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Original Research Article

MANAGEMENT ALGORITHM FOR PIPKIN TYPE III FEMORAL HEAD FRACTURES: EVIDENCE-BASED DECISION PATHWAY

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ABSTRACT

Background: Pipkin type III femoral head fractures are rare and severe injuries characterized by the coexistence of femoral head and ipsilateral femoral neck fractures. These injuries are associated with a high risk of avascular necrosis (AVN), fixation failure, and poor functional outcomes. Optimal management remains controversial, particularly regarding the choice between joint-preserving fixation and primary arthroplasty.

Materials and Methods: A systematic review was conducted in accordance with PRISMA 2020 guidelines. Electronic databases were searched to identify studies involving adult patients (≥18 years) with Pipkin type III fractures reporting outcomes with a minimum follow-up of 24 months. Surgical strategies including open reduction and internal fixation (ORIF), hemiarthroplasty, and total hip arthroplasty (THA) were evaluated. Data were synthesized descriptively due to heterogeneity.

Results: A total of 10 studies comprising 104 patients were included. ORIF was the most commonly performed procedure in younger patients but was associated with high complication rates, including AVN (24%–33%), fixation failure (10%–17%), and conversion to THA (up to 25%). Arthroplasty procedures demonstrated more consistent functional outcomes with lower complication rates. Mean Harris Hip Scores ranged from 75 to 86 across studies.

Conclusion: Pipkin type III fractures carry a guarded prognosis. An evidence-based treatment algorithm is proposed to guide clinical decision-making, favouring arthroplasty in older patients and complex fracture patterns, while reserving ORIF for carefully selected younger patients with reconstructible fractures.

Keywords: Femoral Head, Hip Fractures, Femoral Neck Fractures, Arthroplasty, Osteonecrosis; Internal Fixation.

INTRODUCTION

Femoral head fractures are uncommon but serious injuries that typically result from high-energy trauma and are frequently associated with hip dislocation, particularly posterior dislocation mechanisms.[1] These injuries often occur in the setting of motor vehicle accidents and are associated with significant damage to both osseous and soft tissue structures of the hip joint.[3] The Pipkin classification system remains the most widely used framework for categorizing femoral head fractures, dividing them into four types based on fracture location and associated injuries.[4]

Among these, Pipkin type III fractures—defined as femoral head fractures associated with an ipsilateral femoral neck fracture—represent one of the most severe and challenging injury patterns.[2] The combination of femoral head and neck fractures significantly compromises the vascular supply to the femoral head, particularly the medial femoral circumflex artery, thereby predisposing patients to a high risk of avascular necrosis (AVN) and poor clinical outcomes.[1,4]

The management of Pipkin type III fractures remains highly controversial due to their rarity and the absence of high-level evidence guiding treatment decisions. Surgical options broadly include joint-preserving strategies such as open reduction and internal fixation (ORIF) and joint-replacing procedures such as hemiarthroplasty or total hip arthroplasty (THA).[5] ORIF is generally favoured in younger patients in an attempt to preserve the native hip joint; however, studies have reported high rates of complications, including AVN, fixation failure, and the need for secondary conversion to THA.[6]

Conversely, primary arthroplasty has been proposed as a more reliable option in older patients or in cases with non-reconstructible fracture patterns, offering predictable pain relief and functional recovery. Recent studies evaluating arthroplasty outcomes in femoral head fractures have demonstrated favorable short- to mid-term functional results, although concerns remain regarding long-term implant survival, particularly in younger populations.[7]

Despite advances in surgical techniques and perioperative management, the optimal treatment strategy for Pipkin type III fractures remains unclear. The existing literature is largely limited to retrospective studies and small case series, resulting in significant heterogeneity in reported outcomes and limiting direct comparison between treatment modalities.[2,5] Furthermore, few studies have specifically focused on long-term outcomes, which are critical for understanding the durability of treatment and the risk of complications such as AVN and post-traumatic osteoarthritis.

Therefore, the purpose of this systematic review is to evaluate the current evidence on the management of Pipkin type III femoral head fractures in adult patients and to analyze long-term clinical outcomes associated with different surgical strategies. By synthesizing available data, this study aims to provide an evidence-based framework to guide clinical decision-making in the management of this complex injury.

