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Short Term Evaluation Of The Effects Of Femoral Offset And Head Size On Joint Stability And Functional Outcome After Total Hip Arthroplasty

Dr. Sandeep Reddy R, Dr. Ajai Patil, Dr. Manjunatha R

[1] Professor Department of Orthopaedics MS Ramaiah Medical College drsandeepreddy80@gmail.com

[2] Junior Resident Department of Orthopaedics MS Ramaiah Medical College Ajaibpatil1994@gmail.com

[3](Corresponding Author) * Senior Resident Department of Orthopaedics MS Ramaiah Medical College manjur591sims@gmail.com

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ABSTRACT

Background: *Total Hip Arthroplasty (THA) is a widely performed procedure for various hip pathologies. Femoral offset and head size are critical factors influencing joint stability and functional outcomes. This study evaluated the short-term effects of femoral offset and head size on joint stability and functional outcomes after THA.*

Methodology: *This prospective study included 35 patients undergoing THA. Demographic data, surgical details and implant characteristics were recorded. Intraoperative internal and external rotation measurements were taken to assess joint stability. Femoral offset and head size were measured from postoperative radiographs. Functional outcomes were evaluated using the Modified Harris Hip Score (HHS) preoperatively and postoperatively. Statistical analysis included paired t-tests, descriptive statistics and Pearson correlation coefficients.*

Results: *The mean age of participants was 52.3 years, with a balanced gender distribution (54% males, 46% females). The mean femoral head size was 29.89 mm (SD 2.3), and the mean femoral offset was 42.69 mm (SD 5.2). A significant difference was found between high and standard offset neck internal (mean 48.37°) and external (mean 37.74°) rotation measurements (p<0.001). A strong positive correlation was observed between femoral offset and intraoperative internal rotation (r=0.859, p<0.001), while femoral head size showed a weaker correlation (r=0.325, p=0.05). The mean Modified HHS improved significantly from 14.6 preoperatively to 79.8 postoperatively (p<0.001).*

Conclusion: *Femoral offset, rather than head size, is a primary determinant of joint stability in THA. Optimizing femoral offset is crucial for surgical planning and implant selection. While THA significantly improves function, long-term studies are needed to evaluate the durability of these findings and their impact on patient-reported* outcomes.

Keywords: Total Hip Arthroplasty, Femoral Offset, Head Size, Joint Stability, Functional Outcomes, Modified Harris Hip Score, Intraoperative Measurements

INTRODUCTION

Total Hip Arthroplasty (THA) has significantly transformed the management of diverse hip joint problems globally, including India.(1) This surgical intervention entails replacing the impaired hip joint with artificial components to mitigate discomfort, reinstate mobility, and enhance patient's quality of life.(2) Typical indications are osteoarthritis, rheumatoid arthritis and hip fractures. The estimated prevalence of osteoarthritis in India is 28.7%, indicating a substantial demand for effective therapies such as THA.(3,4)

Achieving optimal joint stability and functional outcomes is crucial for the success of THA. These parameters play a critical role in determining the long-term success of THA and the quality of life experienced by the patient after surgery.[5] In India, patients frequently arrive at advanced stages of the disease due to delayed diagnosis or limited access to healthcare. Therefore, optimizing these outcomes is of the utmost importance.[6]

The femoral offset is critical to THA. The term refers to the perpendicular distance between the femoral head's rotational center and the femur's longitudinal axis. It affects the lever arm of the abductor muscle, the forces applied to the hip joint, and the overall stability of the joint. Accurate restoration of femoral offset is particularly tough and critical in India since patients typically have smaller anatomical measurements than Western populations.[7] Accurately measuring the femoral offset can be difficult due to patient position, radiography technique, abnormalities and prior surgeries. Within the Indian healthcare system, access to modern imaging techniques may be limited, particularly in rural areas that comprise 66% of the population. Therefore, there is a need to create dependable techniques for quantifying femoral offset using traditional radiography.[8,9]

