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ORIGINAL ARTICLE

Factors Associated with Acetabular Degeneration and Protrusion in Bipolar Hip Hemiarthroplasty

Bipolar Kalça Hemiartroplastisinde Asetabuler Dejenerasyon ve Protrüzyon ile İlişkili Faktörler

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ABSTRACT

Purpose: This study aims to investigate the effect of some factors such as the diameter of bipolar prosthetic heads, body mass index (BMI), age, gender, bone mineral density (BMD) and leg length discrepancy (LLD) on the acetabular protrusion in elderly patients who had hip bipolar hemiarthroplasty (BHA) after femoral neck fractures.
Methods: The study included a total of 209 patients with a mean age of 77.4 ± 6.0 years who underwent BHA. The difference between the femoral head diameter of the patients and the diameter of the bipolar prosthetic head was divided into two groups, ranging from 0 to -2 mm (same and 1,2 mm small size) . Acetabular enlargement and cartilage degeneration were followed by standard AP pelvis radiographs and clinical outcomes were evaluated by the Harris Hip Score (HHS) after surgery and during 5 years of follow-up.
Results: During the 5-year follow-up, while HHS values decreased, acetabular diameter increased. Acetabular protrusion developed in 21 (10%) patients, acetabular revision surgery was performed for 36 (17%) patients, the difference between native femoral head diameter and prosthetic head diameter was significantly higher in these groups, as was mean LLD (p = 0.0001). Mean T scores obtained with BMD were lower in these groups (p = 0.0001).
Conclusion: It is safer and more reliable to use a bipolar prosthetic head the same size as the patient's native femoral head in BHA. When considering the acetabular protrusion and revision surgery rate in this study, small-size bipolar prosthetic head implantation is not recommended and may cause devastating complications.

Keywords: Bipolar hip hemiarthroplasty, Acetabular protrusion, Revision surgery, Femoral neck fracture

ÖZ

Amaç: Çalışmanın amacı, femur boyun kırığı sonrasında bipolar kalça hemiartroplastisi uygulanan yaşlı hastalarda bipolar protez başlarının çapı, vücut kitle indeksi, yaş, cinsiyet, kemik mineral yoğunluğu ve bacak uzunluk farkı gibi bazı faktörlerin asetabular protrüzyon üzerine etkisini araştırmaktır.
Gereç ve Yöntem: Çalışmaya bipolar kalça hemiartroplastisi uygulanan toplam 209 hasta dahil edildi. Hastaların ortalama yaşı 77.4 ± 6.0 yıldı. Hastaların femur başı çapı ile bipolar protez başı çapı arasındaki fark 0 ile -2 mm 2 gruba (aynı çap ve 1 veya 2 mm küçük çap) ayrıldı. Asetabular genişleme ve kıkırdak dejenerasyonunu standart AP pelvis radyografileri ile değerlendirildi. Takip süresince klinik sonuçlar Harris Hip Skor'u (HHS) ile değerlendirildi.
Bulgular: Beş yıllık izlemde HHS değerleri düşerken asetabulum çapı arttı. 21 (%10) hastada asetabuler protrüzyon gelişti, 36 (%17) hastaya asetabular revizyon cerrahisi yapıldı. Bu gruplarda doğal femur başı çapı ile protez baş çapı arasındaki fark ve bacak uzunluk farkı anlamlı olarak daha yüksekti. (p = 0.0001) . Kemik mineral yoğunluğu ile elde edilen ortalama T skorları bu gruplarda daha düşüktü (p = 0.0001).
Sonuç: Bipolar kalça artroplastisi'nde hastanın doğal femur başı ile aynı boyutta bipolar protez başı kullanmak daha güvenilirdir. Bu çalışmada asetabular protrüzyon ve revizyon cerrahi oranı göz önüne alındığında, küçük boyutlu bipolar protez baş implantasyonu önerilmemektedir ve yıkıcı komplikasyonlara neden olabilir.