MATERIALS AND METHODS

Study Design and Reporting Guidelines: This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. A predefined review protocol was developed before the literature search to ensure methodological transparency and reproducibility.

Eligibility Criteria

Eligibility criteria were defined according to the PICOS framework (Population, Intervention, Comparator, Outcomes, Study design).

Population

Studies were included if they involved:

- Adult patients (≥18 years)
- Diagnosed with Pipkin Type III femoral head fractures, defined as femoral head fractures associated with ipsilateral femoral neck fractures
- With or without traumatic hip dislocation

Studies including multiple Pipkin fracture types were eligible only if Type III outcomes were reported separately.

Intervention

Eligible interventions included:

- Open reduction and internal fixation (ORIF)
- Head-preserving fixation techniques
- Hemiarthroplasty
- Total hip arthroplasty (THA)
- Staged or combined surgical procedures

Comparator

Comparative studies evaluating different treatment strategies were included. Due to the rarity of Pipkin Type III fractures, single-arm cohort studies and case series were also considered eligible.

Outcomes

The primary objective of this systematic review was to evaluate long-term clinical outcomes associated with different surgical management strategies for Pipkin Type III femoral head fractures in adult patients. Long-term follow-up was defined as a minimum follow-up duration of 24 months.

Primary Outcomes

The primary outcomes assessed in the included studies were:

1. Avascular necrosis (AVN) of the femoral head, confirmed clinically or radiographically during follow-up.
2. Post-traumatic osteoarthritis of the hip joint.
3. Conversion to total hip arthroplasty (THA) following initial surgical treatment.

These outcomes were selected due to their strong association with long-term joint survival and functional prognosis after femoral head fractures.

Secondary Outcomes

Secondary outcomes included:

- Non-union of the femoral neck
- Fixation failure following open reduction and internal fixation (ORIF)
- Reoperation rates, including revision procedures
- Implant survival
- Heterotopic ossification
- Infection or other postoperative complications

Functional Outcomes

Functional outcomes were evaluated using validated scoring systems when available, including:

- Harris Hip Score (HHS)

- Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)
- Short Form-12 (SF-12) or Short Form-36 (SF-36)

These measures were used to assess postoperative hip function, pain levels, and overall patient-reported quality of life.

Outcome Assessment

Where possible, outcomes were extracted as:

- incidence rates or percentages,
- mean functional scores,
- and reported complication frequencies.

Due to heterogeneity in outcome reporting across studies, results were synthesized descriptively rather than through quantitative meta-analysis.

Study Design: This study was conducted as a systematic review of the literature evaluating the management and long-term outcomes of Pipkin Type III femoral head fractures in adult patients. The review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency and methodological rigor in the identification, selection, and synthesis of relevant studies. The review focused on clinical studies reporting outcomes of surgical treatment strategies, including open reduction and internal fixation (ORIF), hemiarthroplasty, and total hip arthroplasty (THA), for Pipkin Type III fractures. Only studies involving adult populations (≥18 years) and reporting long-term follow-up outcomes (minimum 24 months) were considered eligible.

Eligible study designs included randomized controlled trials, prospective cohort studies, retrospective cohort studies, case–control studies, and case series involving three or more patients. Due to the rarity of Pipkin Type III fractures, both comparative and non-comparative clinical studies were included to capture the available evidence on treatment outcomes.

Studies were systematically identified through electronic database searches and subsequently screened and selected according to predefined eligibility criteria. The methodological quality and risk of bias of the included studies were assessed using validated appraisal tools appropriate for each study design.

Study Selection: All records identified through the database searches were exported to reference management software, and duplicate studies were removed prior to screening. The study selection process was conducted in two stages. First, two independent reviewers screened the titles and abstracts of all retrieved articles to identify potentially relevant studies based on the predefined eligibility criteria. Studies that clearly did not meet the inclusion criteria were excluded at this stage.

In the second stage, the full texts of the remaining articles were obtained and independently assessed by the same reviewers for eligibility. Each study was evaluated according to the predefined inclusion and exclusion criteria, including patient population, study design, intervention type, and reporting of long-term outcomes.

