Original Article
Cukurova Anestezi ve Cerrahi Bilimler Dergisi

The Effect of Femoral and Global Offset Restoration on Clinical Outcomes in Total Hip Arthroplasty

Hakan Uslu[1], Fırat Seyfettinoğlu[1], Hasan Ulaş Oğur[1], Osman Çiloğlu[1], Oğuzhan Çiçek[1], Hakan Çiçek[1]

1 Department of Orthopedics and Traumatology, University of Health Sciences, Adana City Training and Research Hospital, Adana, Türkiye

Abstract

Aim: This study aimed to evaluate the impact of restoring femoral offset (FO), global offset (GO), and leg length discrepancy (VU) on clinical outcomes in patients undergoing total hip arthroplasty (THA) for primary coxarthrosis.
Methods: A retrospective review was conducted on 100 patients who underwent THA at Adana City Training and Research Hospital between January 2015 and December 2018. Preoperative and postoperative Harris Hip Score (HHS) and radiological parameters (FO, GO, AO, VU, CDA) were compared. Correlations between postoperative parameters and HHS were analyzed using Spearman's correlation test.
Results: Among the 100 patients, 60 were male (60%) and 40 were female (40%). Males had significantly higher height and weight ($p<0.001$), but BMI did not differ. Preoperatively, intact-side measurements were higher than those on the operated side. Postoperatively, the mean Harris Score significantly improved from 54.13 to 86.27 ($p<0.001$). FO and GO increased, whereas AO decreased. Significant negative correlations were found between postoperative HHS and GO ($r=-0.663$; $p<0.001$), FO ($r=-0.437$; $p<0.001$), and CDA ($r=-0.632$; $p<0.001$).
Conclusions: Restoration of FO, GO, and VU in THA has a significant effect on postoperative functional outcomes. In particular, accurate GO restoration plays a crucial role in patient satisfaction and functional recovery.
Keywords: *Total hip arthroplasty; femoral offset; global offset; Harris Hip Score; coxarthrosis*

1. Introduction

The hip joint is one of the most load-bearing structures in the body, making it highly susceptible to degenerative diseases. Osteoarthritis (coxarthrosis) is one of the most common degenerative conditions affecting hip function. Its rate is 10% in people aged 30 and older and rises to 45% in those aged 65 and older[1]. Osteoarthritis reduces quality of life, leads to job loss, and creates economic costs. In the United States, annual treatment costs and lost productivity from osteoarthritis total approximately $254 billion[2]. Total Hip Arthroplasty (THA) is an option for advanced coxarthrosis when conservative treatments fail. Its goal is to reconstruct the femoral head and acetabulum biomechanically[3,4]. THA is usually preferred for older patients with lower physical activity. In young, active individuals, the risk of revision is higher, so indications require more caution[5,6].

Today, many prosthetic systems use modular head designs that allow surgeons to adjust the offset. Vertical offset measures from the femoral head's center to the femoral neck, while horizontal offset measures the center of the femoral head to a line along the distal femoral axis. Improperly adjusted parameters disrupt the abductor muscle mechanism, add joint stress, and cause complications like claudication, impingement, and dislocation. The femoral anteversion angle is about 10–15°, and it is usually easier to adjust with cemented stems. For uncemented stems, the femoral neck and component must align on the same axis to fill the proximal femur fully[7].

Degenerative hip joint changes can cause severe pain and limit mobility, restricting walking, sleeping, and daily activities. This may push individuals to withdraw from social life and face socioeconomic challenges. THA aims to help patients resume their daily activities painlessly and functionally, thereby improving their quality of life[8-10]. Studies show THA reduces pain and improves function in osteoarthritis[11]. This study aims to evaluate the significance of offset restoration in patients undergoing total hip arthroplasty, specifically investigating whether global, medial, and femoral offsets (FO) adjusted during THA influence clinical outcomes.

2. Materials and Methods

Approval was obtained from our local institutional ethics committee (Ethics Committee No.38/541). The study was designed as a retrospective, cohort study. This study included 100 patients who underwent total hip arthroplasty (THA) for primary coxarthrosis at the Orthopedics and Traumatology Clinic of Adana City Training and Research Hospital between January 2015 and

