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Risk of Vancouver-Type AG Greater Trochanteric Periprosthetic Fractures After Cementless Total Hip Arthroplasty: A Retrospective Comparison of Anterolateral and Posterolateral Approaches in 118 Patients

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Background: Surgical approach and body mass index (BMI) can influence early complications after cementless total hip arthroplasty (THA). This retrospective study aimed to compare Vancouver-type AG greater trochanteric periprosthetic fracture rates between anterolateral and posterolateral approaches in cementless THA and to examine whether higher BMI was more frequently observed among patients with these fractures.

Material/Methods: This single-center retrospective cohort study included 118 patients who underwent primary cementless THA between January 2019 and February 2023. Twenty-eight patients were treated using an anterolateral approach and 90 were treated with a posterolateral approach. Demographic data, BMI, Harris Hip Score (HHS), postoperative complications, acetabular inclination, and component migration were evaluated. Group comparisons, correlation analyses, and receiver operating characteristic (ROC) analysis were performed.

Results: Vancouver-type AG fractures were more frequent after the anterolateral approach than after the posterolateral approach (25.0% vs 3.3%, $P=0.02$). Within the anterolateral group, patients with fractures had higher BMI, whereas no similar pattern was observed in the posterolateral group. Postoperative HHS was similar between approaches (85.86 ± 12.33 vs 84.53 ± 14.21 , $P=0.74$). Acetabular vertical migration >2 mm was associated with lower postoperative HHS ($P=0.01$) and showed good discriminative ability for lower functional outcome ($AUC=0.81$, $P=0.01$).

Conclusions: In this cohort, Vancouver-type AG greater trochanteric periprosthetic fractures were more frequently observed after the anterolateral approach, and higher BMI was more common among patients with fractures, particularly within the anterolateral group. Early acetabular migration was associated with lower postoperative HHS scores and may help identify patients who require closer radiographic follow-up.

Keywords: **Arthroplasty, Replacement, Hip • Body Mass Index • Hip Prosthesis • Obesity • Periprosthetic Fractures • Surgical Procedures, Operative • Orthopedics • Fractures, Bone • Retrospective Studies**

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Introduction

Cementless total hip arthroplasty (THA) is widely used for degenerative and selected traumatic hip disorders, particularly in patients in whom biological implant fixation is expected to provide durable long-term stability. In cementless THA, initial press-fit stability and subsequent osseointegration are essential for implant fixation and long-term survival [1]. Despite these advantages, periprosthetic femoral fractures remain a major postoperative complication and are a leading reason for early revision. In some series, they account for about 20.7% of revision procedures [2]. Vancouver-type AG fractures involve the greater trochanteric region and are generally considered stable when the femoral stem is not loose; however, they can still cause abductor dysfunction, persistent pain, gait asymmetry, and delayed rehabilitation [3].

The occurrence of Vancouver-type AG fractures can be influenced by local biomechanical stress during femoral canal preparation, rasping, trial reduction, and final stem insertion. Surgery can modify these stresses by changing the direction of femoral exposure and the amount of soft-tissue traction required. The anterolateral approach uses the interval between the tensor fasciae latae and gluteus medius and provides anterior access to the hip joint. Although this approach has been associated with lower dislocation rates, it can require greater manipulation of the abductor mechanism and increased traction around the greater trochanter during femoral preparation [4]. In contrast, the posterolateral approach provides posterior access to the hip joint through the gluteus maximus and the short external rotator interval. This approach allows direct femoral exposure but has traditionally been associated with concerns regarding posterior soft-tissue repair and postoperative instability. A higher body mass index (BMI) increases soft-tissue tension, reduces visualization, and often necessitates stronger manipulation forces during femoral exposure. These findings suggest that the trochanteric region can be vulnerable during cementless rasping and trial reduction, especially when soft tissues are tight. These biomechanical concerns appear to be amplified in patients with elevated BMI [5].