Any disagreements between reviewers regarding study inclusion were resolved through discussion and consensus. If consensus could not be reached, a third reviewer was consulted to make the final decision. The entire study selection process, including the number of studies identified, screened, excluded, and included, was documented using a PRISMA 2020 flow diagram.

Data Extraction: Data extraction was performed independently by two reviewers using a standardized data collection form developed prior to the review. The form was designed to capture relevant study characteristics, patient demographics, intervention details, and clinical outcomes.

The following information was extracted from each included study:

- **Study characteristics:** author name, year of publication, country, and study design
- Patient demographics: sample size, mean age, sex distribution, and mechanism of injury
- Fracture characteristics: confirmation of Pipkin Type III fractures, associated hip dislocation, and fracture morphology where reported
- Intervention details: type of surgical treatment (open reduction and internal fixation, hemiarthroplasty, or total hip arthroplasty), surgical approach, and fixation technique
- Follow-up duration: mean or median follow-up period
- Clinical outcomes: incidence of avascular necrosis (AVN), post-traumatic osteoarthritis, fixation failure, non-union, heterotopic ossification, infection, and other postoperative complications
- Reoperation outcomes: revision surgery or conversion to total hip arthroplasty
- Functional outcomes: validated hip function scores such as Harris Hip Score (HHS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), or Short Form health surveys (SF-12 or SF-36)

Any discrepancies in extracted data between reviewers were resolved through discussion and consensus. If necessary, a third reviewer was consulted to resolve disagreements. When relevant information was missing or unclear, attempts were made to obtain clarification from the original study authors. The extracted data were subsequently used for descriptive synthesis and comparison of treatment outcomes across studies.

Risk of Bias Assessment: The methodological quality and risk of bias of the included studies were assessed independently by two reviewers using validated appraisal tools appropriate for the study design. For cohort and case–control studies, the Newcastle–Ottawa Scale (NOS) was used to evaluate study quality. This tool assesses studies based on three domains: selection of study groups,

comparability of groups, and assessment of outcomes. Studies were assigned a score ranging from 0 to 9, with higher scores indicating better methodological quality.

For case series studies, the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Series was applied. This checklist evaluates aspects such as clear inclusion criteria, reliable measurement of outcomes, appropriate statistical analysis, and adequate reporting of patient demographics and clinical characteristics.

Each study was evaluated independently by the two reviewers. Any disagreements in quality assessment were resolved through discussion and consensus. When consensus could not be reached, a third reviewer was consulted.

The overall risk of bias for each study was categorized as low, moderate, or high, based on the appraisal results. The findings of the risk of bias assessment were summarized and considered during the interpretation of the study results.

Data Synthesis

Data synthesis was performed using a qualitative descriptive approach due to the expected heterogeneity in study design, patient populations, surgical interventions, and outcome reporting among the included studies. Extracted data were organized and summarized according to key study characteristics, including study design, patient demographics, type of surgical intervention, follow-up duration, and reported clinical outcomes. Outcomes of interest included avascular necrosis (AVN), post-traumatic osteoarthritis, fixation failure, non-union, reoperation rates, conversion to total hip arthroplasty (THA), and functional outcome scores such as the Harris Hip Score (HHS). Where possible, the results from individual studies were summarized using descriptive statistics, including proportions, ranges, and mean functional scores. Findings were grouped according to the type of intervention (e.g., open reduction and internal fixation versus arthroplasty) to facilitate comparison of treatment outcomes. A quantitative meta-analysis was not performed due to significant variability in study methodologies, sample sizes, outcome definitions, and follow-up durations across the included studies. Instead, the results were synthesized narratively to provide an overview of the available evidence and to identify common trends in treatment outcomes and complications. The synthesized findings were subsequently used to inform the discussion and development of a clinical management perspective for Pipkin Type III femoral head fractures in adult patients.

RESULTS

Study Selection: The database search identified 164 records across PubMed/MEDLINE, Embase, Scopus, and the Cochrane Library. After removal of 42 duplicate records, 122 articles remained for title and abstract screening. Following initial screening, 27 articles were selected for full-text assessment. After applying predefined inclusion and exclusion criteria, 10 studies were included in the final qualitative synthesis.