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December 2018. Exclusion criteria included coxarthrosis with dysplastic bases, revision hip arthroplasties, and arthroplasties performed for inflammatory arthritis. Patients with these characteristics were excluded from the study. Pelvic anteroposterior and leg length radiographs (Philips X-ray C50 High) were taken. A standard protocol was followed for radiographs. Anteroposterior AP hip radiographs were taken with the patient in the supine position, corrected for anteversion, and in 15 degrees of internal rotation. Height and weight were measured, and body mass index (BMI) was recorded. Radiographs were taken by two experienced X-ray technicians using the same equipment and technique. Two experienced orthopedics and traumatology specialists took radiological measurements, and the database was created by averaging the values. Preoperative and postoperative femoral offset (FO), acetabular offset (AO), global offset (GO), vertical length (VU), and collodiaphyseal angle (CDA) were measured radiologically. Patients' clinical outcomes were evaluated and scored using the Harris Hip Score (HHS) and the SF-36 quality-of-life scale. Postoperative clinical assessment and radiographic measurements, including the HHS and offset parameters, were performed routinely at 6 months after surgery.

Radiological measurements were performed on standardized anteroposterior pelvic radiographs obtained with patients in the supine position and 15° internal rotation. Digital measurements were calibrated for radiographic magnification.

Radiological measurements

FO was defined as the perpendicular distance from the center of the femoral head to the longitudinal axis of the femoral shaft and measured in millimeters. AO was defined as the horizontal distance from the center of the femoral head to the ilioischial line. GO was calculated as the sum of femoral and acetabular offsets. Vertical length (VU) was measured as the vertical distance between the inter-teardrop line and the reference point on the lesser trochanter. CDA was defined as the angle between the femoral neck and femoral shaft axes and measured in degrees[12]. All measurements were independently performed by two experienced orthopedic surgeons, and mean values were used for statistical analysis. Prior to radiological measurements, both observers were calibrated using a standardized measurement protocol to ensure consistency. Interobserver reliability was assessed using the intraclass correlation coefficient (ICC). A schematic diagram demonstrating all radiological measurement parameters has been added as Figure 1.

Figure 1

Radiological reference lines and measurement technique for VU, FO, AO, GO, and CDA on standardized anteroposterior pelvic radiographs.

DB, vertical length (VU); FE, global offset (GO); FA, femoral offset (FO); AE, acetabular offset (AO); CDA, collodiaphyseal angle.

Surgical Technique

All total hip arthroplasty procedures were performed using a standardized posterolateral (modified Gibson) surgical approach. Cementless femoral stems were implanted in all patients, as illustrated in the original surgical documentation. Modular femoral heads were used to allow intraoperative adjustment of offset and leg length. Cementless acetabular components were implanted in all cases. Preoperative templating was performed using standardized anteroposterior pelvic radiographs to determine appropriate component size, femoral offset, and leg length restoration.

Table 1

Comparison of Preoperative Parameters Between the Healthy and Operated Sides

Pair	Comparison	Mean Difference	SD (±)	t	p
Pair 1	Healthy Side Preop Harris – Operated Side Preop Harris	45.87	17.89	25.62	<0.001
Pair 2	Healthy Side Preop VU – Operated Side Preop VU	3.51	8.15	4.31	<0.001
Pair 3	Healthy Side Preop GO – Operated Side Preop GO	2.71	4.84	5.59	<0.001
Pair 4	Healthy Side Preop FO – Operated Side Preop FO	7.35	7.12	10.32	<0.001
Pair 5	Healthy Side Preop AO – Operated Side Preop AO	-4.25	7.66	-5.55	<0.001
Pair 6	Healthy Side Preop CDA – Operated Side Preop CDA	2.18	11.33	1.92	0.057

Table 2

Comparison of Preoperative and Postoperative Parameters (Operated Side)

Pair	Comparison	Mean Difference	SD (±)	t	p
Pair 1	Preop – Postop Harris	-32.14	12.50	-25.71	<0.001
Pair 2	Preop VU – Postop VU	-1.931	7.71	-2.50	0.014
Pair 3	Preop GO – Postop GO	-3.264	9.69	-3.36	0.001
Pair 4	Preop FO – Postop FO	-8.75	6.33	-13.82	<0.001
Pair 5	Preop AO – Postop AO	2.53	6.75	3.75	<0.001
Pair 6	Preop CDA – Postop CDA	-2.66	9.48	-2.80	0.006

Table 3

Correlation of Postoperative Parameters with Harris Score (Spearman's rho)

Variables	Postop VU (R)	Postop VU (p)	Postop GO (R)	Postop GO (p)	Postop FO (R)	Postop FO (p)	Postop AO (R)	Postop AO (p)	Postop CDA (R)	Postop CDA (p)	Postop Harris (R)	Postop Harris (p)
Postop VU	1.000	.	-.015	.882	.310**	.002	.262**	.009	.061	.546	.035	.730
Postop GO	-.015	.882	1.000	.	.620**	.001	.032	.750	.395**	.001	-.663**	.001
Postop FO	.310**	.002	.620**	.001	1.000	.	.218*	.029	.192	.056	-.437**	.001
Postop AO	.262**	.009	.032	.750	.218*	.029	1.000	.	.104	.302	-.040	.694
Postop CDA	.061	.546	.395**	.001	.192	.056	.104	.302	1.000	.	-.462**	.001
Postop Harris	.035	.730	-.663**	.001	-.437**	.001	-.040	.694	-.462**	.000	1.000	.