Previous studies have shown that obesity is associated with more postoperative complications after THA, such as wound problems, dislocation, and early revision [6,7]. However, evidence on how BMI may influence the relationship between surgical approach and Vancouver-type AG fracture risk is still evolving, and available data on its interaction with the anterolateral approach remain limited. In addition to the surgical approach and BMI, early postoperative radiographic and clinical parameters can also affect functional recovery after THA. The Harris Hip Score (HHS) is a commonly used clinical tool for assessing pain, function, deformity, and range of motion after hip surgery. Radiographic parameters such as acetabular

inclination and component migration are also important because abnormal cup orientation or early implant displacement can reflect reduced mechanical stability and may be associated with poorer postoperative outcomes. Heterotopic ossification, dislocation, and infection are further complications that can influence functional recovery. Therefore, evaluating these factors together may provide a more clinically relevant understanding of early outcomes after cementless THA.

Therefore, this retrospective study aimed to compare the occurrence of Vancouver-type AG greater trochanteric periprosthetic fractures between the anterolateral and posterolateral approaches in patients undergoing primary cementless THA. The study also aimed to determine whether BMI differed between patients with and without these fractures, particularly within each surgical approach. Secondary aims were to compare heterotopic ossification between approaches and to evaluate the associations of acetabular inclination, component migration, dislocation, and infection with postoperative HHS.

Material and Methods

Ethics Approval

This study was approved by the Clinical Research Ethics Committee of Adana City Training and Research Hospital (Decision No. 3039, December 21, 2023). All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Because the study was retrospective and used anonymized data from hospital records and radiographic archives, the ethics committee waived the requirement for written informed consent.

Study Design and Patient Selection

This single-center retrospective cohort study was conducted in the Orthopaedics and Traumatology Clinic of Adana City Training and Research Hospital. The electronic medical record system and radiographic archive were retrospectively screened to identify all patients who underwent primary cementless total hip arthroplasty (THA) between January 2019 and February 2023. All procedures were performed by surgeons with more than 5 years of arthroplasty experience.

From this cohort, 150 consecutive patients who underwent primary cementless THA and had at least 1 year (up to 5 years) of follow-up were identified.

Patients were excluded if they had a history of contralateral THA (n=6), developmental dysplasia of the hip (n=10), or irregular or incomplete clinical or radiographic follow-up (n=16). After these exclusions, 118 patients were included in the final

analysis. Of these, 28 underwent THA through an anterolateral approach, and 90 underwent THA through a posterolateral approach.

All operations were elective primary cementless THAs performed for degenerative or noninfectious hip disorders, including primary osteoarthritis, avascular necrosis of the femoral head, and post-traumatic secondary arthritis. The surgical approach was selected according to surgeon preference and patient-related factors, including body habitus, soft-tissue characteristics, and anticipated difficulty with femoral exposure.

Perioperative Management and Surgical Technique

All patients received the same type of femoral implant: a proximally engaging, distally fluted, fully porous-coated, rectangular cross-section cementless stem. A cementless hemispherical acetabular cup was used in all cases, with supplemental screw fixation if required. THA was performed through either the anterolateral (Watson–Jones) [8] or posterolateral (modified Gibson) [9] approach.

All patients were positioned in the lateral decubitus position under anesthesia, with the operated hip facing upward. The operative field and the entire lower extremity were prepared and draped in a sterile fashion according to the same institutional protocol.

In the anterolateral approach, the anterior superior iliac spine and greater trochanter were identified before incision. A skin incision was made beginning approximately 2.5 cm distal and 2.5 cm lateral to the anterior superior iliac spine and directed toward the junction of the middle and posterior thirds of the greater trochanter. The incision was then gently curved over the trochanter and extended distally, with a total length of approximately 10 to 12 cm. After incising the fascia parallel to the skin incision, the interval between the tensor fasciae latae and gluteus medius was developed by blunt dissection to reach the anterior capsule. The anterior capsule was incised, the hip was dislocated anteriorly, and a femoral neck osteotomy was performed.