Anahtar Kelimeler: bipolar kalça hemiarthroplastisi,, asetabular protrusyon, revizyon cerrahisi, femur boyun kırığı

Introduction

Bipolar hip hemiarthroplasty (BHA) is a common procedure in the treatment of hip fractures in elderly patients [1,2]. For several decades, bipolar prostheses replacement have been the most widely used implants with the less acetabular wear rate and lower dislocation rate compared to unipolar prostheses, which is out-of-date today [3]. Despite favorable outcomes in mid-term follow-up studies with BHA implants, acetabular protrusion of the bipolar cup as a result of excessive acetabular cartilage degeneration in the long-term decrease the success rates [4,5]. This is mostly attributed to excessive pressure due to the incongruence between the metallic bipolar head and the acetabulum. Besides, the bipolar head functions as a unipolar head after a few months, which may lead to higher acetabular degeneration and protrusion [6,7].

It is postulated that the cartilage damage is associated with the interaction between the acetabular cartilage and the artificial metal cup [4]. Therefore, the bipolar head size should be the same in diameter as the patient's native femoral head, but this may not be practically possible in some situations where the native head size is measured as odd numbers intraoperatively. Native femoral heads cannot be perfectly replaced with currently available implants as the native head

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is not a spherical structure [8]. Prosthetic designs are spherical and produced in increments ranging from 1 to 2 mm. Therefore, in some cases, the size of the bipolar prosthetic head determined by intraoperative femoral head measurement may not be suitable for the acetabulum and a smaller prosthetic head may be preferred. Since some prostheses are produced at 2 mm intervals, the appropriate head diameter cannot be used and a smaller one may have to be used. On the other hand, in some cases, a smaller sized head is chosen to facilitate intraoperative reduction of the hip joint.

Regarding the arc of motion provided by the bipolar head, its size should be as close as possible to the extracted native head to avoid further cartilage degeneration in the acetabular cavity. Otherwise, the degenerative process can lead to linear and volumetric acetabular erosion, which may result in intrapelvic migration of the implants. Patient-related factors (age, gender, body mass index (BMI), bone mineral density (BMD) and surgical technique related factors may cause and accelerate acetabular protrusion.

Our aim in this study is to evaluate the effect of consistency between the bipolar prosthetic head diameter and the patient's femoral head diameter on acetabular wear. We also investigated the effects of leg discrepancy, osteoporosis, and gender on acetabular erosion.

Methods

After ethical approval, we retrospectively reviewed a series of 362 patients (362 hips) who underwent primary BHA for the treatment of femur neck fractures between January 2009 and March 2016. Patients aged between seventy and ninety-five years at the time of surgery, BMI < 35, and mobilized without support after surgery were included in the study. The exclusion criteria of the study were the patients who were not in the specified age range, those who were operated for pathological fractures, those who had osteoarthritic changes in the hip joint before surgery, those who had revision surgery for reasons other than acetabular erosion, and those with a follow-up period of less than 3 years. Thirteen patients with missing data and 140 patients who died before we conducted this study were excluded. Thus, a total of 209 patients (140 female, 69 male 209) were enrolled in the study. Preoperative height and weight of the patients were recorded, and BMI values were calculated as $kg/m^{2.}$

Surgical technique

The bipolar hip prosthesis used in this study were Biomet's Echo™ Hip System (UK). All surgeries were done by a single surgeon via a posterior approach with cemented technique. During the operation, after the femoral head of the patients was excised, the diameter of the bipolar prosthetic head was determined by measuring the diameter of the femoral head with a caliper at the head equator. The diameter of the bipolar prosthetic heads ranged between 42 and 58 mm. The implanted bipolar prosthetic heads were of the same diameters as the femoral heads in 127 hips, 1 mm smaller (the next smaller size) in 53 hips, 2 mm smaller in 29 hips. No bipolar prosthetic head larger than the measured femoral head diameter was used for any of the patients. The median duration of surgery was 38 minutes (range: 30-58 minutes).

