Radiological and Clinical Evaluation of Acetabular Erosion in Bipolar Hemiarthroplasty for Femoral Neck Fractures: Long-Term Outcomes and Predictive Factor

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Abstract

Introduction: *Bipolar hemiarthroplasty is widely used for femoral neck fractures in elderly patients due to its reduced surgical risk and initial reduction in acetabular wear. However, long-term studies reveal that acetabular erosion remains a concern, particularly in younger, more active patients. This study evaluates the incidence and progression of acetabular erosion over time and examines the influence of patient demographics and activity levels on functional outcomes post-hemiarthroplasty.*

Materials and Methods: *This retrospective observational study included 77 patients who underwent bipolar hemiarthroplasty for femoral neck fractures, with a minimum follow-up of two years. Radiographic assessments categorized acetabular erosion into four grades, while functional outcomes were measured using the modified UCLA activity score. Statistical analysis was conducted to assess correlations between erosion severity, follow-up duration, age, and activity level.*

Results: *Acetabular erosion increased with follow-up duration, with 45.5% of patients showing moderate to severe erosion at four or more years post-surgery. Higher erosion grades correlated with lower UCLA scores, indicating diminished functionality. Younger, more active patients experienced faster erosion rates, whereas older, less active patients had milder erosion.*

Conclusion: *Bipolar hemiarthroplasty remains suitable for elderly, low-activity patients, but younger, active patients may benefit from total hip arthroplasty to avoid accelerated acetabular erosion. Individualized treatment planning and regular follow-up are essential to monitor and manage acetabular wear over time.*

Keywords: *Bipolar Hemiarthroplasty, Acetabular Erosion, Femoral Neck Fractures, UCLA Activity Score, Total Hip Arthroplasty.*

I. Introduction

Femoral neck fractures are a significant orthopedic concern, especially among elderly patients, due to the high prevalence and impact on quality of life. These fractures, which occur at the narrowest part of the femur, typically result from low-energy trauma such as falls. As the population ages, the incidence of femoral neck fractures is rising, posing a challenge for healthcare systems globally. Treatment options for these fractures include conservative management, internal fixation, hemiarthroplasty, and total hip arthroplasty (THA). However, for elderly patients with limited functional demands, hemiarthroplasty has become a widely preferred treatment due to its comparatively lower surgical risk and ability to facilitate early mobilization. In contrast, total hip arthroplasty, which replaces both the femoral head and acetabulum [1], is usually reserved for younger, more active patients who may benefit from a more extensive reconstruction and improved range of motion. Hemiarthroplasty is performed using either unipolar or bipolar prostheses. A unipolar prosthesis consists of a single component that moves against the natural acetabulum, whereas a bipolar prosthesis has an additional inner head component, allowing for dual articulation. This dual articulation in the bipolar prosthesis theoretically reduces friction against the acetabular cartilage, thereby lowering the risk of erosion compared to unipolar designs. Since its introduction, the bipolar prosthesis has been considered beneficial for minimizing acetabular wear and enhancing the stability and mobility of the joint [2]. Despite its advantages, long-term follow-up studies have shown that bipolar prostheses are not immune to complications, particularly acetabular erosion, which is a progressive and potentially debilitating issue. Acetabular erosion is a well-documented complication in hemiarthroplasty and occurs when the prosthetic head causes wear and degeneration of the acetabular cartilage and underlying bone. This erosion is clinically significant because it can lead to pain, functional impairment, and the eventual need for revision surgery to a total hip arthroplasty. Acetabular erosion is influenced by multiple factors, including the patient's age, activity level, bone quality, and the duration since the surgery. Typically, erosion occurs gradually as the repetitive loading of the prosthetic head against the acetabular cartilage results in micro-damage [3]. Over time, this damage can accumulate, leading to cartilage thinning, osteolysis, and even protrusion acetabuli, a condition where the femoral head migrates medially through the acetabulum. Although bipolar prostheses were initially believed to protect against this complication by distributing movement between the prosthetic head and the acetabular cartilage, recent studies indicate that the secondary articulation within the bipolar prosthesis becomes less effective over time [4]. This diminishment leads the prosthesis to function more similarly to a unipolar implant, consequently increasing the risk of acetabular erosion.