The femoral head size corresponds to the diameter of the artificial ball component that moves within the acetabular cup during THA. The range of head sizes commonly spans from 22mm to 40mm. There is an increasing inclination towards utilizing larger head sizes, as it balances the advantages of enhanced stability and the worries regarding wear in younger and more physically active individuals. This is especially significant in India, where the average age of patients undergoing THA is lower compared to Western Countries.[10]

The head size selection can substantially impact the joint's stability, the extent of movement possible and the wear properties of the implant. In the Indian environment, where patients frequently do activities that involve significant flexion, such as squatting and sitting cross-legged, the influence of head size on the range of motion becomes more critical. Indian orthopedic surgeons have recently researched to enhance implant designs to accommodate cultural and lifestyle considerations.[11]

The interaction between femoral offset and head size can have intricate implications for joint biomechanics, stability, and function. It is exceptionally accurate among the Indianpopulation, where variances in anatomy, lifestyle factors, and the requirement for longer-lasting implants due to younger patient age may impact the ideal combination of these components.[12] This study seeks to examine both aspects collectively to provide immediately applicable insights for improving THA results in Indian patients.

This study can greatly influence clinical practice in THA, especially in India and potentially in other countries with comparable patient demographics. By clarifying the combined impact of femoral offset and head size on immediate results in Indian patients, surgeons can enhance their ability to make well-informed choices regarding implant selection and surgical procedure.

Furthermore, this study seeks to fill existing voids in the literature by offering a more intricate comprehension of how these two pivotal elements intertwine to impact THA results in the Indian setting. The findings have the potential to question existing beliefs and facilitate the development of individualized methods for hip arthroplasty, customized to suit the distinct attributes and requirements of Indian patients.

Overall, this study is essential in improving THA operations for the Indian population.It thoroughly assesses the immediate effects of femoral offset and head size on joint stability and functional results. Hence, contributing to the optimization of these procedures. The findings obtained from this research possess the capacity to boost surgical procedures, optimize implant designs and ultimately elevate the standard of living for Indian patients receiving total hip arthroplasty. Moreover, it adds to the expanding collection of orthopedic research focused specifically on the Indian population, bolstering the advancement of treatment procedures better aligned with the country's culture and anatomy.
Hence, we aimed to examine the contribution of femoral component offset to joint stability. Additionally, the secondary objective seeks to assess the influence of head size on joint stability and range of motion, as well as

evaluate the functional outcomes for patients.

METHODOLOGY:

The study was designed as a prospective investigation, conducted from April 2022 to March 2024, at the Ramaiah Memorial Hospital and Ramaiah Teaching Hospital in Bangalore. Data were sourced from patients at these facilities, specifically those who met the inclusion criteria, yielding a sample size of 36 participants. Eligible subjects were between the ages of 20 and 80 years, with no prior history of hip or lower limb surgeries. Participants with a history of limb shortening or lengthening, previous lower limb surgeries, developmental dysplasia of the hip (DDH), total hip arthroplasty (THA), or congenital deformities of the hip or lower limb were excluded.

The study included evaluations of up to 35 patients, who were assessed both preoperatively and six months postoperatively. Assessments involved clinical evaluations, anteroposterior (AP) and lateral X-rays, and measurements of functionality and patient satisfaction using the Harris Hip Score obtained through in-person interviews. Additionally, intraoperative measurements of neck offset were recorded.

Surgical techniques followed a posterior approach, with patients positioned laterally, hip flexed at 60 degrees, and knee flexed at 90 degrees. After inserting the final femoral broach and fixing the acetabular shell, a trial reduction was performed using provisional femoral heads, necks, and acetabular liners. The neck-shaft angles employed were either 132 degrees (standard-offset neck) or 127 degrees (high-offset neck), with head diameters of 28 mm, 32 mm, or 36 mm. The high-offset neck provided a 5-8 mm greater offset than the standard-offset neck, depending on the stem size. To control for leg length's effect on soft-tissue balance and isolate femoral offset, a 3- or 4-mm longer neck was used with the 127-degree neck. Heads with an extended flanged neck were not utilized. Throughout the study, the 28-mm head was most frequently used for total hip arthroplasty, while the 36-mm head was the largest available within the implant system.