After removal of the periacetabular soft tissues, acetabular exposure was achieved with appropriately placed retractors. The acetabulum was reamed to approximately 15° to 20° of anteversion and 35° to 45° of inclination, and a press-fit acetabular cup was implanted. When supplemental screws were used, they were placed in the posterosuperior quadrant to enhance cup stability, and the liner was then impacted. For femoral preparation, the hip was flexed and adducted. Retractors were placed around the greater and lesser trochanter to expose the proximal femur. The femoral canal was opened with a box osteotome and sequentially rasped. The definitive femoral

stem was inserted in a neutral version relative to the femoral neck axis. After trial reduction and stability assessment, the definitive femoral head was implanted, the hip was reduced, hemostasis was secured, a suction drain was placed, and the fascia, subcutaneous tissue, and skin were closed in layers.

In the posterolateral approach, the borders of the greater trochanter were marked before incision. A skin incision was initiated posterior to the greater trochanter, curved proximally over the posterior aspect of the trochanter, and extended distally in line with the femoral shaft, with a total length of approximately 10 to 15 cm. The fascia was incised parallel to the skin incision, and the gluteus maximus muscle was split bluntly. A retractor was placed under the gluteus medius to improve exposure. The bursa overlying the short external rotators was excised. The short external rotator tendons were identified, tagged with sutures, and detached from their insertion to expose the posterior capsule. The posterior capsule was then incised, the hip was dislocated posteriorly, and a femoral neck osteotomy was performed.

Acetabular exposure and cup implantation were performed in a standardized manner, similar to the anterolateral group. The acetabulum was reamed to approximately 15° to 20° of anteversion and approximately 45° of inclination, followed by press-fit cup implantation and supplemental screw fixation in the posterosuperior quadrant when required. The liner was then inserted. Femoral exposure was obtained with retractors placed around the greater and lesser trochanter. The femoral canal was opened using a box osteotome and sequentially rasped in approximately 15° to 20° of anteversion. The definitive stem was implanted in the corresponding anteversion. After trial reduction and stability assessment, the definitive femoral head was implanted, and the hip was reduced. At the end of the procedure, the posterior capsule and tagged short external rotator tendons were repaired to the greater trochanter when feasible. The wound was irrigated, a suction drain was inserted, and the layers were closed routinely.

Preoperative assessment included medical history, physical examination, routine laboratory tests (complete blood count, biochemistry, and coagulation profile), infectious disease screening, and consultations with internal medicine, general surgery, urology, or gynecology as necessary. Long-term medications were reviewed and adjusted according to specialist recommendations.

Antibiotic prophylaxis consisted of 2 g of a first-generation intravenous cephalosporin administered 30 minutes before incision, followed by 1 g intravenously 3 times daily for 2 days postoperatively. Venous thromboembolism prophylaxis was provided with low-molecular-weight heparin for 3 weeks after surgery.

Clinical and Functional Evaluation

Clinical assessments were recorded in the hospital information system and verified during outpatient follow-up. Preoperative hip range of motion, limb length discrepancy, and muscle strength were documented and reassessed postoperatively. Laboratory results, comorbidities, chronic medications, and relevant specialty consultations were also reviewed.

Body mass index (BMI) was calculated as weight (kg)/height (m²). For descriptive purposes, BMI categories based on WHO definitions (normal <25 kg/m²; overweight 25-29.9 kg/m²; obese ≥30 kg/m²) were reported. These categories were not used in the primary analyses, as BMI was analyzed as a continuous variable. Subgroup analyses explored whether higher BMI was more common among patients who sustained Vancouver-type AG fractures within each surgical approach.

Functional status was evaluated using the HHS, which was recorded preoperatively and at the final follow-up visit. The HHS is a 100-point clinical scoring system that evaluates pain, function, deformity, and range of motion, with higher scores indicating better hip function. Scores were categorized as excellent, good, fair, or poor according to standard definitions [10].

Periprosthetic femoral fractures were classified according to the Vancouver classification system [11]. Vancouver-type AG fractures were defined as fractures involving the greater trochanteric region that occurred intraoperatively or during the early postoperative period without evidence of femoral stem loosening. Fracture displacement was recorded descriptively but was not used as a defining classification criterion. Heterotopic ossification was graded according to the Brooker classification [12].