Rehabilitation

Standard antibiotic prophylaxis (intravenous 1 gr cefazolin) and anticoagulants (subcutaneous enoxaparin sodium 4,000 IU (40 mg) were administered and compression stockings were used to prevent deep vein thrombosis. Weight-bearing was allowed as tolerated on the postoperative first day.

Radiographic evaluation

Radiographic assessment was performed on a standard anteroposterior (AP) view of the pelvis immediately after surgery by a computer program and annually. In these radiographs, three points were marked: the superior outer margin of the acetabulum, the inferior lower margin of the acetabulum, and the acetabular bony margin (Fig. 1) [9]. The distance between the superior outer margin and the inferior inner margin of the acetabulum was measured as the acetabulum diameter. Finally, the acetabular articular cartilage degeneration was calculated from the vertical distance between the acetabular bony margin and the acetabulum diameter [9]. Acetabular protrusion was defined as the crossing of the bipolar prosthetic head over Kohler's line. The kohler's line, also known as the ilioischial line, runs along the lateral border of the obturator foramen to the medial border of the iliac wing. The kohler's line passes through the acetabular teardrop in normal hip joints.

In the first postoperative year of follow-up, t scores measured by BMD were recorded for all patients. Dual-energy X-ray absorptiometry (DEXA) scanning was used to evaluate patients' BMD scores.

Clinical evaluation

Clinical evaluation included the Harris Hip Score (HHS) and complications. Functional assessment was performed via the HHS in the third month, the first year, the third year, and the fifth year after surgery.

The patients were divided into two groups as those with (n=21) and without (n=188) acetabular protrusion, those with (n=36) and without (n=173) revision surgery, those with the same size bipolar prosthetic head (n=127) and those with the small size (1 and 2 mm) bipolar prosthetic head (n=82) use. The indications of revision surgery were acetabular protrusion for 16 patients, acetabular degeneration and worsening of HHS for 20 patients. Five patients with protrusion have rejected revision surgery because of their bad general

medical conditions. Demographic characteristics of these patients, BMI and BMD values, leg length discrepancy (LLD) (measured from anterior superior iliac spine to medial malleolus clinically), and HHS scores at 5-year follow-up, acetabular diameter and acetabular degeneration measured annually for 5 years, the difference in diameter between the femoral head and the bipolar prosthetic head were evaluated.

Statistical analysis

Statistical analysis was performed using the SPSS statistical package (Version 25.0, IBM Corp., Armonk, NY, USA). If continuous variables were normal, they were described as mean ± standard deviation ($p > 0.05$ in Kolmogorov-Smirnov or Shapiro-Wilk tests ($n < 30$)), and if the continuous variables were not normal, they were described as medians. Comparisons between groups were applied using the Student t-test for normally distributed data and the Mann-Whitney U test for the data not normally distributed. Repeated measures data were analyzed with repeated-measures ANOVA. Categorical variables were analyzed between the groups by using the chi-square test or Fisher exact test. Correlations between variables were tested by Pearson's correlation coefficient. Values of $p < 0.05$ were considered statistically significant.

Results

The demographic data of all patients, postoperative LLD, BMD values, the patient's mean femoral head diameter, the head diameter of the bipolar prosthesis used, and the diameter difference between them are shown in Table 1. The mean age of the patients was 77.4 ± 6.0 years and the average LLD was 0.8 ± 1.2 cm. Since the patients were from the elderly population, mean T-score values as measured by BMD indicated that the patients were osteoporotic. Also, a mean difference of -0.6 ± 0.9 mm was detected between the patients' femoral head diameter and the head diameter of the prosthesis used.

Table 2 presents the change over time in the HHS values used in functional evaluation in the postoperative follow-up of the patients and acetabular diameter values measured radiographically. In patients with greater diameter difference between the femoral head and bipolar prosthetic head, the HHS scores decreased faster and the acetabular diameter increased more rapidly in the 5-year follow-up period (Fig. 2,3).