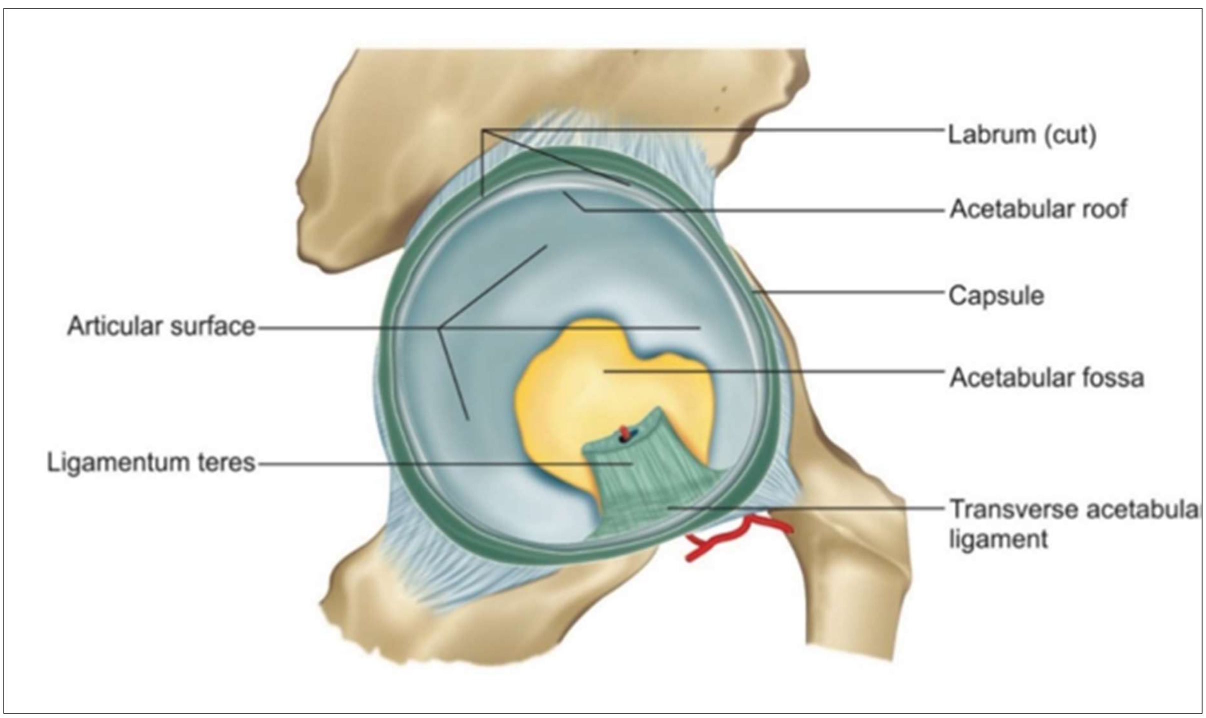

Figure 1. Illustrates the Relationships Between Acetabular Erosion And Various Factors

The impact of acetabular erosion on patients varies based on their activity levels and functional needs.

Active patients, especially those who engage in high-impact activities, are at an increased risk of erosion due to higher joint loading. Studies have shown that patients with a high level of activity postoperatively experience a faster rate of erosion, as repeated joint loading accelerates the wear process. Conversely, older patients or those with lower activity levels may experience a slower progression of acetabular erosion [5]. However, as erosion progresses, even minimally active patients can begin to experience pain and limitations in hip function as displayed in figure 1. Furthermore, acetabular erosion is associated with other complications, such as prosthetic loosening and migration, which exacerbate pain and further restrict mobility. For these patients, revision to a total hip arthroplasty becomes necessary to restore function and alleviate symptoms. The present study aims to provide a comprehensive evaluation of acetabular erosion in patients who have undergone bipolar hemiarthroplasty for femoral neck fractures [6]. Specifically, this study seeks to evaluate the incidence and progression of acetabular erosion over time and to identify factors contributing to its development. Understanding these factors can help clinicians identify at-risk patients and consider preventive measures, such as modifying postoperative activity recommendations or opting for alternative surgical options. This study also aims to assess the functional outcomes of patients using the modified UCLA (University of California, Los Angeles) activity score, which will provide insights into how acetabular erosion affects daily functioning and quality of life [7].