Radiological Evaluation

Standardized radiographs were obtained in all patients, including standing anteroposterior (AP) pelvic radiographs and AP and lateral views of the operated hip. The tube-to-film distance was

100 cm. Radiostereometric analysis was not available. Immediate postoperative radiographs were taken following surgery, and follow-up radiographs were obtained at routine visits. Postoperative radiographic follow-up was performed according to the institutional routine protocol, with radiographs obtained in the immediate postoperative period and at postoperative 3 weeks, 6 weeks, 3 months, 6 months, and 1 year. Additional radiographs were obtained when clinically indicated by symptoms such as pain, limping, or suspected instability. All measurements were performed digitally using the hospital Picture Archiving and Communication System (PACS).

Vancouver-type AG fractures were considered intraoperative if identified during surgery, or early postoperative if detected within 3 months after THA. Early postoperative fractures were identified on routine follow-up radiographs obtained during this period or on additional radiographs obtained because of clinical symptoms. No fractures occurring after this 3-month window were included in this category.

Femoral component vertical migration was defined as cranial or caudal displacement of the femoral stem within the femoral canal on serial radiographs. Acetabular component migration was measured according to the method described by Callaghan et al [13]. Vertical migration was defined as the change in distance from the inter-teardrop line to the superior edge of the acetabular cup, whereas horizontal migration was defined as the change in distance from the teardrop reference point to the medial margin of the cup. Displacement greater than 2 mm in either plane was considered radiographically significant.

Cup inclination was measured on AP radiographs, and angles between 35° and 55° were considered to be within the Lewinnek safe zone [14]. Heterotopic ossification was graded on radiographs obtained at approximately 6 months postoperatively. Radiographic evaluations were performed by observers who were blinded to functional outcome data.

Statistical Analysis

All data were coded and entered into a digital database. Statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean±standard deviation, and categorical variables as frequencies and percentages. Normality was assessed using visual inspection of histograms and the Shapiro-Wilk test.

Between-group comparisons were performed using the chi-square test or Fisher's exact test for categorical variables, as appropriate according to expected cell counts. The Mann-Whitney U test was used to compare non-normally distributed continuous variables, including age, BMI, and HHS. The Kruskal-Wallis test was used to compare more than 2 independent groups, including acetabular inclination categories. The Wilcoxon signed-rank test was used to compare preoperative and postoperative HHS values within the same group. Spearman correlation analysis was used to assess associations between radiographic migration values, functional scores, and other ordinal or continuous variables.

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the ability of radiographic migration parameters to discriminate lower postoperative functional outcome, defined as postoperative HHS <80. The area under the

Table 1. Baseline characteristics of the patients according to surgical approach.

Variable	Anterolateral approach (n=28)	Posterolateral approach (n=90)	P
Age (years), mean±SD	52.71±12.98	57.60±10.87	0.25
Sex, Male (%)	15 (53.6%)	41 (45.6%)	0.45
BMI (kg/m ²), mean±SD	26.8±9.7	29.4±8.3	0.08
Operated side, right (%)	12 (42.9%)	36 (40.0%)	0.59
Preoperative HHS, mean±SD	44.43±7.12	41.13±6.19	0.05

Values are presented as mean±standard deviation or number (%). Group comparisons were performed using the Mann-Whitney U test for continuous variables and the chi-square test for categorical variables. Abbreviations: BMI, body mass index; HHS, Harris Hip Score; SD, standard deviation.

Table 2. Postoperative complications according to surgical approach.

Variable	Anterolateral approach (n=28)	Posterolateral approach (n=90)	P
Vancouver-type AG fracture	7 (25.0%)	3 (3.3%)	0.02
Dislocation	0 (0%)	7 (7.8%)	0.36
Infection	0 (0%)	6 (6.7%)	0.56
HO (Brooker I)	5 (17.9%)	3 (3.3%)	0.04
Nerve palsy	0 (0%)	1 (1.1%)	0.65

Values are presented as number (%). Complication rates were compared using the chi-square test or Fisher's exact test, as appropriate. Abbreviations: AG, greater trochanter; Brooker I, grade I HO according to the Brooker classification.