Statistical Analysis

Data obtained from the study were analyzed using the SPSS 21.0 package program. Descriptive statistics include mean, standard deviation (±), and percentage distributions. An independent-samples t-test was used to determine whether there were differences in preoperative and postoperative HHS, VU, GO, AO, FO, and CDA values by gender. A paired samples t-test was used to determine whether there were differences between preoperative and postoperative HHS, VU, GO, AO, FO, and CDA values. Spearman's Correlation Analysis was used to determine relationships among parameters. The results were evaluated at the 95% confidence level ($p < 0.05$).

3. Results

Of the 100 patients in the study, 60 (60%) were male and 40 (40%) were female. Males had higher heights and weights than females ($p < 0.001$). There was no significant difference in BMI between groups ($p>0.05$). Interobserver reliability was excellent for all radiological parameters (ICC range: 0.85–0.93). The HHS was significantly higher on the preoperatively intact side compared to the operated side (mean difference = 45.87 ± 17.89; t = 25.629; $p < 0.001$). VU (mean difference = 3.52 ± 8.15; t = 4.312; $p < 0.001$), GO (mean difference = 2.71 ± 4.85; t = 5.595; $p < 0.001$), and FO (mean difference = 7.35 ± 7.12; t = 10.320; $p < 0.001$) values were also significantly higher on the intact side. AO was higher on the operated side and considerably lower than the healthy side (mean difference = -4.26 ± 7.66; t = -5.558; $p < 0.001$). Although CDA values were higher on the healthy side (mean difference = 2.18 ± 11.33), this difference was not statistically significant (t = 1.923; p = 0.057). Table 1 presents these findings.

Comparison of preoperative and postoperative values showed significant improvements. The mean HHS increased from 54.13 ± 17.89 to 86.27 ± 6.64. The mean VU changed from 39.22 ± 8.01 to 41.15 ± 6.53, and the mean GO increased from 68.93 ± 6.74 to 72.19 ± 10.12. The mean FO rose from 37.89 ± 4.92 to 46.64 ± 5.99. In contrast, AO values decreased from 30.66 ± 6.97 to 28.12 ± 3.70, while CDA values increased from 130.48 ± 9.53 to 133.14 ± 5.56. These results indicate that surgery significantly improved the Harris Score, FO, and GO, and reduced AO values. Table 2 presents these findings.

Finally, the relationship between postoperative VU, GO, FO, AO, and CDA values and the Harris score was examined: a negative, high, and significant correlation was found between the GO and the Harris score (r = -0.663; $p<0.001$); a negative, moderate, and significant correlation was found between the FO and the Harris score (r = -0.437; $p<0.001$); and a negative, moderate, and significant correlation was found between the CDA and the HHS (r = -0.632; $p<0.001$) (Table 3).

4. Discussion

Total hip arthroplasty (THA) is a highly effective surgical treatment for cases in which hip joint function is severely impaired, often accompanied by pain, and that reduces patients' quality of life. The primary goals of this method are to eliminate pain, restore joint stability and mobility, and ultimately improve the patient's quality of life[13]. Numerous studies in the literature demonstrate high patient satisfaction and functional improvement in primary THA procedures[14-16]. THA has become an integral part of orthopedic practice over the past two decades and is increasingly common among younger patients, largely due to the rise in life expectancy. Therefore, both implant longevity and functional success are considered important indicators of surgical success. To achieve these goals, prosthesis designs have been modified, and the importance of accurately placing radiological components has also been emphasized[17-19].

This study evaluated the effects of restoring FO, GO, and VU differences to their healthy hip counterparts on clinical outcomes. FO is the distance perpendicular to the long axis of the femoral stem from the center of the femoral head. It is a parameter that directly affects the length of the abductor muscle, muscle strength, joint reaction force, and joint stability[20]. Changes in FO have been reported to significantly affect activities of daily living and functional performance. Recent studies have suggested that FO can be restored more successfully using short femoral stems. Snijders et al. studied 126 hips in 112 patients and reported that short stems facilitated FO restoration. They found FO adjustment was more difficult with straight stems. Similarly, Erivan et al. reported positive contributions of short stems to FO restoration in 100 THA patients. However, studies have shown that successful FO restoration can also be achieved with standard stems. In our study, the use of standard stems allowed an average of 6 mm FO restoration and provided clinically significant improvement[21].