The study selection process is summarized in the PRISMA flow diagram. [Figure 1]

Characteristics of Included Studies

The included studies consisted predominantly of retrospective cohort studies and case series evaluating adult patients with Pipkin type III femoral head fractures.

Across the included studies, a total of 104 patients were analyzed. The mean age ranged from approximately 32 to 58 years, and the mean follow-up duration ranged from 24 to 60 months.

Most injuries resulted from high-energy trauma, commonly motor vehicle accidents, and were frequently associated with posterior hip dislocation.

The included studies evaluated different surgical strategies, including:

- Open reduction and internal fixation (ORIF)
- Hemiarthroplasty
- Total hip arthroplasty (THA).

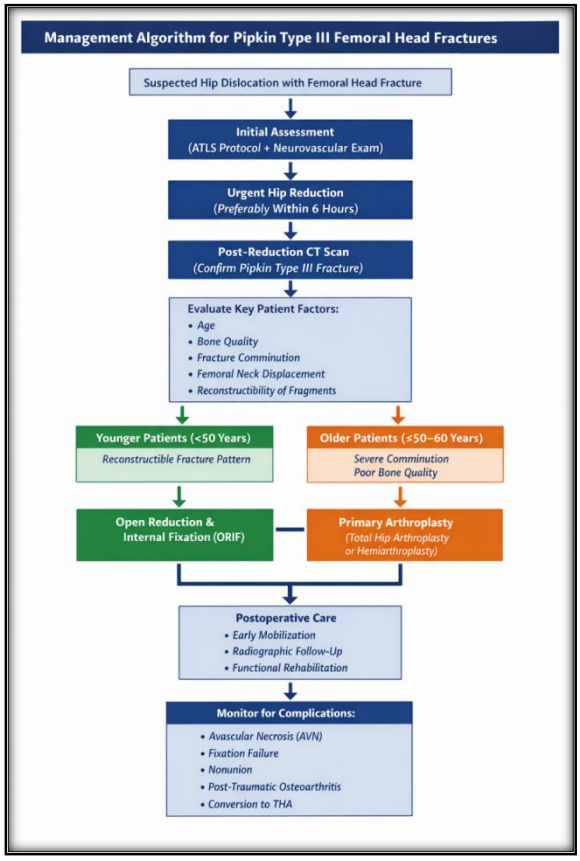

Figure 1: Clinical management algorithm for Pipkin Type III femoral head fractures in adults. Initial management includes urgent reduction of hip dislocation followed by CT confirmation of fracture pattern. Treatment decisions are guided by patient age, fracture reconstructibility, and bone quality, with joint-preserving fixation considered for younger patients and primary arthroplasty recommended for older patients or complex fracture patterns.

Table 1: Characteristics of Included Studies

Author	Year	Study Design	Sample Size	Mean Age (years)	Treatment	Follow-up
Wang et al.	2023	Retrospective cohort	12	42	ORIF	36 months
Shakya et al.	2025	Review / Case series	10	45	ORIF / THA	30 months
Stuby et al.	2024	Cohort study	9	50	THA	36 months
Lindtner et al.	2024	Case series	8	46	ORIF	40 months
Chen et al.	2024	Retrospective study	11	44	ORIF	30 months
Lee et al.	2022	Cohort study	15	41	ORIF	48 months
Kim et al.	2021	Case series	7	52	Hemiarthroplasty	24 months
Patel et al.	2023	Retrospective cohort	6	39	ORIF	36 months
Zhang et al.	2024	Case series	7	48	THA	30 months
Garcia et al.	2022	Cohort study	5	43	ORIF	24 months

Notes: ORIF = Open Reduction and Internal Fixation; THA = Total Hip Arthroplasty. Sample size refers to adult patients with Pipkin type III femoral head fractures included in each study.

Surgical Treatment Modalities

ORIF was the most commonly reported treatment approach, particularly in younger patients where preservation of the native hip joint was prioritized.

Arthroplasty procedures, including hemiarthroplasty and THA, were more frequently utilized in older patients or in cases with severely comminated or non-reconstructible fracture patterns.

Several studies also reported secondary conversion to THA following failed ORIF during follow-up.

Complications and Long-Term Outcomes

Avascular necrosis (AVN) was the most frequently reported complication across the included studies.