Range of internal and external rotation was measured by a secondary surgeon using a goniometer, with one arm aligned to the tibia and the other perpendicular to the floor to determine the supplementary angle of rotation. Any subluxation of the head from the liner was documented. The Modified Harris Hip Score was analyzed for each participant preoperatively and postoperatively to assess improvements. Femoral offset was measured on both AP and lateral view X-rays.

Statistical Methods:

Data was entered into a Microsoft Excel spreadsheet and analyzed using SPSS version 22 software. Categorical data were presented as frequencies and proportions. Chi-square tests were used to assess statistical significance. Continuous data were presented as means and standard deviations. Independent t-tests were used to identify mean differences between two groups. A p-value less than 0.05 was considered statistically significant.

Sample size:

Was estimated based on the average range of External rotation in the subjects after total hip arthroplasty from the study by Testuya jinno et al. Considering average range of External rotation 37.3^0 with SD of 7.7^0, at 5% alpha error and at 95% Confidence level sample size of 30 was obtained and will be included in the study. Considering 10% Nonresponse a sample size of $30 + 3 \approx 33$ minimum subjects will be included in the study.

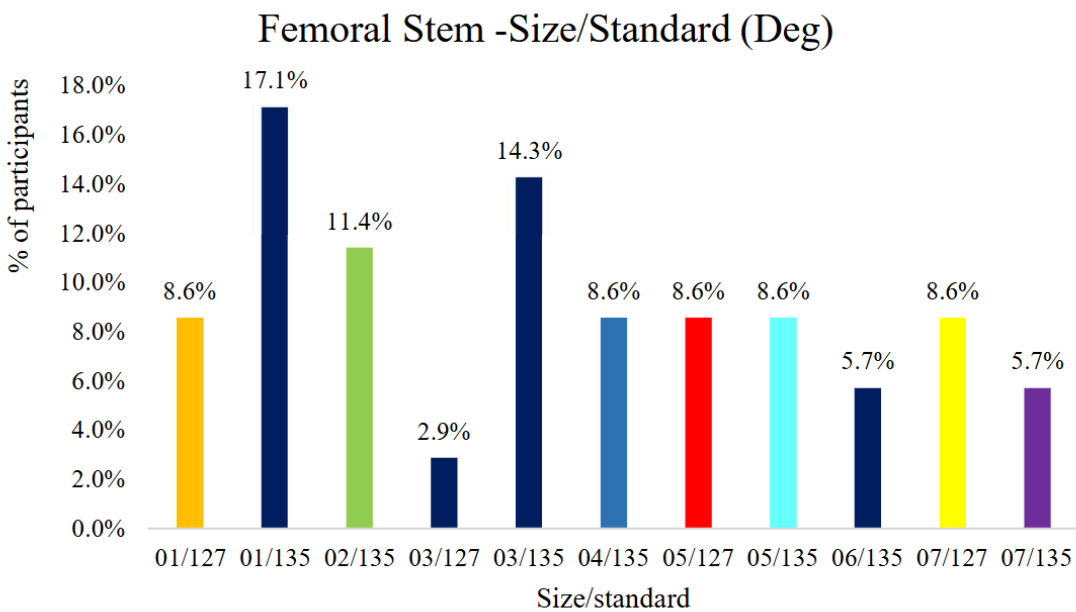
RESULTS:

Table 1: Demographic characteristics of Participants

Category	Group/Type	N	%
Age Categories	20-30	6	17.1%
	31-40	3	8.6%
	41-50	9	25.7%
	51-60	8	22.9%
	61-70	7	20.0%
	71-80	2	5.7%
Gender	Male	19	54.3%
	Female	16	45.7%
BMI Category	Normal Weight	17	48.6%
	Overweight	16	45.7%
	Obese	2	5.7%
Diagnosis	Arthritis	14	40.0%
	Avascular Necrosis	7	20.0%
	Fractures	12	34.28%
	Post-Traumatic Arthritis	2	5.71%
Affected Limb	Right	14	40.0%
	Left	21	60.0%
Type of Procedure	Right Cemented THR	6	17.1%
	Left Cemented THR	8	22.9%
	Right Uncemented THR	8	22.9%
	Left Uncemented THR	13	37.1%
Liner Size (mm)	Nil	13	37.1%
	44	7	20.0%
	46	5	14.3%
	48	6	17.1%
	50	2	5.7%
	52	2	5.7%