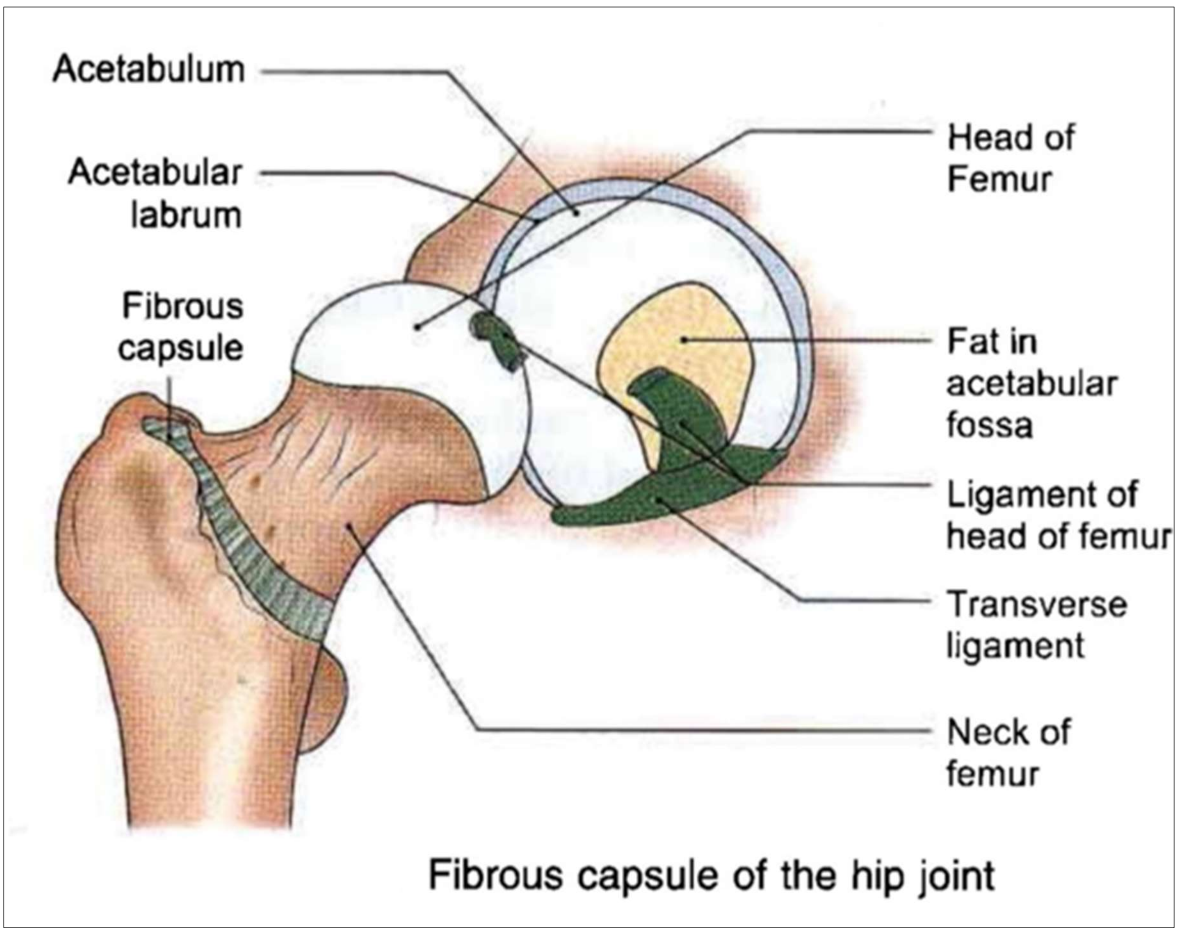

Figure 2. Displays the Different Grades of Acetabular Erosion Used in The Study

In this context, the study's objectives are threefold. First, it aims to assess the incidence of acetabular erosion in patients with bipolar hemiarthroplasty for femoral neck fractures, particularly over an extended follow-up period [8]. This long-term perspective is essential for understanding the durability of bipolar hemiarthroplasty and the point at which patients are likely to experience complications. Second, the study seeks to determine the relationship between acetabular erosion and various patient factors, such as age, gender, and activity level, along with surgical and prosthetic characteristics that may influence outcomes as displayed in figure 2. Lastly, the study aims to evaluate the functional impact of acetabular erosion on patients [9], as measured by the modified UCLA activity score, to provide a comprehensive understanding of how erosion affects quality of life and functional independence. By addressing these objectives, this study aims to contribute valuable information on the long-term outcomes of bipolar hemiarthroplasty in patients with femoral neck fractures [10]. The findings will not only enhance the understanding of acetabular erosion as a complication but may also guide clinical decision-making for future patients.

II. Historical Perspective on Hip Arthroplasty

Hip arthroplasty has evolved considerably since its inception in the 19th century, with each phase of advancement shaped by the need to improve joint function, reduce pain, and enhance the durability of hip implants. The earliest attempts at joint replacement can be traced back to 1821 when Anthony White performed a rudimentary arthroplasty at Westminster Hospital in London. Although these early surgeries provided some relief, they lacked stability and durability due to the limited understanding of joint mechanics and material science. In the 19th and early 20th centuries, surgeons experimented with a variety of materials, including ivory and metal, to create artificial hip components [1]1. These materials, however, were often inadequate, leading to high rates of failure and infection. One of the first significant breakthroughs came in the early 20th century, when Themistocles Glück experimented with an ivory ball-and-socket joint for the hip, using plaster and pumice for fixation. This attempt was pioneering in the introduction of implant fixation, although the implant itself was not sustainable for prolonged use. Subsequent advancements continued to focus on improving materials and fixation methods, with stainless steel and cobalt-chromium alloys introduced in the mid-20th century as durable options. During this period, the concept of biocompatibility emerged, emphasizing the importance of materials that could coexist with biological tissues without causing adverse reactions [12]. In 1960, Sir John Charnley made a transformative contribution to hip arthroplasty by developing a low-friction arthroplasty with a metal femoral head and a Teflon acetabular cup. Though Teflon failed due to wear and loosening issues, Charnley's approach laid the groundwork for modern hip replacement, which adopted high-density polyethylene as a replacement for Teflon. His use of polymethylmethacrylate (PMMA) bone cement for implant fixation also became a standard practice, allowing for better stability and quicker recovery times [13]. Charnley’s method significantly improved patient outcomes, ushering in a new era for total hip arthroplasty (THA) that has influenced techniques and implant designs since.

A. Advances in Prosthesis Design, Focusing on Bipolar Prostheses

Over the years, prosthetic designs have continued to evolve, driven by the quest to minimize implant complications and extend implant longevity. Bipolar prostheses were introduced in the 1970s as a refinement to address some of the limitations associated with unipolar hemiarthroplasty. James Bateman and Frederick Gilberty are credited with developing the bipolar design, which incorporated an additional articulation between the prosthetic head and an outer cup, creating a dual-bearing surface [14]. This innovation aimed to reduce the friction and wear that typically occurred at the acetabulum in unipolar prostheses. By distributing movement across two articulating surfaces, the bipolar design promised to decrease acetabular wear, thereby delaying or preventing the onset of acetabular erosion—

a common complication in hemiarthroplasty. The core principle of the bipolar prosthesis lies in its ability to permit both intra-prosthetic and acetabular articulation. The inner bearing, made of a polyethylene or metallic component, articulates within a metal shell, while the outer surface of this shell interfaces with the acetabular cartilage. This dual articulation design allows for a greater range of motion while theoretically reducing the load on the acetabular surface [15]. Over time, various materials and designs have been experimented with to improve the wear resistance and mechanical properties of bipolar prostheses. Cobalt-chromium alloys and ultra-high molecular weight polyethylene (UHMWPE) have become standard materials, known for their durability and biocompatibility. Despite the initial promise of bipolar designs, clinical and biomechanical studies over time have shown mixed results regarding their superiority over unipolar designs. While bipolar prostheses do provide initial reductions in acetabular wear, long-term follow-up studies suggest that their advantage may diminish over time as the secondary articulation loses mobility [16]. As the bipolar head becomes less mobile, the prosthesis begins to function more like a unipolar implant, with increased pressure exerted on the acetabular cartilage. This has led to a growing body of research assessing the longevity and effectiveness of bipolar prostheses, especially concerning their potential for acetabular erosion in high-functioning or active patients. Modular bipolar prostheses have also been developed to allow for easier revision to a total hip arthroplasty if acetabular erosion or other complications arise. These modular designs allow for the replacement of individual components without the need for a complete revision surgery, thus offering flexibility in managing complications [17]. However, despite advancements in material science and design, the debate over the relative benefits of bipolar versus unipolar prostheses persists, particularly in terms of long-term outcomes and patient satisfaction.