ROC curve (AUC), sensitivity, and specificity were calculated for each radiographic parameter.

Subgroup analyses were performed within each surgical approach to examine whether BMI differed between patients with and without Vancouver-type AG fractures. A *P* value <0.05 was considered statistically significant.

Results

A total of 118 patients met the inclusion criteria. Of these, 28 patients (23.7%) underwent THA via the anterolateral approach, and 90 patients (76.3%) underwent THA via the posterolateral approach. Baseline demographic and preoperative clinical characteristics are summarized in **Table 1**. Age, sex, BMI, and operated side were comparable between the groups, while preoperative HHS showed a borderline difference (*P*=0.05).

Postoperative Complications

The occurrence of Vancouver-type AG greater trochanteric periprosthetic fractures differed significantly between surgical

approaches. These fractures were observed more frequently in the anterolateral group than in the posterolateral group (25.0%, 7/28 vs 3.3%, 3/90; *P*=0.02) (**Table 2**).

Among the 10 Vancouver-type AG fractures identified, 6 occurred intraoperatively, and 4 were detected on early postoperative radiographs within the first 3 months. No late postoperative fractures were observed. All fractures involved the greater trochanter region, and none showed stem loosening or required revision.

Dislocation was observed only in the posterolateral group (7.8%, 7/90), although the difference between approaches was not statistically significant (*P*=0.36).

Early postoperative infection was also observed only in the posterolateral group (6.7%, 6/90), without a statistically significant difference between approaches (*P*=0.56). Patients who developed early postoperative infection were older than those without infection (*P*=0.04).

Brooker type I heterotopic ossification was more frequent in the anterolateral group than in the posterolateral group (17.9%

Table 3. Characteristics of patients with and without periprosthetic fracture.

Variable	Fracture (Yes) n=10	Fracture (No) n=108	P
Age (years, mean±SD)	58.17±9.85	54.52±12.36	0.35
BMI (kg/m ² , mean±SD)	32.37±8.9	27.85±13.23	0.05
Surgical approach, anterolateral approach (%)	7 (70%)	21 (19.4%)	0.02
Posterolateral (%)	3 (30%)	87 (80.6%)	—
Postoperative HHS (mean±SD)	85.00±11.93	85.94±12.67	0.82
Sex (Male/Female)	6/4	50/58	0.41

Values are presented as mean±standard deviation or number (%). Comparisons between patients with and without periprosthetic fractures were performed using the Mann-Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables, as appropriate. Abbreviations: BMI, body mass index; HHS, Harris Hip Score; SD, standard deviation.

Table 4. Age and postoperative Harris Hip Score according to radiographic parameters.

Radiographic parameter	Group	Age, mean±SD	P	Postoperative HHS, mean±SD	P
Femoral stem vertical migration	≤5 mm	53.06±13.91	0.47	87.06±11.78	0.17
	>5 mm	57.59±7.39		82.09±15.10	
Acetabular vertical migration	≤2 mm	53.88±13.15	0.25	89.62±7.42	0.01
	>2 mm	57.13±8.12		73.50±17.73	
Acetabular horizontal migration	≤2 mm	55.52±11.73	0.72	88.59±12.36	0.04
	>2 mm	54.03±12.42		81.76±13.40	
Acetabular inclination angle	35°-55°	54.06±12.06	0.15	86.00±12.43	0.01
	<35°	68.00±5.66		90.00±5.66	
	>55°	61.00±2.83		58.00±14.14	

Values are presented as mean±standard deviation. Age and postoperative Harris Hip Score (HHS) values were compared between radiographic subgroups using the Mann-Whitney U test for 2-group comparisons and the Kruskal-Wallis test for acetabular inclination categories. Migration thresholds were defined as ≤5 mm or >5 mm for femoral stem vertical migration and ≤2 mm or >2 mm for acetabular vertical/horizontal migration. Cup inclination was categorized according to Lewinnek's safe zone criteria. Abbreviations: HHS, Harris Hip Score; SD, standard deviation.

vs 3.3%; $P = 0.04$). One sciatic nerve palsy occurred in the posterolateral group, with no statistically significant difference between approaches ($P=0.65$).

