

An Association of Extent of Osteonecrosis of Femoral Head by Kerboul Angle with Functional Status: A Cross-Sectional Study

Krishnamurthy T¹, Amith D², Rahul Raykar³

¹Assistant Professor, Department of Orthopaedics, Shri Atal Bihari Vajpayee Medical College and Research Institute

²Senior Resident, Department of Orthopaedics, Shri Atal Bihari Vajpayee Medical College and Research Institute

³Senior Resident, Department of Orthopaedics, Shri Atal Bihari Vajpayee Medical College and Research Institute

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Corresponding Author: Dr. Krishnamurthy T

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Abstract:

Background: Osteonecrosis of the femoral head (ONFH) is a debilitating condition that can lead to severe functional impairment. The Kerboul angle, measured on magnetic resonance imaging (MRI), has been used to assess the extent of necrosis in ONFH. However, the relationship between the Kerboul angle and functional status remains unclear.

Objectives: This study aimed to evaluate the extent of ONFH using the Kerboul angle and investigate its correlation with functional status, as assessed by the Harris Hip Score (HHS).

Methods: A cross-sectional study was conducted among 140 adult patients with ONFH. The Kerboul angle was measured on MRI, and functional status was assessed using the HHS. The correlation between the Kerboul angle and HHS was analyzed using Pearson's correlation test.

Results: The mean age of the study subjects was 41.57±15.76 years, with a male predominance (70.7%). The mean duration of pain was 9.52±6.94 months. The mean HHS was 64.49±15.38, with 61.43% of subjects having a poor score (<70). The mean Kerboul angle was 177.28±47.88. A highly significant negative correlation ($r=-0.647$, $p<0.01$) was observed between the Kerboul angle and HHS.

Conclusion: This study demonstrates a significant negative correlation between the extent of necrosis, as measured by the Kerboul angle, and functional status in patients with ONFH. The findings suggest that the Kerboul angle could be a valuable tool for predicting functional outcomes in ONFH and highlight the importance of early diagnosis and intervention.

Keywords: Osteonecrosis of the femoral head, Kerboul angle, Harris Hip Score, functional status, magnetic resonance imaging.

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Introduction

Osteonecrosis of the femoral head (ONFH) is a debilitating condition that can lead to the collapse of the femoral head and subsequent osteoarthritis of the hip joint [1]. It is a multifactorial disease with various etiologies, including trauma, corticosteroid use, alcohol abuse, and hematological disorders [2]. The disease typically affects young and middle-aged adults, with a mean age of 38 years [3].

The incidence of ONFH is estimated to be 20,000 to 30,000 new cases per year in the United States [4]. The diagnosis of ONFH is based on clinical presentation, radiographic imaging, and magnetic resonance imaging (MRI) [5]. The Ficat and Arlet classification system is commonly used to stage the disease based on radiographic findings [6]. However, the Kerboul angle, which measures the

extent of necrosis on MRI, has been shown to be a more accurate predictor of disease progression and outcomes [7]. The Kerboul angle is measured on MRI by drawing two lines from the center of the femoral head to the edges of the necrotic lesion [8]. The angle formed by these lines is then measured, and a larger angle indicates a greater extent of necrosis. A Kerboul angle of less than 200 degrees is considered a small lesion, while an angle greater than 200 degrees is considered a large lesion [9].

The extent of necrosis, as measured by the Kerboul angle, has been shown to correlate with the risk of femoral head collapse and the need for total hip arthroplasty (THA) [10]. In a study by Nishii et al., patients with a Kerboul angle greater than 240 degrees had a significantly higher rate of femoral

head collapse and THA compared to those with a smaller angle [7]. However, the association between the extent of necrosis and functional outcomes has not been well-studied. Functional outcomes, such as pain, range of motion, and ability to perform activities of daily living, are important considerations in the management of ONFH. A better understanding of the relationship between the extent of necrosis and functional outcomes could help guide treatment decisions and improve patient outcomes.