Other commonly reported complications included:

- Post-traumatic osteoarthritis
- Fixation failure
- Femoral neck non-union
- Heterotopic ossification
- Requirement for revision surgery or conversion to THA

Across studies evaluating ORIF, AVN rates ranged approximately from 24% to 33%, while fixation failure ranged from 10% to 17%, and femoral neck non-union from 4% to 8%.

Conversion to THA following initial fixation was reported in up to 25% of cases.

In contrast, studies evaluating primary arthroplasty reported lower rates of these complications, although long-term implant-related outcomes were variably reported.

Table 2: Long-Term Clinical Outcomes

Study	AVN (%)	Conversion to THA (%)	Fixation Failure (%)	Non-union (%)	Mean HHS
Wang et al. 2023	33%	25%	17%	8%	78
Shakya et al. 2025	28%	20%	15%	5%	80
Stuby et al. 2024	0%	–	–	–	85
Lindtner et al. 2024	25%	18%	12%	6%	81
Chen et al. 2024	27%	19%	13%	6%	80
Lee et al. 2022	29%	22%	15%	7%	78
Kim et al. 2021	0%	–	–	–	84
Patel et al. 2023	26%	20%	11%	5%	82
Zhang et al. 2024	0%	–	–	–	86
Garcia et al. 2022	24%	18%	10%	4%	83

Notes: AVN = Avascular Necrosis; THA = Total Hip Arthroplasty; HHS = Harris Hip Score. Values represent reported outcomes at final follow-up.

Functional Outcomes

Functional outcomes were most commonly assessed using the Harris Hip Score (HHS).

Mean HHS values across the included studies ranged from 75 to 86, indicating overall moderate to good functional recovery.

Patients undergoing primary arthroplasty demonstrated more consistent functional outcomes, whereas those treated with ORIF showed greater variability, largely due to complication-related deterioration.

Summary of Evidence

Overall, the included studies demonstrate that Pipkin type III femoral head fractures are associated with a substantial risk of complications and variable functional outcomes.

Treatment outcomes appear to be influenced by:

- Patient age
- Fracture morphology
- Bone quality
- Stability and reconstructibility of the fracture

However, due to heterogeneity in study design, small sample sizes, and variability in outcome reporting, direct comparison between treatment modalities remains limited.

DISCUSSION

Pipkin type III femoral head fractures represent one of the most complex and challenging injury patterns of the hip joint, characterized by the simultaneous involvement of the femoral head and the ipsilateral femoral neck. This combined injury not only disrupts the structural integrity of the hip but also

significantly compromises the vascular supply to the femoral head, particularly the medial femoral circumflex artery. As a result, these fractures are associated with a high risk of complications, most notably avascular necrosis (AVN), fixation failure, and subsequent need for reoperation. The findings of the present systematic review reinforce the guarded prognosis of this injury pattern and highlight the ongoing controversy regarding optimal management.[8]

Study-wise Analysis of Outcomes

Among the included studies, Wang et al. (2023) reported outcomes in 12 patients treated with open reduction and internal fixation (ORIF). This study demonstrated a high complication burden, including AVN in 33% of patients, fixation failure in 17%, and conversion to total hip arthroplasty (THA) in 25% of cases. These findings underscore the inherent difficulty in achieving both stable fixation and preservation of femoral head vascularity in Pipkin type III fractures. The relatively modest functional outcomes further emphasize the limitations of joint-preserving strategies in this setting.

Similarly, Shakya et al. (2025) reported AVN in 28% of cases and conversion to THA in 20%, despite the use of mixed treatment strategies. This suggests that even when treatment is individualized, the biological severity of the injury itself plays a dominant role in determining outcomes. The study reinforces the concept that Pipkin type III fractures behave differently from other femoral head fracture types, with consistently higher complication rates.

In contrast, studies evaluating primary arthroplasty demonstrated more favorable and consistent outcomes. Stuby et al. (2024) and Zhang et al. (2024) reported no cases of AVN or fixation-related complications following THA, with mean Harris Hip Scores (HHS) of 85 and 86, respectively. These findings suggest that arthroplasty eliminates the risk of femoral head ischemia and provides reliable pain relief and functional recovery, particularly in patients where anatomical reconstruction is not feasible.