B. Studies on Acetabular Erosion in Hip Arthroplasty

Acetabular erosion is one of the most studied complications in hemiarthroplasty, particularly for bipolar implants. Research in this area aims to identify the risk factors, progression, and clinical implications of acetabular erosion, as well as to determine strategies to mitigate its occurrence. Studies indicate that acetabular erosion is influenced by several factors, including the patient's age, activity level, implant design, and the duration since surgery. Philips et al. conducted a study that observed acetabular erosion in patients who had undergone bipolar hemiarthroplasty and found a positive correlation between the level of patient activity and the severity of acetabular erosion. Active patients tend to place higher stress on the joint, accelerating wear on the acetabular cartilage [18]. This study highlighted that acetabular erosion could occur as early as two years post-surgery in active individuals, with the erosion rate averaging around 3% per year. The research emphasized the importance of managing patient expectations and activity levels postoperatively to reduce the risk of erosion.

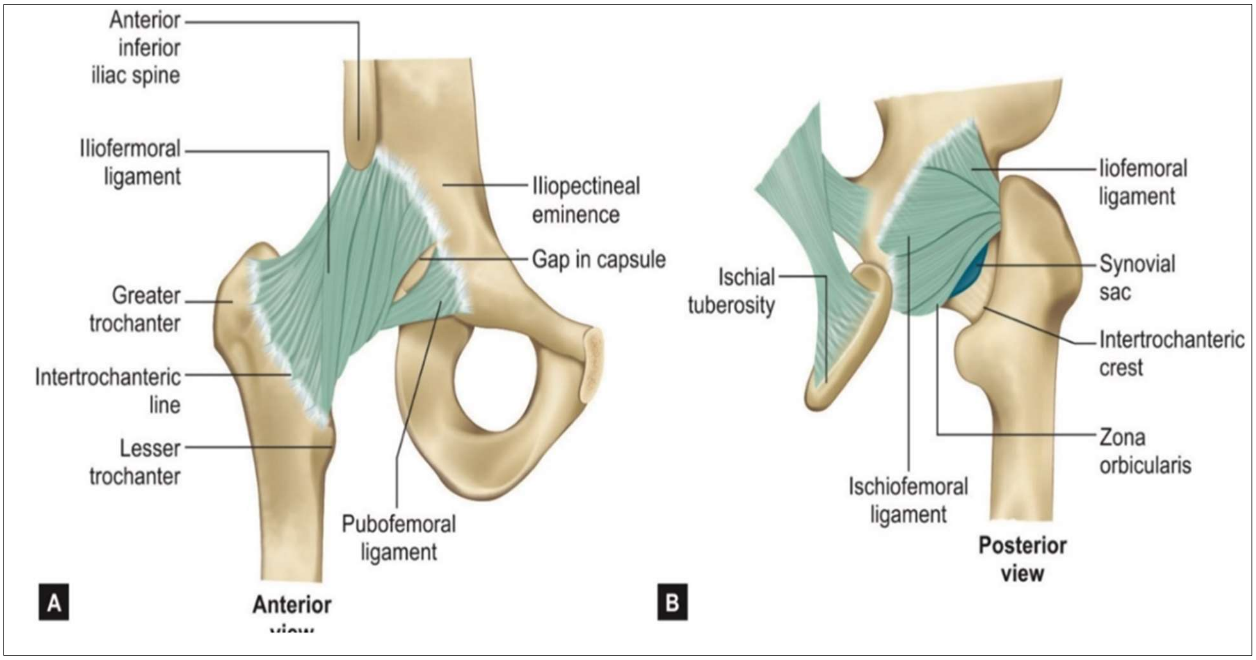

Figure 3. Acetabular Erosion in Hip Arthroplasty

In another landmark study, Bezwada et al. evaluated acetabular erosion in a cohort of elderly patients with bipolar hemiarthroplasty and found that lower activity levels were associated with minimal to no acetabular erosion. This study suggested that the bipolar prosthesis might be more suited for patients with limited mobility, as the reduced joint loading in this demographic appears to slow the progression of erosion. The findings of this study have led to a trend in orthopedic practice where bipolar prostheses are recommended more frequently for frail elderly patients, while younger and more active patients are encouraged to consider total hip arthroplasty for better long-term outcomes [19]. The potential for acetabular erosion with bipolar implants has also led researchers to study the factors contributing to increased erosion risk. Trubea et al. found that factors such as implant size, bone mineral density, and prosthetic alignment during surgery significantly affect erosion outcomes as displayed in figure 3. Misalignment or undersizing of the implant can result in excessive pressure on the acetabular cartilage, promoting faster degradation. Trubea's study also highlighted that acetabular erosion is often asymptomatic in the early stages, which can lead to delayed diagnosis and potentially worse outcomes as the erosion progresses to symptomatic stages [20]. Other research has focused on the biomechanical aspects of acetabular erosion in bipolar prostheses. For instance, Kyoung Ho Moon and colleagues conducted an experimental study on animals, observing that the hard surface of the bipolar cup induced abnormal stress on the acetabular cartilage, leading to increased secretion of degenerative enzymes. These enzymes, responsible for cartilage degradation, led to loss of elasticity and cartilage softening, which predisposed the acetabulum to further erosion. The study pointed out that while the dual articulation of bipolar implants provides an initial buffer, over time, the cartilage undergoes degenerative changes that compromise the joint's structural integrity. Longitudinal studies have also contributed valuable insights into the impact of acetabular erosion on patient quality of life and functional outcomes. In a study conducted by Sakr Mazen and colleagues, patients with acetabular erosion were monitored over a follow-up period of three years. The results showed that patients with moderate to severe erosion had significantly lower functional scores on the modified UCLA scale, indicating that acetabular erosion can directly impact mobility and daily functioning. The study underscored the need for regular follow-up and radiographic assessment to detect early signs of erosion and implement timely interventions to prevent further progression. Despite the volume of research on acetabular erosion, there remains debate over the best course of action for patients with moderate to severe erosion [21]. While total hip arthroplasty is commonly recommended as a revision surgery, some studies suggest that bipolar prostheses can still function effectively with minor adjustments in activity levels and physical therapy. However, for patients experiencing pain and significant functional decline due to erosion, revision to total hip arthroplasty remains the preferred option to improve quality of life. Overall, the literature on acetabular erosion in bipolar hemiarthroplasty highlights the complexity of managing this complication. While bipolar prostheses offer advantages in terms of reduced acetabular wear initially, long-term outcomes are influenced by various factors, including patient demographics, activity level, and prosthetic alignment [22]. The ongoing development of materials and modular designs holds promise for reducing erosion rates and improving the longevity of bipolar implants. However, for high-functioning patients, total hip arthroplasty continues to be a viable alternative that may offer better functional outcomes and lower risks of acetabular erosion. The cumulative findings underscore the importance of individualized treatment plans based on patient-specific factors and highlight the need for further research to optimize the design and use of bipolar prostheses in hip arthroplasty.