Aim and Objectives

The aim of this study was to evaluate the extent of osteonecrosis of the femoral head by Kerboul angle and its correlation with functional status. The specific objectives were to detect adult patients with osteonecrosis of the femoral head, assess the necrotic extent by Kerboul angle, assess the functional status using the Harris Hip Score, and find any correlation between radiological findings and functional status.

Materials and Methods

Study Design and Setting: This cross-sectional study was conducted in the Department of Orthopaedics at Shri Atal Bihari Vajpayee Medical College and Research Institute from January 2023 to June 2024, after obtaining clearance from the college Research Centre and Ethical Committee.

Sample Size and Participant Selection: Due to the low prevalence of osteonecrosis of the femoral head (ONFH) and the lack of studies regarding its prevalence in the Indian population, a time-bound approach was adopted for this study. During the study period, 140 subjects who met the inclusion and exclusion criteria were recruited from the outpatient and inpatient departments of orthopaedics.

Inclusion criteria were as follows: all patients presenting to the orthopaedic OPD with non-traumatic hip pain and X-ray proven or suspected cases of osteonecrosis, including all genders, and those who provided informed and written consent. Exclusion criteria included previously treated surgical cases of unilateral ONFH, traumatic hip pain, patients on analgesics for 1 week, any other pathological cause, collapsed femoral head (stage 3 and above of Ficat & Arlet classification), deformity of the lower limb, and refusal to enrol in the study.

Data Collection and Analysis: Plain radiographs of the pelvis with bilateral hips were obtained for all participants. Normal X-rays were excluded from the study. The functional status of each patient was assessed using the Harris Hip Score (HHS). The center of the femoral head was assessed using a template, and the Kerboul angle was measured in anteroposterior and lateral views of the X-ray

pelvis with bilateral hips, where the maximum lesion size was measured. Four independent observers measured the angle, and the mean angle was calculated.

For accurate and precise measurements, magnified images of X-rays with a diameter of the femoral head between 2.5 and 3.5 cm were recommended, and the center of the femoral head was measured using a template (Figure 1). Data were tabulated in an Excel sheet with the assistance of a statistician. The frequency of measurements for each group was analyzed using SPSS 24.00. The Pearson correlation test was used to evaluate the relationship between the Kerboul angle and the Harris Hip Score, with a significance threshold of $p < 0.05$.

Results

The present cross-sectional study was conducted in the Department of Orthopaedics, Shri Atal Bihari Vajpayee Medical College and Research Institute among 140 adult patients with osteonecrosis of the femoral head (ONFH) who fulfilled the inclusion and exclusion criteria. The goal of this research was to study the extent of ONFH by Kerboul angle and its correlation with functional status.

Table 1 shows the age and gender distribution among the study subjects. The maximum number of subjects were from the age group of 31-40 years (32.86%), followed by 18-30 years (26.43%) and 41-50 years (17.86%). The minimum number of subjects were from the age group of 51-60 years. The mean age among the study subjects was 41.57 ± 15.76 years. Males (70.7%) were comparatively more than females (29.3%) in this study.

The side affected, duration of pain, and risk factors among the study subjects are presented in Table 2. Both sides (right and left) were equally affected (50% each). The mean duration of pain among the study subjects was 9.52 ± 6.94 months, with a minimum of 1 month and a maximum of 24 months. Risk factors, including alcohol consumption and smoking, were reported in 52.86% of the study subjects. Table 3 illustrates the co-morbidities among the study subjects. The most common co-morbidity was obesity (17.1%), followed by diabetes mellitus (12.8%). Hypertension and diabetes mellitus were both revealed in 5.7% of the subjects. Psoriasis was the least common co-morbidity, reported in 1.4% of the subjects.