Factors Associated With Periprosthetic Fracture

Patients with Vancouver-type AG fractures had higher BMI values than those without fractures ($32.37±8.90$ vs $27.85±13.23$ kg/m²; $P=0.05$). Most fractures occurred in patients who underwent the anterolateral approach (70.0%, 7/10; $P=0.02$) (Table 3). Within the anterolateral cohort, patients who sustained fractures had higher BMI than those who did

not. No similar BMI difference was observed within the posterolateral group. Postoperative HHS did not differ between patients with and without fractures.

Functional Outcomes

Functional recovery was comparable between approaches. Mean postoperative HHS values were similar between the anterolateral and posterolateral groups ($85.86±12.33$ vs $84.53±14.21$; $P=0.74$). Both groups showed significant improvement from preoperative to postoperative HHS ($P<0.01$), with an overall postoperative mean HHS of $85.17±13.23$.

Table 5. ROC analysis of radiographic migration parameters for discrimination of lower postoperative Harris Hip Score (HHS <80).

Parameter	AUC	Sensitivity	Specificity	P
Acetabular vertical migration >2 mm	0.81	83%	80%	0.01
Acetabular horizontal migration >2 mm	0.71	75%	77%	0.03
Femoral stem migration >5 mm	0.56	57%	56%	0.18

Diagnostic accuracy was evaluated using receiver operating characteristic (ROC) curve analysis for discrimination of lower postoperative Harris Hip Score (HHS), defined as HHS <80. The area under the curve (AUC), sensitivity, specificity, and P-values are presented. Abbreviations: AUC, area under the curve; HHS, Harris Hip Score; ROC, receiver operating characteristic.

Age and postoperative HHS did not differ between male and female patients ($P=0.74$ and $P=0.58$, respectively).

Postoperative complications were associated with lower functional scores. Patients with dislocation had significantly lower postoperative HHS than those without dislocation (53.33 ± 12.86 vs 86.94 ± 11.03 ; $P=0.01$). Similarly, patients with early postoperative infection had lower postoperative HHS than those without infection (65.50 ± 30.41 vs 85.88 ± 12.25 ; $P=0.01$).

Radiographic Outcomes

Femoral stem migration greater than 5 mm was rare (2.5%) and was not significantly associated with postoperative HHS. In contrast, acetabular component migration was associated with lower functional scores. Patients with vertical acetabular migration >2 mm had lower postoperative HHS than those with migration ≤ 2 mm (73.50 ± 17.73 vs 89.62 ± 7.42 ; $P=0.01$). Horizontal acetabular migration >2 mm was also associated with lower postoperative HHS (81.76 ± 13.40 vs 88.59 ± 12.36 ; $P=0.04$) (Table 4).

Postoperative HHS differed significantly according to acetabular inclination category ($P=0.01$). The lowest postoperative HHS values were observed in patients with cup inclination >55°, whereas patients with cup inclination within the Lewinnek safe zone had higher functional scores than those with inclination >55°.

Diagnostic Performance of Radiographic Parameters

Receiver operating characteristic analysis showed that vertical acetabular migration had good discriminative ability for identifying patients with lower postoperative HHS, defined as HHS <80 (area under the curve [AUC]=0.81; $P=0.01$).

Horizontal acetabular migration also showed significant but more moderate discriminative ability (AUC=0.71; $P=0.03$). Femoral stem migration did not show significant discriminative ability for lower postoperative HHS (Table 5).

Discussion

This retrospective cohort study compared the anterolateral and posterolateral approaches in cementless primary THA, with specific attention to Vancouver-type AG periprosthetic fractures and the role of body mass index. The main findings were that AG fractures occurred more frequently in the anterolateral group and that, within this group, patients with fractures had higher BMI than those without fractures. BMI did not show a similar association in the posterolateral group. Dislocation and infection were uncommon and did not differ significantly between approaches, whereas low-grade heterotopic ossification was observed more frequently in the anterolateral group. Functional improvement was similar in both groups, but increased acetabular vertical and horizontal migration was associated with lower postoperative HHS.