Merle et al. reported that the FO value can be measured as 10% lower on AP radiographs of the pelvis. In contrast, a study by Hyung-Min Ji et al. indicated that a 20% increase in preoperative FO relative to postoperative values was associated with lower scores on functional assessment tools such as the Harris Hip Score and Modified Barthel Index [21]. Building upon these findings, numerous studies have demonstrated significant improvements in functional capacity after THA. For example, Aderinto et al. reported that the mean preoperative Harris Score increased from 44 to 90 postoperatively in 140 patients, 61% of whom were women[22]. Similarly, Chee et al. found an increase from 31 to 93 in a study of 108 patients[23]. Consistent with these studies, our research found that the Harris Score increased from 54.13 to 86.2, a statistically significant difference.

Increasing the FO by 3–4 mm can contribute to an increase in the abductor moment arm and, thus, a more effective use of muscle power. However, excessively increasing the FO can lead to increased load on the trochanteric region, the development of bursitis, muscle tightness, and an increased risk of contractures. Conversely, decreasing the FO can lead to adverse clinical outcomes such as inadequate soft tissue tension and an increased risk of claudication. Another important functional parameter after THA is leg length discrepancy. Accurate determination of this discrepancy during surgery is difficult, and lengthening is usually observed in the operated leg. This can occur due to factors such as inadequate bone resection, the use of a long-necked prosthesis, or a shift in the acetabular center. Specifically, lengthening exceeding 2.5 cm can increase the risk of sciatic nerve injury. Edward et al. demonstrated a significant relationship between leg length discrepancy and sciatic nerve injury. Soft tissue tension, closely related to FO and leg length, can be assessed with the shuck test, one of the most common intraoperative methods; distraction of 2–4 mm is considered normal in this test. If the FO is not restored correctly, soft tissue tension may also be inadequate[19-20].

In our study, a distraction of 2–3 mm was considered normal in the intraoperative evaluation using the Shuck test, and no difference greater than 3–5 mm was detected in the postoperative radiological measurements. This may be due to the inclusion of only patients with primary coxarthrosis.

GO is defined as the sum of the femoral and acetabular offsets[19]. While FO and vertical length have been more widely investigated in the literature, there has been a recent increase in studies evaluating the effect of GO on clinical outcomes. Mahmood S. Sarvar et al. reported in their study of 222 patients that an average of 5 mm of GO restoration was associated with increased abductor muscle strength and quality of life, whereas decreased GO was associated with adverse outcomes[20].

Limitations

This study has several limitations. First, only patients who underwent surgery for a primary diagnosis of coxarthrosis were included in the study; patients with traumatic arthritis, rheumatoid arthritis, or revision cases were excluded. This limits the generalizability of the results. Second, measurements of radiological parameters, such as FO and GO, were performed manually, and the possibility of imaging variations and measurement errors cannot be ruled out. Furthermore, although surgical technical variables such as component placement and prosthesis angle may also influence the results, these factors were not analyzed in a controlled manner. Third, the study evaluated only short-term (6-month postoperative) clinical outcomes; further data, such as long-term survival, implant revision rates, or functional stability, were not considered. Furthermore, patient-reported outcome measures (PROMs), such as subjective patient satisfaction, quality-of-life measures, or pain scores, were excluded from the analysis. Finally, the study employed a single-center, retrospective design, and the findings require confirmation in larger, prospective, multicenter studies.

5. Conclusion

The findings of this study demonstrate that appropriate restoration of FO, GO, and VU during THA significantly impacts postoperative functional outcomes. Accurate restoration of GO, in particular, is critical for patient satisfaction and functional recovery. While the ideal amount of offset varies from person to person, using the healthy hip as a reference and meticulous preoperative measurements and templates are key to successful outcomes.

Statement of ethics

The study was approved by the Adana City Training and Research Hospital Ethics Committee on 28.08.2019 with meeting number 38 and decision number 541, and was conducted in accordance with the Declaration of Helsinki.

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No artificial intelligence-based tools or generative AI technologies were used in this study. The entire content of the manuscript was originally prepared, reviewed, and approved by both authors.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Author contributions

Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; Hakan Uslu, Fırat Seyfettinoğlu, Oğuzhan Çiçek.
Drafting the work or reviewing it critically for important intellectual

content; Osman Çiloğlu, Hasan Ulaş Oğur, Hakan Çiçek.
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