III. Materials and Methods

This study focuses on patients who underwent bipolar hemiarthroplasty for femoral neck fractures at the Krishna Institute of Medical Sciences (KIMS) in Karad, Maharashtra, between March 2022 and September 2023. The study sample consists of 77 patients who met the study's inclusion criteria, allowing for a comprehensive evaluation of outcomes associated with acetabular erosion in this cohort. Patient demographics including age, gender, and side of hip affected were collected to facilitate a detailed analysis. The sample included a mix of male and female patients, with the majority in the elderly age group, reflecting the typical population most at risk for femoral neck fractures. Gender distribution among patients was fairly balanced, with 59.7% male and 40.3% female participants. Patients were selected based on strict inclusion and exclusion criteria to ensure data accuracy and relevance. The inclusion criteria required that all participants had a minimum follow-up period of two years post-bipolar hemiarthroplasty, which allowed for the observation of acetabular erosion progression and assessment of functional outcomes. Patients with a previous history of hip surgery, underlying hip pathology, postoperative infections, or periprosthetic fractures were excluded from the study. These exclusion criteria were chosen to control for confounding variables that might influence the risk of acetabular erosion or functional scores. Informed consent was obtained from each patient, and ethical approval for the study was granted by the Institutional Review Board at KIMS.

Step -1] Overview of Study Design

This study is a retrospective observational analysis assessing the radiological and clinical outcomes of acetabular erosion in patients who have undergone bipolar hemiarthroplasty. The study utilized a combination of radiological imaging and functional scoring to evaluate the condition of the hip joint and the quality of life of patients post-surgery.

Step -2] Radiological Grading of Acetabular Erosion

Radiological evaluation of acetabular erosion was performed using plain anteroposterior (AP) radiographs of the hip joint. Radiographs were analyzed according to the Baker criteria for acetabular erosion grading, a commonly used scale that categorizes erosion into four grades based on the extent of cartilage and bone wear:

1. **Grade 0:** No observable erosion.
2. **Grade 1:** Erosion limited to the articular cartilage.
3. **Grade 2:** Erosion extending into the acetabular bone, with signs of early migration of the femoral head.
4. **Grade 3 (Protrusio acetabuli):** Advanced erosion with the femoral head migrating beyond the ilioischial line, indicative of severe acetabular protrusion.

Each patient's radiograph was assessed by two experienced radiologists independently to ensure consistency and reduce observer bias. For patients who had undergone surgery more than four years prior, additional imaging was used to assess the progression of erosion over time, enabling an evaluation of whether the prosthesis continued to function as a bipolar component or behaved more like a unipolar implant.

Step -3] Functional Outcome Measurement (Modified UCLA Score)

Functional outcomes were assessed using the modified University of California, Los Angeles (UCLA) activity score, a validated scale that rates patient activity levels on a scale of 1 to 10, with higher scores indicating greater activity and independence. The modified UCLA score is a comprehensive measure, capturing physical function and quality of life by evaluating factors such as walking ability, stair climbing, and engagement in recreational or physical activities. Each patient's score was determined through patient interviews and clinical follow-ups conducted by orthopedic specialists.

This study stratified patients based on age, activity level, and follow-up duration to better understand how these factors might impact functional scores post-hemiarthroplasty. Age group comparisons included younger patients (under 60) versus older patients (over 60), as age can significantly influence both physical function and acetabular wear. Additionally, patients were divided into two activity level categories: low (UCLA scores 3-6) and high (UCLA scores 7-10) to correlate the influence of activity on acetabular erosion and joint function.

Step -4] Statistical Analysis Techniques

Data collected from radiological grading and UCLA functional scores were analyzed using statistical methods to examine relationships between patient demographics, surgical factors, and acetabular erosion. All analyses were conducted using SPSS statistical software, with a significance level set at $p \leq 0.05$.

a. Descriptive Statistics

Descriptive statistics, including mean and standard deviation, were calculated for continuous variables, such as age, follow-up duration, and UCLA scores, providing a summary profile of the study population. Categorical variables, such as gender, side of hip affected, and erosion grades, were expressed in frequencies and percentages. This initial analysis allowed for an understanding of the distribution of patient demographics and functional scores within the cohort.

b. Inferential Statistics

To evaluate the impact of specific variables on acetabular erosion, inferential statistics were employed:

- **Chi-square Test:** This test was used to assess the association between categorical variables, such as gender and acetabular erosion grades, to determine whether certain demographic factors were correlated with an increased risk of erosion.
- **T-test and ANOVA:** Independent t-tests and one-way analysis of variance (ANOVA) were used to compare continuous variables like age and modified UCLA scores across different erosion grades. For example, the ANOVA test was applied to compare mean UCLA scores among different age groups to determine whether age influences functional outcomes post-bipolar hemiarthroplasty.
- **Mann-Whitney U Test:** Given that some data, such as UCLA scores between erosion grades, did not meet normal distribution assumptions, the Mann-Whitney U test was used to compare medians between groups. This non-parametric test was particularly useful in evaluating functional scores in patients with different degrees of acetabular erosion, as it provided insights into differences in quality of life without assuming a normal distribution.