When the mean follow-up period of 5 years is taken into account, a statistically significant decrease in HHS values over time was detected in those who used small size compared to those who used the same size. (Table 3) The diameter of the acetabulum was measured annually radiographically during the first 5-year follow-up period, and a significant increase was seen in the small size used in all measurements except the first postoperative measurement compared to the same size measurements. (Table 3) The mean degeneration of the acetabular cartilage was 0.6 ± 0.03 mm/year in all patients, 2.94 ± 0.21 mm/year in patients with the acetabular protrusion, and 1.45 ± 0.09 mm/year in patients with smaller cups. Patients undergoing acetabular revision surgery were not included when calculating HHS, acetabulum diameter, and acetabular cartilage measurements.

Protrusion group: Comparison of the characteristics of the patients with and without acetabular protrusion during postoperative follow-up is shown in Table 4. The preoperative and postoperative LLD and the difference between femoral head diameter and bipolar prosthetic head diameter were significantly higher in the acetabular protrusion group ($p = 0.001$) (Table 4). Also, the mean T score measured by BMD was lower in the protrusion group than the other ($p = 0.001$). In addition, 20 of the 21 patients with acetabular protrusion were female ($p = 0.003$). (Fig. 4) On the other hand, there was no statistically significant difference between parameters such as age and BMI.

Revision group: In patients who underwent acetabular revision surgery, the difference between the preoperative and postoperative leg length and the difference between femoral head diameter and bipolar prosthetic head diameter was higher, as in patients with the acetabular protrusion, and this was statistically significant ($p = 0.001$) (Table 5). Likewise, it was noticed that the mean T score values measured by BMD were lower in the group undergoing revision surgery ($p = 0.001$). Again, in correlation with patients with the acetabular protrusion, more revision surgery was required in the female population ($p = 0.001$). No significant difference was found in terms of parameters such as age and BMI.

Table 1. Demographic characteristics of the patients, leg length change, BMD values, femoral head diameter of the patients, the diameter of the bipolar prosthetic head and the difference between them

	n	Mean ± SD	Median (Min-Max)
Age (year)	209	77,4 ± 6,0	76 (72-94)
BMI (kg/m^2)	209	26,4 ± 3,2	25,9 (19,3-34,6)
LLD (cm)	209	0,8 ± 1,2	1 ((-2)-3)
BMD (T score)	209	-2,0 ± 1,0	-2,1 ((-3,5)-1)
Patient's femoral head diameter (mm)	209	50,2 ± 3,7	49 (44-60)
Bipolar prosthetic head diameter (mm)	209	49,5 ± 3,8	48 (42-58)
Diameter difference (mm)	209	-0.6±0.9	0 ((0)-2)

n: Number of patients, SD: Standard deviation BMI: Body mass index, LLD: Leg length discrepancy, BMD: Bone mineral density

Table 2. The change of HHS scores and acetabular diameters of the patients by years during the 5-year follow-up period.

HHS		n	Mean ± SD	Median (Min-Max)	p
	3. Month	209	84,6 ± 3,5	84 (72,1-91,5)	0,003*
	1. Year	209	82,6 ± 4,6	82 (65,5-93,5)	0,0001*
	3. Year	205	81,8 ± 6,5	80 (54,9-90,5)	0,0001*
	5. Year	173	80,8 ± 3,8	82 (62-90)	0,030*
Acetabulum diameter (mm)					
	0. Year	209	51,5 ± 4,0	51 (45-62)	0,134
	1. Year	209	52,1 ± 3,8	52 (45-62)	0,013*
	2. Year	209	53,1 ± 3,9	52 (46-64)	0,0001*
	3. Year	205	53,9 ± 3,9	53 (47-65)	0,005*
	4. Year	196	54,9 ± 4,0	54 (48-69)	0,0001*
	5. Year	173	55,5 ± 4,0	55 (49-68)	0,0001*

HHS: Harris hip score, n: Number of patients, SD: Standard deviation, *: Statistically significant

Table 3 The change of acetabular diameters of the patients (same and smaller size) by years during the 5-year follow-up period.

