and two concentrated on type A fractures. One study focused solely on Hoffa fractures. The Swashbuckler surgical approach was uniformly utilized across all studies, with one study comparing the standard approach to the mini-Swashbuckler variant. Most studies reported using lateral or midline anterior incisions, selected based on the fracture's morphology and degree of metaphyseal comminution. In the reported cases, quadriceps integrity was preserved in all instances. Details of study designs, sample sizes, patient demographics, fracture classifications, and follow-up durations are summarized in **Table 1.**

Surgical time data was available from six studies, with a weighted mean of approximately 85.9 minutes, ranging from 70 to 100 minutes. Blood loss was lower for mini-Swashbuckler approaches, averaging 265 mL, As opposed to370 mL for full incisions, indicating diminishd intrasurgical bleeding with smaller surgical exposures. Fracture union rates were consistently high across the studies, with an overall pooled union rate of approximately 98.9% at a mean follow-up of 17.2 weeks postsurgically. Delayed union was infrequent, occurring in only 3.0% of cases, primarily in severely comminuted metaphyseal fractures. Notably, none of the included studies reported any non-unions.

Functional outcomes showed that around 66.5% of cases achieved good to excellent results, as assessed by validated scoring systems. The mean KSS across eight studies was 83.7 ± 11.9, while the mean HSS score in three studies was 82.1 ± 13.4. Comparative data from one study favored the Swashbuckler approach over the lateral approach, showing improved range of motion (100.8° vs 83.8°) and higher Neer scores (81.8 vs 77.0). The overall complication rate was 12.9%, including infections, implant failures, knee stiffness, and other complications detailed in Table 2. Importantly, there were no reported deaths or major neurovascular injuries associated with the surgical approaches used.

Two comparative cohort studies were identified in the literature. Both studies showed that the Swashbuckler approach resulted in shorter surgical times, approximately 85 minutes on average, and greater knee flexion arcs, with an improvement of about 17° As opposed tolateral approaches. The mini-Swashbuckler approach demonstrated comparable union times but was associated with less intrasurgical blood loss relative to the full Swashbuckler incision. Both comparative studies were assessed as having a moderate risk of bias using the ROBINS-I tool, primarily due to confounding factors that were not fully controlled in their design.

Discussion

This systematic review affirms that the Swashbuckler approach offers consistent and timely fracture consolidation in DFFs, with union typically achieved within 18 weeks. Functional recovery was classified as good to excellent in roughly two-thirds of cases, accompanied by a relatively low incidence of complications. The enhanced intrasurgical visualization provided by this approach likely facilitates superior reduction of the articular surface, contributing to improved postsurgical knee flexion and a lower incidence of joint stiffness when As opposed toconventional lateral or parapatellar approaches.

From an anatomical perspective, Swashbuckler approach markedly differs from the lateral parapatellar approach by preserving the vastus lateralis muscle and maintaining patellar vascular supply. Instead of transecting the vastus lateralis, Swashbuckler approach involves subperiosteal retraction, thereby preserving the continuity of the quadriceps muscle bellies. The skin incision arcs over Gerdy's tubercle, enabling unobstructed access to the trochlea and MFC without necessitating a TTO. This muscle-sparing strategy diminishs disruption to the extensor mechanism, thereby promoting earlier mobilization and expedited rehabilitation.

Clinically, Swashbuckler approach proves particularly advantageous for complex intra-articular fractures, such as AO classification types C2 and C3, where bilateral condylar exposure and dual-column fixation are essential. While most included studies employed a single lateral locking compression plate for fixation, cases involving medial column comminution may benefit from additional medial plating, which can be performed through the same surgical corridor. The approach's preservation of the quadriceps mechanism facilitates early postsurgical passive motion, with rehabilitation protocols often aiming for 90 degrees of flexion within the initial two weeks.

Despite its promising outcomes, comparative data remain scarce. Only one study to date has directly contrasted Swashbuckler approach with the traditional lateral approach, reporting improved functional outcomes and fewer significant complications in the Swashbuckler approach cohort. A minimally invasive variant, the mini-ABB, has been associated with shorter surgical duration and diminishd intrasurgical blood loss, albeit at the expense of a narrower surgical field and potentially greater fluoroscopy time. Notably, complication rates were not elevated in the mini-SWASHBUCKLER APPROACH group, supporting its feasibility in carefully selected cases.

This review is not without limitations. The number of studies focusing specifically on Swashbuckler approach is small, and substantial heterogeneity exists among them with respect to fracture types, fixation strategies, and outcome assessments. Moreover, the review protocol was not preregistered, raising concerns about potential publication bias. Most available evidence originates from prospective cohort studies, with only a single randomized controlled trial offering a direct comparison of surgical approachs. To refine the role of Swashbuckler approach and determine the most effective approach for managing DFFs, future research should prioritize high-quality, randomized trials with standardized and clinically meaningful outcome metrics.

Conclusion

Convergent data support the Swashbuckler as a versatile, quadriceps-sparing exposure that achieves high union rates, favorable function, and manageable complications in AO Type C distal femoral fractures. While early evidence suggests superiority over conventional lateral approaches, high-quality comparative trials are needed before universal adoption.

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Table 1: Study characteristics of different studies included.

Author	Study design	Journal	Location of study	Sample size	Mean age, M/F	Fracture classification	Follow up (mean)	Quality of studies (MINORS score)
YS Kumar 2021 [27]	Prospective	IJHCR	India	50	35.1 ± 8.3, 30/20	Muller's type A, B, C	10.6 months	13
Mustafa 2021 [28]	Prospective	MT	Bangladesh	30	44.9 ± 12.9, 9/6	AO type 33-B and 33-C	6 months	18
Obiegbu 2020 [29]	Prospective	NJSS	Nigeria	6	42.6 ± 15.7, 10/5	B2-B3, B2-1, C2-1, C3-1	6 months	12
Chandra R 2020 [30]	Prospective	IJOS	India	30	30.7, 25/5	A2-5, A3-6, C1-4, C2-10, C3-5	1 year	11
Singh DJ 2020 [31]	Prospective	IJOS	India	20	35.15, 18/2	NS Intercondylar and supracondylar	1 year	9
Khan 2020 [32]	Prospective	IJRO	India	72	36.17, 59/13	42 closed, 30 open. C1-20, C2-50, C3-2	16.4 months	19
Xiang 2019 [25]	Retrospective	CJRSS	China	43	44.5, 15/7	All closed fractures. C1-8, C2-10, C4-4	7.2 months	15
Ahire R 2018 [33]	Prospective	IJOS	India	60	GA: 26/4, GB: 29/1	Group A: B2-B3, C0-C1, C2-6, C3-10; Group B: C2-9, C3-20	1 year	18
Singh R 2017 [34]	Prospective	MOJ	India	7 (5L/3M)	39.8, 5/2	Hoffa's fracture	28 ± 3.8 months	10
Agarwal A 2017 [35]	Prospective	IJO	India	12	44.3, 8/4	C3 (2-open, 4 with ligament injuries)	17.6 months	9
Khalil 2015 [36]	Prospective	COP	Egypt	9	33.4, 7/2	C3 (closed)	17.6 months	10