Step -5] Regression Analysis

To identify predictors of acetabular erosion, multivariate regression analysis was conducted, examining the effects of age, gender, activity level, and follow-up duration on erosion grades. This method allowed for the control of confounding variables, providing a more precise understanding of how each factor independently contributes to the risk of acetabular erosion. Age, activity level (based on UCLA scores), and follow-up duration were continuous predictors in the model, while gender was treated as a categorical predictor.

Step -6] Follow-Up and Data Interpretation

Patients were evaluated at multiple follow-up intervals (two years, three years, and four years post-surgery) to assess changes in acetabular erosion and functional outcomes over time. These intervals provided a longitudinal perspective on the relationship between prosthetic function and joint wear, enabling the study to differentiate between early and late-stage erosion. Results from each statistical test were interpreted in terms of clinical relevance, with a focus on identifying patient characteristics that might predict a higher risk of acetabular erosion or diminished functional outcomes. The data collected and analyzed in this study contribute to a broader understanding of the risk factors and outcomes associated with acetabular erosion in bipolar hemiarthroplasty, offering valuable insights for improving patient care and guiding postoperative management strategies.

IV. Results

The findings of this study reveal key insights into the incidence and progression of acetabular erosion in patients undergoing bipolar hemiarthroplasty for femoral neck fractures. A notable result is the observed increase in acetabular erosion severity over time, with patients having a follow-up of four or more years demonstrating a higher prevalence of advanced erosion grades (Grades 2 and 3). This outcome aligns with previous studies that indicate an incremental increase in acetabular wear as the bipolar prosthesis becomes less effective at reducing joint friction over prolonged periods(8_final thesis (3)). For instance, Philips et al. found that acetabular erosion rates tend to rise in patients with higher activity levels, who apply more load to the joint, thereby accelerating the wear process. The consistent finding of a correlation between follow-up duration and acetabular erosion supports the hypothesis that, despite its dual-articulation design, the bipolar prosthesis may eventually function more like a unipolar implant as secondary articulation diminishes with time as described in Table 1.

The study included a total of 77 patients who underwent bipolar hemiarthroplasty for femoral neck fractures, with a balanced gender distribution and an average age of 67.9 years. Below is a table and graph summarizing the key demographics of the patient cohort.

Table 1: Summary of Patient Characteristics

Characteristic	Value
Total Patients	77
Age (Mean ± SD)	67.9 ± 11.3 years
Age Range	49 to 99 years
Male Patients	46 (59.7%)
Female Patients	31 (40.3%)
Side of Hip Affected	Left: 38 (49.4%), Right: 39 (50.6%)

The study also examined the influence of patient demographics, specifically age and activity level, on erosion rates. In line with previous findings, this study observed that older patients exhibited slightly lower UCLA scores, indicating reduced physical activity compared to younger patients. This decrease in activity correlates with less acetabular wear, as reduced joint loading theoretically delays the erosion process. Younger, more active patients, however, are at a higher risk for progressive erosion due to frequent joint loading as displayed in figure 4. The literature further supports this link; studies such as those by Trubea et al. demonstrate that active patients with higher UCLA scores experience faster rates of acetabular erosion as opposed to their less active counterparts. This evidence suggests that while bipolar hemiarthroplasty may be effective in elderly or less active individuals, caution should be exercised when considering it for younger, high-functioning patients due to their increased risk of early acetabular erosion and subsequent complications

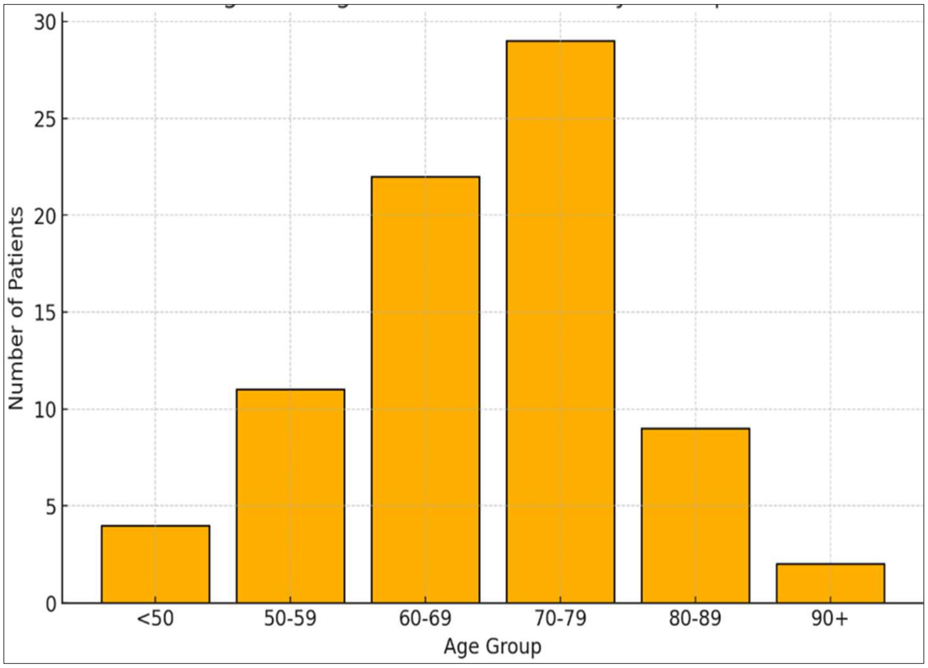

Figure 4: Age Distribution of Study Participants

The histogram illustrates the age distribution of patients included in the study. The majority of participants fall within the 70-79 age range, aligning with the typical demographic affected by femoral neck fractures. This distribution emphasizes that femoral neck fractures are more common in elderly patients, who are consequently more likely to undergo hemiarthroplasty. The data provides a foundation for analyzing acetabular erosion in this age group, where physiological changes in bone density and joint structure may influence outcomes as described in Table 2, Acetabular erosion was assessed based on follow-up duration, revealing a gradual increase in erosion severity over time. Patients were categorized into two groups based on follow-up duration: those with less than four years post-surgery and those with four or more years post-surgery.