Acetabular Diameters	Same Size(0) (n=127)	Smaller Size (-1,-2) (n=82)	p
0. Year	51,1±3,8	51,9±4,2	0,179
1. Year	51,6±3,6	52,9±4,0	**0,022***
2. Year	52,3±3,6	54,2±4,0	**0,0001***
3. Year	52,9±3,6	55,4±4,0	**0,0001***
4. Year	53,8±3,5	56,6±4,2	**0,0001***
5. Year	54,6±3,4	57,4±4,5	**0,0001***
HHS			
3. Month	85,0±3,5	83,9±3,2	**0,022***
1. Year	84,2±3,5	80,4±5,2	**0,0001***
3. Year	83,2±3,7	77,1±7,9	**0,0001***
5. Year	82,2±3,3	80,6±4,7	**0,010***

HHS: Harris hip score, n: Number of patients, *: Statistically significant

Table 4. Distribution of demographic and clinical characteristics of patients with and without acetabular protrusion.

	Non acetabular protruding (Mean ± SD)	Acetabular protruding (Mean ± SD)	p
n (number of patients)	188	21	
Age (year)	77.2 ± 5.9	79.5 ± 6.8	0,093
BMI (kg/m^2)	26.5 ± 3.1	26.3 ± 3.4	0,803
LLD (cm)	0.1 ± 1.7	2.3 ± 1.9	0,0001*
BMD (T score)	-1.1 ± 1.3	-2.9 ± 0.8	0,0001*
Diameter difference between femoral head and bipolar prosthetic head (mm)	0.1 ± 1.4	2.2 ± 2.1	0,0001*
Gender (n and %)			
Male	68 (36.2%)	1 (4,8%)	0,003*
Female	120 (63,8%)	20 (95,2%)	

SD: Standard deviation, n: Number of patients, BMI: Body mass index, LLD: Leg length discrepancy, BMD: Bone mineral density, *: Statistically significant

Table 5. Distribution of demographic and clinical characteristics of patients who had and did not undergo acetabular revision surgery.

	No revision surgery (Mean ± SD)	Revision surgery (Mean ± SD)	p
n (number of patients)	173	36	
Age (year)	77.4 ± 5.9	77.4 ± 6.3	0,959
BMI (kg/m^2)	26.4 ± 3.2	26.4 ± 2.9	0,976
LLD (cm)	0.3 ± 2.3	2.4 ± 1.4	0,0001*
BMD (T score)	-1.9 ± 1.5	-2.9 ± 0.9	0,0001*
Diameter difference between femoral head and bipolar prosthetic head (mm)	0.2 ± 0.9	1.7 ± 1.2	0,0001*
Gender (n and %)			
Male	66 (38,2%)	3 (8,3%)	0,0001*
Female	107 (61,8%)	33 (91,7%)	

SD: Standard deviation, n: Number of patients, BMI: Body mass index, LLD: Leg length discrepancy, BMD: Bone mineral density, *: Statistically significant

Revision survival analysis graph of patients who underwent hemiarthroplasty is shown in figure 5. Revision was applied to 63.9% (n=23) patients at 5 years, 25% (n=9) at 4 years, and 11.1% (n=4) at 3 years.

An 85-year-old patient had sciatic nerve palsy after surgery; however, it resolved spontaneously at the

postoperative sixth month. Prosthesis dislocation occurred in 8 patients within the first month after surgery due to a simple fall. All patients were treated with closed reduction under anesthesia and mobilization restrictions for 3 weeks. No recurrent dislocation was observed in any of them. There were no deep vein thromboses or heterotopic ossifications during follow-up. Infection developed in five patients during follow-up. While intravenous antibiotics (IV teicoplanin) were sufficient in the treatment of three patients, the treatment of two patients who developed an infection in the acute period were completed with wound debridement, irrigation, and intravenous antibiotics (IV teicoplanin and IV sulperazone).