Periprosthetic fractures after THA arise from a combination of patient-related factors, implant design, and technical elements of the procedure. Herndon et al reported that early femoral fractures after mini-antrolateral THA were associated with age, sex, Dorr type, and fixation method, but not with the surgical approach itself [15]. Even so, several studies have drawn attention to a particular vulnerability of the greater trochanter during minimally invasive anterolateral techniques, especially in obese patients [5]. Luger et al similarly described fracture rates approaching 10% in obese individuals undergoing minimally invasive anterolateral THA, compared with roughly 3% in non-obese patients [16]. These reports provide a relevant background for evaluating whether elevated BMI may increase trochanteric vulnerability during anterolateral cementless THA.

In our cohort, all Vancouver-type AG fractures were confined to the trochanteric region and occurred more frequently in the anterolateral group. Within this group, patients who sustained fractures had higher BMI, whereas no BMI–fracture relationship was observed in the posterolateral cohort. Although the overall number of fractures was modest and none required revision, this pattern suggests a possible association between elevated BMI and fracture occurrence in patients treated with the anterolateral approach. One plausible explanation is that,

in patients with elevated BMI, femoral exposure may require greater soft-tissue retraction and more forceful manipulation during canal preparation, rasping, trial reduction, and stem insertion. These technical demands may increase mechanical stress around the greater trochanter, particularly when a rectangular, fully porous-coated cementless stem is used. Recent evidence also suggests that femoral stem design can influence operative time, intraoperative bleeding, soft-tissue damage, and early functional recovery after primary cementless THA [17]. Together with meta-analytic evidence showing higher complication and revision rates in obese and morbidly obese patients undergoing THA [18], the present findings suggest that elevated BMI may be particularly relevant during anterolateral femoral exposure. Clinically, this supports a cautious approach in patients with high BMI when difficult femoral exposure is anticipated. Strategies may include careful soft-tissue release, controlled femoral elevation, the use of intraoperative fluoroscopy, or choosing implant designs that reduce stress at the trochanter. Larger prospective studies are needed to determine whether BMI-adjusted surgical planning could reduce fracture risk and whether preoperative identification of very high BMI or challenging femoral morphology should influence approach or implant selection.

The relationship between surgical approach and dislocation is well documented. Sköldenberg et al showed that using an anterolateral approach reduced dislocation risk in patients with femoral neck fractures [19]. Meta-analyses and recent studies have confirmed that posterior approaches without thorough soft-tissue repair have higher dislocation rates than anterior-based or direct lateral approaches, whereas structured posterior repair substantially reduces this difference [20,21]. Patient factors such as advanced age, neuromuscular disease, and cognitive impairment also contribute to instability [22,23]. In our study, dislocations occurred only in the posterolateral group, although the between-group difference was not statistically significant. Dislocation was also associated with worse postoperative HHS. These findings are consistent with prior work linking instability with inferior functional outcomes [24]. Because our series was relatively small, definitive conclusions regarding true differences in dislocation rates between approaches cannot be drawn; however, the results reinforce the importance of meticulous soft-tissue repair and accurate component positioning when the posterolateral approach is used.

Heterotopic ossification (HO) is a frequent radiographic finding after THA, although low-grade lesions rarely affect function. Reported rates vary widely, with most cases classified as Brooker grades I or II [25,26]. Some studies have suggested there are higher HO rates after lateral or anterolateral approaches, although the evidence is mixed [27]. In this study, only Brooker grade I HO was observed, more frequently in the anterolateral group, and without a measurable impact on functional scores.

This aligns with previous findings that low-grade HO is typically asymptomatic [28]. The absence of pharmacologic or radiation prophylaxis in our cohort and the relatively short follow-up may also have influenced the low clinical burden of HO.