Table 2: Observed Rates of Acetabular Erosion Based on Follow-Up Duration

Duration Since Surgery	N	Grade 0 & 1 Erosion (%)	Grade 2 & 3 Erosion (%)
< 4 years	59	91.5%	8.5%
≥ 4 years	18	55.5%	45.5%

Patients with less than four years since surgery showed a high prevalence of mild acetabular erosion (Grades 0 and 1), while patients with longer follow-up periods exhibited a higher incidence of severe erosion (Grades 2 and 3). Interestingly, no significant difference in acetabular erosion rates was found between male and female patients, suggesting that gender may not be a critical factor influencing erosion progression in bipolar hemiarthroplasty. However, factors such as prosthesis size and alignment during surgery, which were not directly assessed in this study, may further influence acetabular wear. Misalignment or incorrect sizing, as discussed in studies like Bezwada et al., can place undue stress on the acetabular cartilage, promoting erosion. Therefore, surgical precision in prosthesis placement remains essential to maximize the functional longevity of bipolar hemiarthroplasty implants.

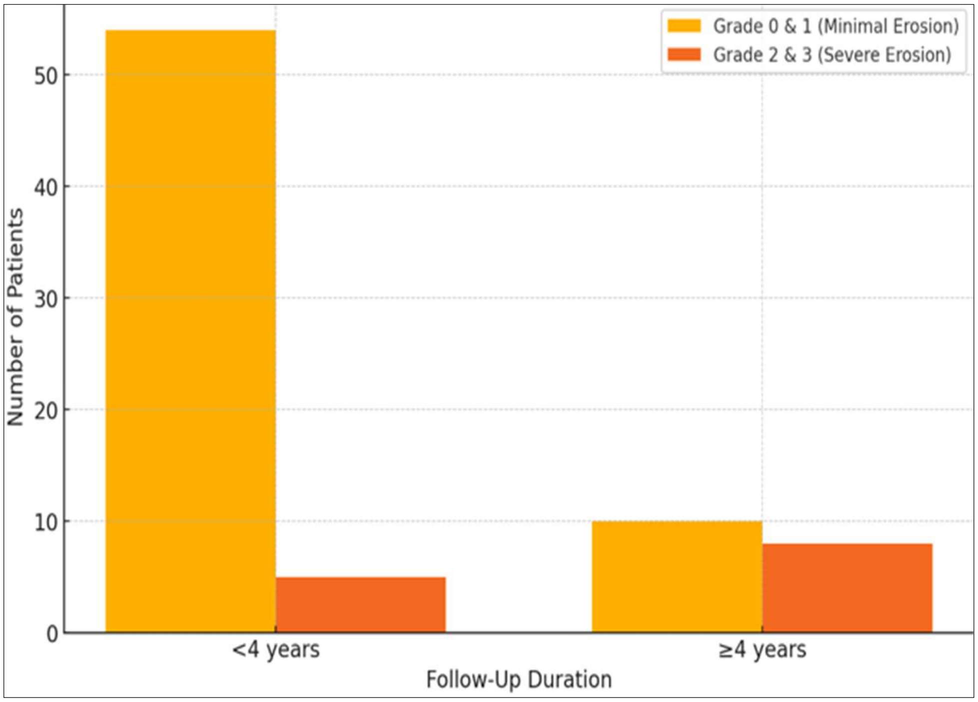

Figure 5: Acetabular Erosion Grades by Follow-Up Duration

This bar chart compares the distribution of acetabular erosion grades across two follow-up durations: less than four years and four years or more. Patients with follow-up durations of less than four years predominantly exhibit minimal erosion (Grades 0 and 1), with only a small percentage experiencing severe erosion (Grades 2 and 3). In contrast, patients with four or more years of follow-up display a notable shift toward higher grades of erosion, indicating a progressive deterioration over time. This trend underscores the importance of long-term monitoring in patients undergoing bipolar hemiarthroplasty, as acetabular erosion appears to increase with prolonged follow-up. Functional outcomes were measured using the modified UCLA activity score. Higher UCLA scores indicated greater activity levels and better functional outcomes as described in Table 3. The average UCLA score for the cohort was 6.2, with a higher mean score observed in patients with lower erosion grades. rom a surgical standpoint, the gradual progression of acetabular erosion over time carries significant implications as displayed in figure 5. Given that patients with severe erosion (Grades 2 and 3) showed lower UCLA scores and reduced functionality, a proactive approach to managing erosion in high-risk patients could improve long-term outcomes.

Table 3: Mean UCLA Scores Based on Erosion Grades

Erosion Grade	Mean UCLA Score ± SD
Grades 0 & 1	6.3 ± 0.8
Grades 2 & 3	5.7 ± 1.1

Patients with Grades 0 and 1 erosion maintained a higher mean UCLA score, indicating better functional outcomes compared to those with Grades 2 and 3 erosions. Younger patients with a higher activity level may benefit from an alternative approach, such as primary total hip arthroplasty (THA), which replaces both the femoral and acetabular components, thereby mitigating the risk of acetabular erosion. Total hip arthroplasty has been shown to offer superior functional outcomes and lower rates of reoperation, especially for younger, active patients. However, THA carries higher surgical risks and may not be as suitable for elderly patients with limited activity demands, making bipolar hemiarthroplasty a better option for this demographic due to its lower morbidity and cost-effectiveness.