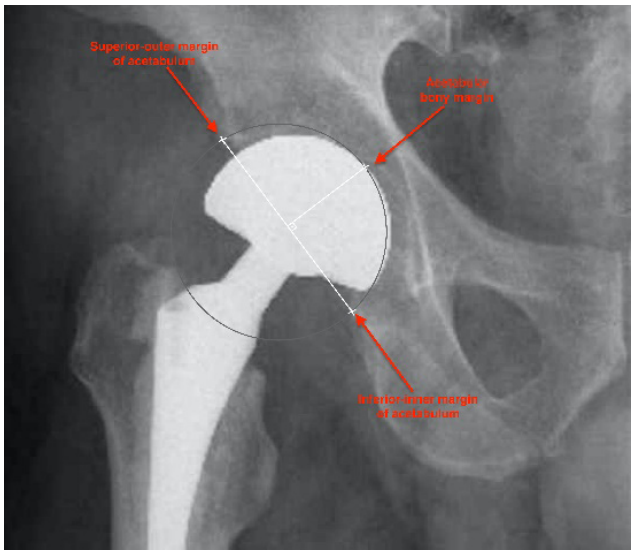

Figure 1. Measurement of acetabular articular cartilage degeneration on an AP pelvis radiograph. First, three points are marked: the superior outer margin of the acetabulum, the inferior inner margin of the acetabulum, and the acetabular bony margin. A circle is drawn through these three margins. The distance between the superior outer margin and the inferior inner margin of the acetabulum is measured as the acetabulum diameter. Finally, the estimated acetabular erosion is calculated by measuring the vertical distance of the acetabular bony margin to the acetabulum diameter

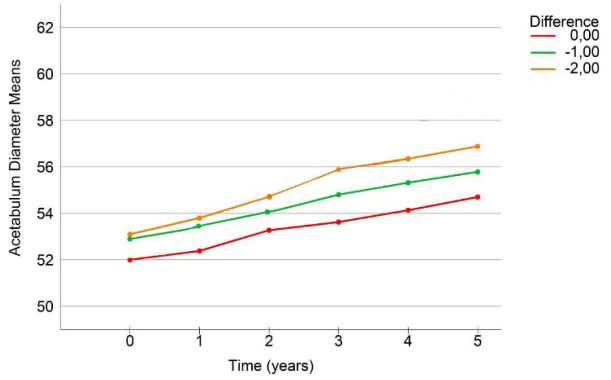

Figure 2. The mean acetabular diameter changes in the 5-year follow-up of the patients are shown in this graphic. As the diameter difference between the native femoral head and bipolar prosthetic head increases, acetabular erosion and enlargement progress faster

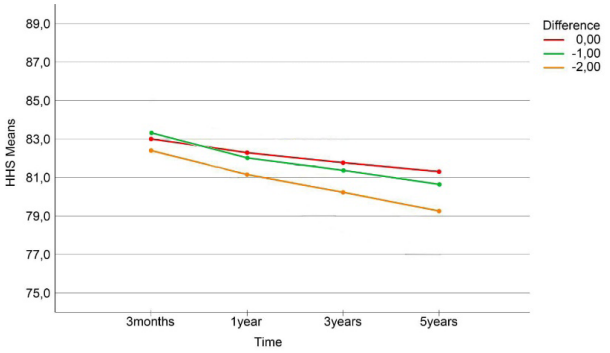

Figure 3. The mean HHS changes in the 5-year follow-up of the patients are shown in this graphic. As the diameter difference between the native femoral head and bipolar prosthetic head increases, the decrease in HHS values is greater

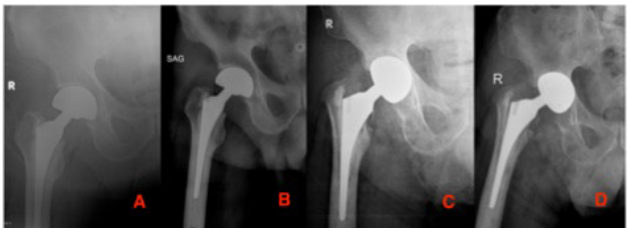

Figure 4. A 70-year-old male patient underwent bipolar hemiarthroplasty for right femoral neck fracture (A). It was seen that acetabular erosion started at the 6 month of follow-up (B). On the 20-month follow-up radiograph, advanced erosion was observed (C), and on the 26-month radiograph, protrusion had occurred (D)