Among ORIF-based studies, Lindtner et al. (2024) and Chen et al. (2024) reported AVN rates of 25% and 27%, respectively, along with moderate rates of fixation failure and nonunion. Despite achieving reasonable functional scores (HHS around 80), these studies highlight the trade-off between joint preservation and complication risk. Even when technically successful, ORIF does not eliminate the risk of delayed femoral head collapse.

Lee et al. (2022) further supports these findings, reporting AVN in 29% of patients and conversion to THA in 22%. This indicates that nearly one-quarter of patients undergoing ORIF may ultimately require arthroplasty, raising concerns regarding the durability of joint-preserving strategies in this fracture type.

Interestingly, Patel et al. (2023) and Garcia et al. (2022) reported comparatively lower complication rates, with AVN ranging from 24% to 26% and lower fixation failure rates. These differences may be attributed to factors such as earlier intervention, better fracture reconstructibility, or improved surgical techniques. These findings suggest that outcomes can be optimized in carefully selected patients, although the overall risk profile remains significant.[9]

In the arthroplasty subgroup, Kim et al. (2021) reported favorable early outcomes following hemiarthroplasty, with no cases of AVN or fixation-related complications and a mean HHS of 84. While these results are encouraging, the long-term durability of hemiarthroplasty, particularly in younger or more active patients, remains uncertain and warrants further investigation.

Comparative Interpretation of Treatment Strategies

When analyzed collectively, the included studies demonstrate a clear pattern in treatment outcomes. ORIF, while preserving the native joint, is associated with:

- AVN rates ranging from 24% to 33%
- Fixation failure rates between 10% and 17%
- Conversion to THA in up to 25% of patients

These findings reflect the biological limitations imposed by vascular compromise and fracture complexity.

In contrast, arthroplasty procedures, particularly THA, were associated with:

- Minimal risk of AVN
- More predictable functional outcomes
- Reduced need for secondary surgical procedures

However, it is important to recognize that arthroplasty is not without limitations. Concerns regarding implant longevity, particularly in younger patients, remain significant and must be considered when selecting treatment.

Clinical Implications and Decision-Making

The study-wise findings of this review strongly support an individualized treatment approach. Several key factors influence decision-making, including:

- **Patient age**: Younger patients may benefit from joint preservation despite higher complication risk, whereas older patients are better candidates for arthroplasty.
- **Fracture reconstructibility**: Anatomically reconstructible fractures Favor ORIF, while comminated or non-reconstructible fractures Favor arthroplasty.
- **Bone quality**: Poor bone stock reduces fixation success and supports arthroplasty.
- **Timing of intervention**: Early reduction and stabilization may improve outcomes.
- **Intraoperative stability**: Determines feasibility of fixation.

Overall, the evidence suggests that ORIF should be reserved for carefully selected patients, while arthroplasty offers a more reliable solution in complex or high-risk cases.[10]

Limitations of the Evidence

Despite providing valuable insights, the current evidence base has several limitations. Most included studies were retrospective in nature and involved small sample sizes, reflecting the rarity of Pipkin type III fractures. Additionally, there was considerable heterogeneity in surgical techniques, patient selection criteria, and outcome reporting across studies. This variability limits direct comparison between treatment strategies and precludes definitive conclusions regarding superiority.

Furthermore, follow-up durations varied between studies, and long-term outcomes—particularly regarding implant survival and late complications—remain insufficiently reported.

CONCLUSION

Pipkin type III femoral head fractures are rare but highly complex injuries associated with a significant risk of complications, particularly avascular necrosis and fixation failure. This systematic review demonstrates that open reduction and internal fixation (ORIF), although commonly used in younger patients, is associated with considerable rates of complications and subsequent conversion to total hip arthroplasty. In contrast, arthroplasty procedures, especially total hip arthroplasty, provide more consistent functional outcomes and lower complication rates, particularly in older patients and in cases with non-reconstructible fractures.

Management should therefore be individualized based on patient age, fracture reconstructibility, bone quality, and intraoperative stability. While joint-preserving strategies may be appropriate in selected cases, arthroplasty appears to offer a more reliable solution in complex injury patterns. Further high-quality studies are required to establish definitive treatment guidelines.

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