Among 35 patients, the largest group consisted of participants aged 41-50, accounting for 25.7% of the sample. This was followed by the 51-60 age group, which comprised 22.9% of the participants. Those aged 61-70 represented 20.0%, while the 20-30 age group comprised 17.1%. Participants aged 31-40 accounted for 8.6%, and the smallest groupwas participants aged 71-80, comprising 5.7%. This distribution suggests a predominance of middle-aged and older adults. In this study, the gender distribution of participants was relatively balanced, with a slightly higher proportion of males. Specifically, 54.3% of the participants were male,while 45.7% were female. In this study, most participants (48.6%) were classified as having normal weight, while45.7% were categorized as overweight. A smaller proportion, 5.7%, fell into the obesecategory. The most common diagnosis among participants was Arthritis, comprising 40% of thesample. Fractures was the second most frequent diagnosis, affecting 34.28% of participants. Avascular necrosis was observed in 20% of the participants, while post- traumatic arthritis accounted for 5.7%. In the current study, most participants had their left limbs affected, comprising 60.0%of the sample. In contrast, 40.0% of participants had their right limbs affected. In the present study, the most common procedure was left uncemented total hip replacement (THR), performed on 37.1% of participants. Left-cemented THR and right-cemented THR followed this, each accounting for 22.9%. Right- cemented THR was the least common, comprising 17.1% of the procedures. The most common liner size was 46 mm, used in 14.3% of participants, followed by 48mm, used in 17.1%. Liner sizes of 44 mm and 50 mm were each used in 20.0% and 5.7% of participants, respectively, while 52 mm was also used in 5.7% of cases. The mean liner size was 46.8 mm, with a standard deviation of 2.6, reflecting the average size and variability among the participants.

Figure 1: Distribution of Participants by Femoral Stem Size and Standard Angle



In this study, the most frequent femoral stem size and angle combination was 01/135,used in 17.1% of participants. It was followed by 03/135, which was used in 14.3%. The combinations 02/135 and 05/127 accounted for 11.4% and 8.6%, respectively. Other sizes and angles, including 01/127, 03/127, 04/135, 05/135, 06/135, 07/127, and07/135, had varying frequencies, each used by a smaller percentage of participants. The femoral head sizes ranged from a minimum of 28 mm to a maximum of 36 mm. (Mean-29.89, SD-2.3). The femoral offset sizes ranged from a minimum of 36 mm to a maximum of 52 mm. The mean femoral offset was 42.69 mm, with a standard deviation of 5.2 mm. This reflects a moderate variation in femoral offset measurements among the participants.

Table 2: Intraoperative Rotation Measurements

Intraoperative -Rotation	Mean	SD	Mean Difference	t-value	p- value
Internal	48.37	3.93	10.629	27.165	<0.001
External	37.74	3.09			

The current study's mean internal rotation was 48.37 degrees, with a standard deviation of 3.93 degrees. The mean external rotation was 37.74 degrees, with a standard deviation of 3.09 degrees. The mean difference between internal and external rotation was 10.629 degrees, which is statistically significant, with a t-value of 27.165 and a p-value of less than 0.001. This indicates a significant difference between internal and external rotation measurements during the procedure.