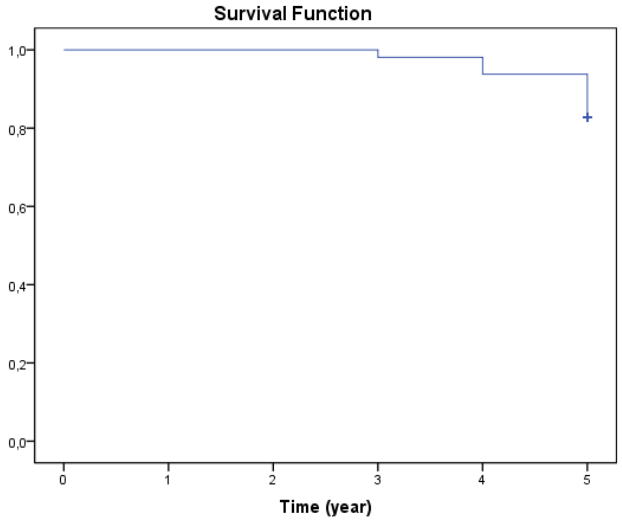

Figure 5. Revision survival analysis graph of patients who underwent bipolar hemiarthroplasty by years

Discussion

Acetabular erosion after BHA has been investigated in various studies because it has a great negative effect on health-related quality of life even in elderly patients [10]. Kurrat et al. [11] reported that the mean thickness of the acetabular cartilage was 1.0-3.3 mm.

In another study, Moon et al. [9] reported that mean linear and volumetric degeneration rates caused by BHA were 0.23 ± 0.107 mm/year and 114 ± 47.2 mm3/year, respectively. Considering that the patient's acetabular cartilage experiences millions of loading cycles during the period of implant use, subsequent acetabular cartilage wear due to the friction between the metal and cartilage increases, which leads to osteolysis and the protrusion of the metallic head, so it is believed that the acetabular cartilage thickness will have been fully lost at approximately 7-10 years after surgery and the risk of protrusion will increase [12,13]. In our study, acetabular diameters of the patients were measured regularly every year and it was found that the acetabulum diameter increased significantly. The presence of acetabular enlargement proves that the bipolar prosthetic head causes wear on the acetabular cartilage.

Many studies have concluded that the progression of acetabular cartilage degeneration is correlated directly with time after BHA surgery, and the acetabular protrusion is a known late complication following BHA. Rubio et al. [14] reported an acetabular erosion rate of 23.6% with uncemented BHA after a mean period of 10 years. Mazen et al. [15] had an erosion rate of 33% with bipolar prostheses during a follow-up period of 3 years. Animal studies about this process also showed abnormal stress delivered to the acetabular surface by the hard bipolar cup that causes the secretion of degenerative enzymes and cartilage erosion [16,17]. In this study, acetabular protrusion developed in 21 (10%) patients during the 5-year follow-up period, and when compared with the literature, we see that the rate of acetabular protrusion development was lower in our patients. Although we have obtained more positive results in this regard compared to the literature, acetabular protrusion remains a possible late complication in elderly patients who undergo BHA surgery due to cartilage degeneration.

One of the main aims of this study was to evaluate the effect of the difference between the patient's femoral head diameter and bipolar prosthetic head diameter on acetabular wear and protrusion. In a study conducted by Schiavi et al. [18], 209 patients who underwent BHA surgery were followed for at least 10 years, acetabular revision rates of bipolar heads smaller than 48 mm 3-fold higher than the revision rates of bigger bipolar heads. The authors stated that a small implant head was a risk factor for acetabular erosion and migration [18]. In this study, we found faster acetabular cartilage degeneration in patients who had smaller bipolar prosthetic cups according to the native femoral head. These findings support the idea that acetabulum degeneration is higher in patients with a prosthetic head smaller than the femoral head excised from the patient and acetabular protrusion occurs subsequently.