Periprosthetic joint infection remains a serious complication after THA. Modern registry data report infection-related revisions in 0.3% to 2% of cases [29]. A recent systematic review found no consistent difference in infection risk between anterior-based and posterior approaches [30]. In the present cohort, early postoperative infection was uncommon and did not show a statistically significant difference between approaches; however, affected patients had lower postoperative HHS. Few studies have directly quantified the functional effect of infection using validated scoring systems. These findings suggest that early postoperative infection, even when successfully treated, can be associated with clinically relevant functional impairment.

Another clinically relevant aspect of this study is the combined assessment of acetabular migration and functional outcome. Radiostereometric studies have reported an association between early cup migration and long-term aseptic loosening [31]. In our cohort, both vertical and horizontal cup migration greater than 2 mm were associated with worse postoperative HHS, and vertical migration showed good discriminative ability for identifying patients with reduced functional recovery. Femoral stem migration did not demonstrate similar associations. These results suggest that early acetabular migration may have clinical relevance beyond radiographic observation alone. However, the lack of RSA measurements and the relatively short follow-up limit conclusions regarding long-term implant survival. Even so, our findings indicate that careful radiographic monitoring of cup position can help identify patients who require closer follow-up.

The improvements in HHS observed in both groups are consistent with contemporary reports of cementless THA, where scores typically rise from the mid-40s to the mid-80s or higher at mid-term follow-up [32]. Despite the higher AG fracture rate in the anterolateral group, functional recovery was similar between patients treated with the 2 surgical approaches. This finding suggests that, in the present cohort, Vancouver-type AG fractures that did not require revision were not associated with a measurable reduction in final HHS. However, because the number of fracture cases was small, this result should be interpreted cautiously.

This study has several limitations. The analysis was conducted in a single institution with uniform perioperative protocols and consistent surgical practice, which supports internal coherence but may limit broader generalizability. The follow-up period was sufficient to evaluate early complications and short-term migration, but longer observation would be required to assess late aseptic loosening, late periprosthetic fractures, and long-term

implant survival. In addition, comparisons of fracture risk between approaches were based on unadjusted observational analyses. Because surgical approach selection was not randomized and was influenced by surgeon preference and patient-related factors, including body habitus, residual confounding and selection bias cannot be excluded. Therefore, the observed association between approach, BMI, and Vancouver-type AG fractures should be interpreted as exploratory rather than definitive. The difference in group sizes between the anterolateral and posterolateral groups should be considered when interpreting fracture-related comparisons between approaches. The small number of Vancouver-type AG fractures also limited the ability to perform robust multivariable analysis or to identify independent predictors of fracture occurrence. Bone quality, femoral morphology, and detailed stem alignment parameters were not systematically adjusted for in the present analysis; therefore, the relative contributions of BMI and anatomical factors to AG fracture risk could not be fully isolated. Radiographic measurements were based on standardized two-dimensional radiographs rather than radiostereometric analysis, which limits the precision of detecting very small degrees of migration. In addition, formal interobserver and intraobserver reliability analyses for radiographic measurements were not performed, which should be considered when interpreting migration and inclination measurements. Finally, functional outcomes were assessed using the HHS alone. While additional patient-reported tools could have provided broader insight, the HHS remains a widely accepted and validated measure for evaluating early postoperative function.

Conclusions

In this retrospective cohort of patients who underwent cementless primary total hip arthroplasty, Vancouver-type AG greater

trochanteric periprosthetic fractures were observed more frequently after the anterolateral approach, and higher BMI was more common among patients with fractures in this group. Overall functional recovery was comparable between the anterolateral and posterolateral approaches. Low-grade HO occurred more frequently after anterolateral exposure but was not associated with reduced functional outcome. Increased acetabular migration was associated with lower postoperative HHS and may help identify patients who require closer radiographic follow-up. These findings support careful preoperative planning and cautious femoral exposure, particularly in patients with high BMI and anticipated technical difficulty.

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Patient Consent Declaration

The requirement for written informed consent was waived by the Clinical Research Ethics Committee of Adana City Training and Research Hospital because this retrospective study used anonymized data from hospital records and radiographic archives.

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