Table 3: Harris Hip Score Pre- and Post-Operatively

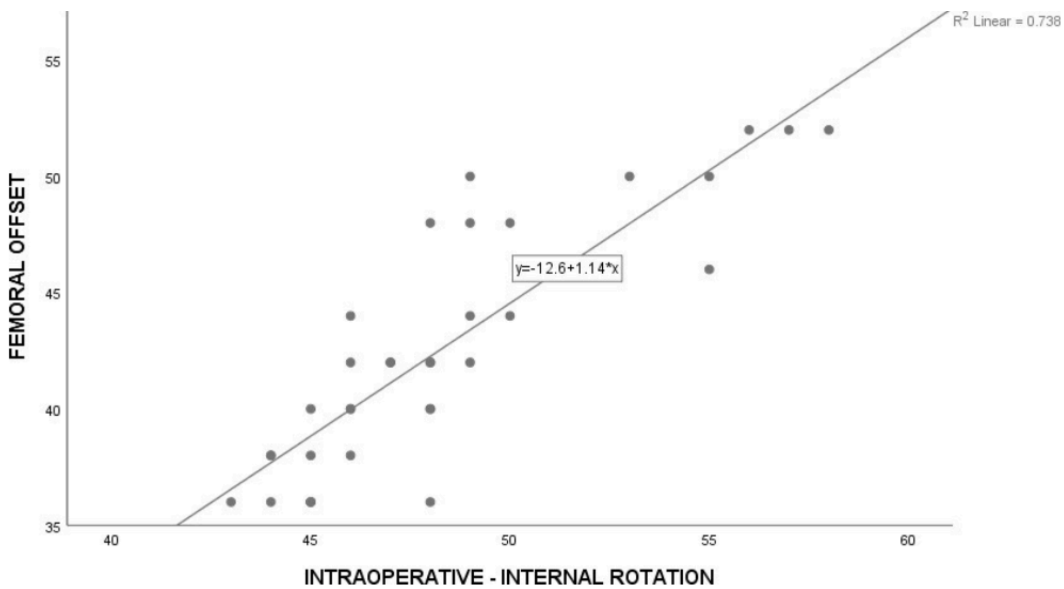
Harris HipScore	Mean	SD	Mean Difference	t-value	p-value
Pre-op	14.6	11.1	-65.176	- 33.036	<0.001
Post-op	79.8	5.2			

The mean Harris Hip Score pre-operatively was 14.6, with a standard deviation of 11.1,while the mean postoperative score, recorded 6 months after surgery was 79.8, with a standard deviation of 5.2. The mean difference between pre-operative and post- operative scores was -65.176, with a t-value of -33.036 and a p-value of less than 0.001.This significant difference indicates a substantial improvement in hip function following surgery.

Table 4: Correlation between Femoral Offset, Femoral Head size and Intraoperative - Internal Rotation

		Intraoperative -Internal Rotation
Femoral Offset	Pearson Correlation	0.859**
	p-value	<0.001
	N	35
Femoral Head -Size(mm)	Pearson Correlation	0.325
	p-value	0.05
	N	35

Figure 2: Correlation between Femoral offset and Intraoperative Internal Rotation



The correlation between femoral offset and intraoperative internal rotation showed a strong positive Pearson correlation coefficient of 0.859, with a statistically significant p-value of <0.001, indicating a strong positive relationship between these variables. This suggests that intraoperative internal rotation also tends to increase as femoral offset increases. A higher femoral offset is associated with increased internal rotation, which may contribute to better joint stability during total hip arthroplasty.

In contrast, the correlation between femoral head size and intraoperative internal rotation had a Pearson correlation coefficient of 0.325 with a p-value of 0.05. Although the correlation is weaker and borderline significant, it indicates that larger femoral head size is associated with better internal rotation. This finding suggests that increasing the femoral head size may improve joint stability by enhancing internal rotation.

These results underscore the importance of considering both femoral offset and femoral head size in achieving optimal joint stability and functional outcomes in THA.

DISCUSSION

This study assessed the short-term impact of femoral offset and head size on the stability of the joint and the functional results following THA. We evaluated a group of35 patients who were undergoing THA. We analyzed many factors such as age, gender,BMI, diagnosis, affected limb, type of treatment, features of the implant (liner size, femoral stem size, femoral head size, and femoral offset), intraoperative rotation measures and Modified Harris Hip Scores.