The Harris Hip Score and Kerboul Angle distribution among the study subjects are shown in Table 4. Poor Harris Hip Score (<70) was reported in 61.43% of the subjects, while fair score (70-80) was observed in 24.29%. Good ($>80-90$) and excellent ($>90-100$) scores were revealed in

12.86% and 1.43% of the subjects, respectively. The mean Harris Hip Score among the study subjects was 64.49 ± 15.38 . The mean Kerboul Angle, calculated from three independent readings, was 177.28 ± 47.88 , with a minimum of 49.09 and a maximum of 283.93.

Table 5 demonstrates the correlation between Kerboul Angle and Harris Hip Score using Pearson's correlation test. A highly significant

negative correlation ($r = -0.647$, $p < 0.01$) was observed between Kerboul Angle and Harris Hip Score, indicating that with an increase in Kerboul Angle, there will be a decrease in Harris Hip Score.

Steroid use and history of COVID among the study subjects are presented in Table 6. Steroid use was reported in 40% of the subjects, while a history of COVID was revealed in 25.71% of the subjects.

Table 1: Age and gender distribution among the study subjects

Age Group (in years)	Male	Female	Total	%
18-30	26	11	37	26.43
31-40	33	13	46	32.86
41-50	17	8	25	17.86
51-60	7	3	10	7.14
>60	16	6	22	15.71
Total	99 (70.7%)	41 (29.3%)	140	100
Mean \pm SD			41.57 \pm 15.76	

Table 2: Side affected, duration of pain, and risk factors among the study subjects

Variable	Categories	N	%
Side affected	Left	70	50
	Right	70	50
Duration of pain (in months)	Minimum	1	
	Maximum	24	
	Mean \pm SD	9.52 \pm 6.94	
Alcohol/smoking/risk factor	No	66	47.14
	Yes	74	52.86

Table 3: Co-morbidity among the study subjects

Co-morbidity	N	%
DM	18	12.8
HTN	6	4.3
HTN & DM	8	5.7
Obesity	24	17.1
Obesity & HTN	6	4.3
Psoriasis	2	1.4
No	76	54.3
Total	140	100

Table 4: Harris Hip Score and Kerboul Angle distribution among the study subjects

Variable	Categories	N	%	Mean \pm SD
Harris Hip Score	<70	86	61.43	64.49 \pm 15.38
	70-80	34	24.29	
	>80-90	18	12.86	
	>90-100	2	1.43	
Kerboul Angle	Minimum		Maximum	Mean \pm SD
	First Reading	49.14	283.69	176.86 \pm 47.97
	Second Reading	48.81	284.36	177.50 \pm 47.96
	Third Reading	49.31	283.73	177.49 \pm 47.78
	Overall Mean	49.09	283.93	177.28 \pm 47.88

Table 5: Correlation between Kerboul Angle & Harris Hip Score

Kerboul Angle		Harris Hip Score
First Reading	Pearson Correlation	-.643**
	Sig. (2-tailed)	<0.01*
Second Reading	Pearson Correlation	-.650**

	Sig. (2-tailed)	<0.01*
Third Reading	Pearson Correlation	-.648**
	Sig. (2-tailed)	<0.01*
Overall Mean	Pearson Correlation	-.647**
	Sig. (2-tailed)	<0.01*
**: highly significant		

Table 6: Steroid use and history of COVID among the study subjects

Variable	Categories	N	%
Steroid use	Yes	56	40
	No	84	60
History of COVID	Yes	36	25.71
	No	104	74.29

Discussion

The present study aimed to evaluate the extent of osteonecrosis of the femoral head (ONFH) using the Kerboul angle and its correlation with functional status, as assessed by the Harris Hip Score (HHS). The study included 140 adult patients with ONFH, with a mean age of 41.57 ± 15.76 years and a male predominance (70.7%).

The age distribution in our study is consistent with the findings of Yoon et al. [11], who reported a mean age of 44.2 years in their study of 403 ONFH patients. Similarly, a male predominance in ONFH has been observed in several studies, including those by Yoon et al. [11] (78.9%) and Zhao et al. [12] (69.8%).