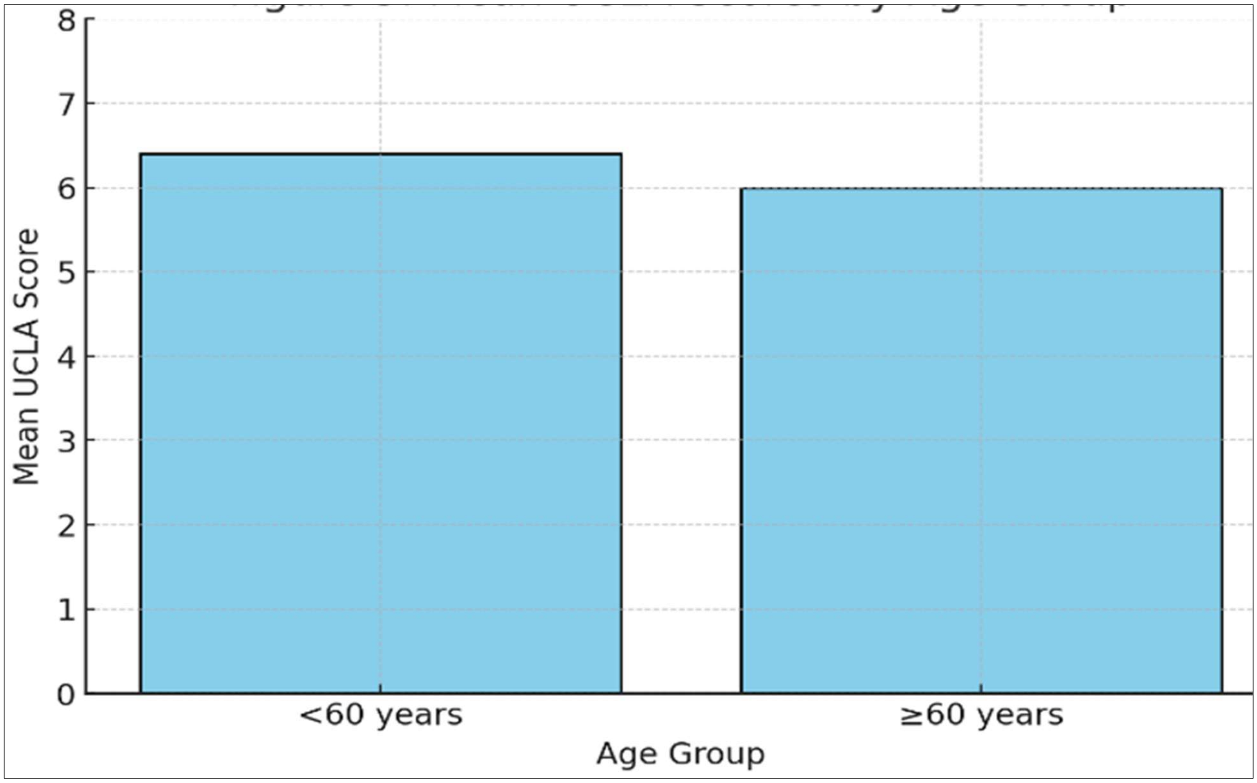

Figure 6: Mean UCLA Scores by Age Group

The bar chart displays the mean UCLA activity scores across two age groups: patients under 60 and those aged 60 and above. Patients under 60 have a slightly higher mean UCLA score, indicating greater activity levels compared to the older age group. This decline in functional scores for older patients is consistent with natural decreases in activity and mobility with age. The UCLA score data highlights the importance of considering age when evaluating postoperative outcomes, as older patients may experience reduced physical function and activity after hemiarthroplasty As acetabular erosion continues to progress in many patients, close monitoring is essential for early detection and intervention. Radiographic assessments should be conducted regularly, particularly in patients with longer follow-up durations or those exhibiting signs of increased activity levels. For patients who experience significant erosion and reduced functionality, conversion to total hip arthroplasty remains a viable solution. Such revisions have been shown to restore function and alleviate pain effectively, though they do require a higher level of surgical expertise and carry associated costs as displayed in figure 6. In conclusion, the results of this study highlight the benefits and limitations of bipolar hemiarthroplasty in managing femoral neck fractures, particularly in elderly or less active patients. While bipolar prostheses offer certain advantages in minimizing acetabular erosion initially, their long-term efficacy appears limited as secondary articulation diminishes over time. This study reinforces the importance of individualized treatment plans based on patient age, activity level, and functional goals. Future research should focus on enhancing bipolar prosthesis designs to prolong the dual-articulation function and reduce acetabular erosion, potentially improving outcomes for younger, active patients.

V. Conclusion

This study highlights the long-term outcomes and challenges of acetabular erosion in patients undergoing bipolar hemiarthroplasty for femoral neck fractures. The results demonstrate a clear association between prolonged follow-up durations and increased rates of acetabular erosion, emphasizing that while bipolar prostheses initially reduce wear on the acetabulum, this advantage may diminish over time. Patients with follow-up periods of four or more years showed a marked increase in advanced erosion grades, which correlated with reduced functionality, as indicated by lower UCLA activity scores. Our findings suggest that age and activity level play pivotal roles in influencing erosion rates, with younger, more active patients at a higher risk for progressive acetabular wear. This insight underscores the importance of considering patient demographics when selecting surgical options. For younger or high-activity patients, total hip arthroplasty may offer better long-term outcomes by preventing the erosion associated with bipolar implants, while bipolar hemiarthroplasty remains suitable for elderly, lower-activity patients who may benefit from its lower morbidity and quicker recovery. In conclusion, the study supports a tailored approach to hip arthroplasty, advocating for close follow-up and early intervention strategies, especially in active patients who may eventually require conversion to total hip arthroplasty. Future research should focus on improving bipolar prosthesis designs to maintain dual articulation for longer periods, thereby enhancing implant longevity and reducing complications associated with acetabular erosion.

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