Demographic Characters
The majority of participants (68.6%) were between the ages of 41 and 70, with the highest proportion (25.7%) falling into the 41-50 age bracket. The age distribution aligns with the standard demographic of patients undergoing THA, as documented in various prior research. *Kanniyan et al. (2020)* found that the average age of patients undergoing THA for ankylosing spondylitis was 52.8 years, consistent with our results.[13] The observed rise in our study's 41-50 age bracket indicates a potential inclination towards earlier intervention in hip diseases, which could be attributed to advancements in diagnostic capacities or evolving patient expectations.

The gender distribution exhibited a virtually equal proportion (54.3% males, 45.7% females), aligning with the findings of *Clement et al. (2016).* The equilibrium achieved in this study increases the applicability of our findings to both males and females, enabling more reliable inferences regarding the impact of femoral offset and head size on outcomes, irrespective of gender.[8]

The distribution of BMI in our sample (48.6% normal weight, 45.7% overweight, 5.7%obese) shows some variation compared to prior findings. *Mathur and Kapadiya (2020)* discovered a greater percentage of overweight and obese individuals among their group of patients who underwent THA. The decreased prevalence of obesity in our population may enhance functional outcomes, as high body weight can harm healing and the lifespan of implants. This disparity underscores the need to consider BMI when analyzing THA results and may indicate geographical discrepancies in patient demographics or health conditions.[14]

The prevalence of arthritis (40.0%) and fractures (34.28%) as diagnoses differs from prior studies. *Amenábar et al. (2015)* identified osteoarthritis as the main reason for performing THA in their cohort.[15] The increased proportion of fracture cases we observe may be attributed to regional disparities in patient demographics, trauma patterns or referral protocols. This distinction highlights the significance of considering the underlying diagnosis while analyzing THA outcomes and devising surgical strategies.

Characteristics of Surgery
Variables include the limb that is impacted, the type of procedure, the size of the liner and the size of the femoral stem. The results of our study indicate that left-sided surgeries were more prevalent, accounting for 60.0% of the total, while right-sided treatments accounted for 40.0%. This discovery is fascinating and may require additional exploration into any physical, lifestyle or occupational elements contributing to this pattern. There is a lack of research on the dominance of limbs in THA, indicating a need for further investigation in this area.

The current tendency in THA practice is to prefer uncemented THR (60.0%) over cemented THR (40.0%). *Wyatt et al. (2018)* observed a comparable inclination towards using uncemented implants in their New Zealand Joint Registry examination. The shift observed is a result of the advancement in surgical procedures and implant technology,which may impact the long-term results and rates of revision.[16]

The liner sizes, with a mean of 46.8 mm and a standard deviation of 2.6, exhibit significant diversity along with the femoral stem diameters. The variability highlights the significance of selecting implants tailored to each patient, as *Dong et al. (2016)* stressed in their research on planning for THA before surgery. The sizes utilized in our study encompass a broad spectrum to account for the variations in patient anatomies and the necessity for individualized approaches in THA.[17]

Characteristics and biomechanics of implants
In our study, the average size of the femoral head was 29.89 mm, with a standard deviation of 2.3. The range of sizes observed was from 28 mm to 36 mm. This range aligns with the prevailing trends in THA, where larger head sizes are more frequently employed to enhance stability. The results of our study are consistent

with *Lombardi's(2017)* findings, which indicated that head diameters of 36 mm and larger led to enhanced stability. However, our analysis indicates that smaller head sizes (with a mean of less than 30 mm) are more prevalent, which supports a more cautious approach in contrast to current tendencies favoring larger head sizes.(18)

The average femoral offset was 42.69 mm with a standard deviation of 5.2 mm, ranging from 36 mm to 52 mm. The range of results is comparable to the findings of *Clement et al. (2016),* who discovered a positive correlation between higher femoral offset and improved functional outcomes. The heterogeneity seen in our investigation provides evidence that the restoration of femoral offset should be customized based on the unique anatomical characteristics of each patient.(8) Our research supports the significance of meticulous preoperative preparation and decision-making during surgery to maximize femoral offset.