In our study, both the left and right sides were equally affected (50% each). This finding is in contrast to the study by Zhao et al. [12], which reported a higher prevalence of ONFH on the left side (54.7%) compared to the right side (45.3%). The mean duration of pain in our study was 9.52 ± 6.94 months, which is shorter than the mean duration of 18.5 months reported by Mont et al. [13] in their study of 136 ONFH patients. Risk factors such as alcohol consumption and smoking were reported in 52.86% of our study subjects. This is consistent with the findings of Fukushima et al. [14], who observed a significant association between alcohol intake and ONFH (odds ratio: 3.41, 95% confidence interval: 1.82-6.38). Obesity was the most common co-morbidity (17.1%) in our study, followed by diabetes mellitus (12.8%). These findings are in line with the study by Zhao et al. [12], which reported obesity and diabetes as significant risk factors for ONFH ($p < 0.05$).

The mean Harris Hip Score in our study was 64.49 ± 15.38 , with 61.43% of subjects having a poor score (< 70). This is comparable to the findings of Yoon et al. [11], who reported a mean HHS of 62.4 ± 14.7 in their study. The mean Kerboul angle in our study was 177.28 ± 47.88 , which is higher than the mean angle of 160.5 ± 48.3 reported by Ha et al. [15]. A highly significant negative correlation ($r = -0.647$, $p < 0.01$) was

observed between the Kerboul angle and the Harris Hip Score in our study. This finding suggests that an increase in the Kerboul angle, indicating a larger extent of necrosis, is associated with a decrease in the functional status of the affected hip. This correlation has also been reported by Ha et al. [15], who found a significant negative correlation between the Kerboul angle and HHS ($r = -0.512$, $p < 0.001$). Steroid use was reported in 40% of our study subjects, which is higher than the 28.2% reported by Zhao et al. [12]. The history of COVID-19 was found in 25.71% of our subjects. Although the association between COVID-19 and ONFH has not been extensively studied, a few case reports have suggested a possible link between the two [16,17].

Our study demonstrates a significant negative correlation between the extent of osteonecrosis, as measured by the Kerboul angle, and the functional status of the affected hip in patients with ONFH. The findings highlight the importance of early diagnosis and intervention in ONFH to prevent the progression of necrosis and preserve hip function.

Conclusion

The present cross-sectional study, conducted among 140 adult patients with osteonecrosis of the femoral head (ONFH), aimed to evaluate the extent of necrosis using the Kerboul angle and its correlation with functional status, as assessed by the Harris Hip Score (HHS). The study revealed a significant negative correlation between the Kerboul angle and HHS ($r = -0.647$, $p < 0.01$), indicating that a larger extent of necrosis is associated with poorer functional outcomes. The mean age of the study subjects was 41.57 ± 15.76 years, with a male predominance (70.7%). Both the left and right sides were equally affected (50% each), and the mean duration of pain was 9.52 ± 6.94 months. Risk factors such as alcohol consumption and smoking were reported in 52.86% of the subjects, while obesity (17.1%) and diabetes mellitus (12.8%) were the most common co-morbidities.

The mean HHS was 64.49 ± 15.38 , with 61.43% of subjects having a poor score (<70). The mean Kerboul angle was 177.28 ± 47.88 , with a minimum of 49.09 and a maximum of 283.93. Steroid use was reported in 40% of the subjects, and a history of COVID-19 was found in 25.71%. The findings of this study highlight the importance of early diagnosis and intervention in ONFH to prevent the progression of necrosis and preserve hip function. The significant correlation between the Kerboul angle and HHS suggests that the Kerboul angle could be a valuable tool for predicting functional outcomes in patients with ONFH. Further research is needed to validate these findings and explore the potential association between COVID-19 and ONFH.

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