In studies investigating the accuracy of head measurement, Harris et al. [19] reported that 1/16-inch undersized femoral heads increased the pressure on the articular cartilage twofold. In two similar studies, Baker et al. [20] emphasized an acetabular erosion rate of 66% with 2-mm increments, while D'Arcy and Devas [21] reported acetabular erosion of 11% with sizing increments of 3.2 mm. None of these authors determined the relation between acetabular protrusion and prosthetic femoral head size. In our study, we found that the difference between the diameter of the patient's femoral head and the diameter of the bipolar prosthetic head used was significantly greater in patients who developed acetabular protrusion and who underwent acetabular revision surgery. Also, the acetabular enlargement increased faster as the diameter difference between the patient's femoral head and bipolar prosthetic head increased over 5 years of follow-up. This is the first study in the literature demonstrating acetabular cartilage loss in a short period due to the incongruency of articulation surfaces following BHA in an elderly population in terms of bipolar prosthetic head size. We think that measuring the femoral head removed from the patient with the correct technique by a caliper and choosing the appropriate bipolar prosthetic head is an important and protective factor in preventing the development of acetabular protrusion and possible revision surgery.

Another aim of our study was to measure the effect of preoperative and postoperative LLD on acetabular protrusion and thus revision surgery. In some cases, surgeons may wish to increase implant stability to prevent dislocation, so they may need to vary the leg length to increase abductor arm tension. Lengthening of the leg increases the tension in the hip joint, causing the bipolar prosthetic head to apply more compression force to the acetabular cartilage and resulting in an increase in acetabular erosion [22]. In our study, while the preoperative and postoperative leg lengths were almost equal in the groups that did not develop acetabular protrusion and did not undergo acetabular revision surgery, a mean increase of 2 cm in postoperative leg length was found in the groups that developed acetabular protrusion and underwent acetabular revision surgery.

The HHS is one of the most preferred scoring systems for evaluating the results after hip surgery and it provides important data in follow-up after BHA surgery [23]. In a report by Moon et al. [9], it was emphasized that higher HHS values are related to slower degeneration rates. In our study, it was seen that HHS values decreased significantly over the years. Furthermore, as the difference in diameter between the patient's femoral head and bipolar prosthetic head increased, we found faster decreases in HHS values over 5 years of follow-up. We think that there was a decrease in HHS values in our patients because the bipolar prosthetic head caused pain and wear in the acetabular cartilage.

Osteoporosis is a disease with loss of trabecular bone and impaired bone quality [24]. The risk of osteoporosis increases with age and postmenopausal estrogen decline in the female population [24]. In

our study, T scores measured by BMD were found to be significantly lower in patients who developed acetabular protrusion and underwent revision surgery compared to the other groups. Besides, it is significant that the female population is at higher risk in terms of acetabular protrusion and revision surgery due to the faster development of osteoporosis at postmenopausal ages. We concluded that the current bone quality of the patients directly affects acetabular protrusion and the results of the surgery.

There are some limitations in our study. First, we performed the measurements on coronal planes; however, the joint motion in bipolar hemiarthroplasty should be considered three-dimensionally. Secondly, the follow-up period was relatively short, and a more extensive follow-up period might influence the results.

Conclusion

In elderly patients undergoing BHA surgery, there is a risk of acetabular erosion in the long term due to the metallic prosthetic head abrading the acetabular cartilage. Patients with bipolar prosthetic heads smaller than the native femoral heads have a higher rate of acetabular cartilage degeneration after BHA. Besides, the LLD and low BMD as in the elderly female population accelerate this protrusion process. While performing BHA surgery, the estimated life expectancy of the patient should be considered in terms of possible complications and revision surgery.

Declarations

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