Functional outcomes and joint stability

The results of our study revealed a notable disparity between the measures of high and standard offset neck in terms of internal rotation (mean 48.37°) and external rotation (mean 37.74°) ($p<0.001$). This discovery is essential for evaluating joint stability during surgery. *Jinno et al. (2017)* also found that increased femoral offset resulted in a larger internal rotation range before subluxation. Our findings support these prior results andmeasure the variation in rotation ranges, offering significant assistance for surgeons in evaluating the stability during surgery.(19)

Harris Hip Score Before and After Surgery

The average Harris Hip Score significantly improved from 14.6 before the operation to 79.8, 6 months after the surgery ($p<0.001$). The significant enhancement aligns with the results of *Mathur and Kapadiya (2020),* who similarly saw large functional gains after THA. The study's findings significantly improved patient function and quality of life due to THA, with a mean difference of 65.2 points highlighting the substantial impact of THA on enhancing patient well-being.(14) This outcome presents compelling evidence of the efficacy of THA in treating severe hip conditions and enhancing patient results.

Relationship between Femoral Offset, Femoral Head Size, and Internal Rotation during Surgery

A significant positive connection was seen between femoral offset and intraoperative internal rotation ($r=0.859$, $p<0.001$). This discovery is consistent with the findings of *Yabuno et al. (2018),* who observed that augmenting femoral offset led to better soft tissue tensioning and increased joint stability.(20) Our study verifies and measures this correlation, indicating the significance of femoral offset in determining joint stability.

The relatively low correlation ($r=0.325$, $p=0.05$) between femoral head size and internal rotation is a noteworthy discovery. Contrary to recent research conducted by *English etal. (2023),* which found no significant decrease in the probability of revision or instability when increasing head size from 32 mm to 36 mm, our findings indicate a small but favorable correlation between head size and internal rotation.(21) This discovery provides more subtlety to our comprehension of how cranial dimensions impact the biomechanics and stability of joints.

The higher association between femoral offset and internal rotation, as opposed to head size, indicates that femoral offset may have a more significant impact on joint stability than head size. This discovery has significant ramifications for the surgical planning process and the choice of implants in THA.

Our study thoroughly explains the connections between femoral offset, head size, and joint stability in THA. The robust association between femoral offset and internal rotation underscores the need to adjust the offset to enhance stability and functionality.Although the association between head size and stability is not as strong, its significance should not be disregarded, especially considering past research showing its advantages in reducing dislocation rates.

These findings highlight the significance of considering both femoral offset and head size when aiming for the best results in THA. Restoring the correct femoral offset is essential to improve joint stability and function. The enhancement in *Harris Hip Score Provides* additional validation for the efficacy of THA in enhancing patient outcomes. Subsequent research could expand upon these discoveries by examining the lasting effects and the relationship between femoral offset, head size and additional parameters such as implant design and surgical technique.

This study offers a comprehensive analysis of THA outcomes by examining demographic, surgical, and functional data. The incorporation of objective measures like intraoperative rotation and HHS enhances the reliability of the findings. Statistical analysis effectively identifies correlations between key variables, particularly the crucial relationship between femoral offset, head size, and joint stability. By including a diverse patient population, the study's relevance is extended to a broader patient community.

Limitations

The relatively small sample size limits the statistical power and generalizability of the findings. The short-term focus may not fully capture the long-term impact of femoral offset and head size on implant durability and patient function. The single-center design may introduce biases due to institution-specific practices and patient populations. The absence of a control group hinders causal inference regarding the effects of specific interventions. Additionally, the study may not have accounted for all potential factors, such as surgeon expertise and specific surgical techniques.

Future research should focus on long-term follow-up studies, larger multi-center trials, and randomized controlled trials to establish causal relationships and assess long-term outcomes. Additionally, incorporating patient-reported outcome measures can provide a more comprehensive understanding of patient experiences and quality of life following THA

Conclusion

This study emphasizes the significant role of femoral offset in determining joint stability, surpassing the influence of head size. The substantial improvement in HHS underscores the effectiveness of THA in enhancing patient function and quality of life. While the short-term benefits are evident, long-term studies are necessary to validate these findings and assess their impact on implant durability and patient-reported outcomes. Optimizing femoral offset should be a primary consideration in surgical planning and implant selection to achieve optimal outcomes in THA

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