The Philippine Journal of Orthopaedics

ORIGINAL ARTICLE

Interprosthetic Joint Motion in Bipolar Partial Hip Arthroplasty after One-year Follow-up

Noreen Joyce L. Yeo, MD, DPBO and Liberato Antonio C. Leagogo Jr., MD, FPOA

Department of Orthopaedics, Makati Medical Center, Philippines

ABSTRACT

Background. Partial hip arthroplasty is the treatment of choice for displaced proximal femoral fractures in the elderly. The bipolar prosthesis was developed to lessen the acetabular erosion encountered with the unipolar prosthesis. However, bipolar prostheses lose their motion between the inner or outer articulation (interprosthetic joint motion) after three months, rendering them biomechanically like unipolar prostheses. Meanwhile, other literature has shown that the interprosthetic joint is mobile radiographically up to one year after the surgery.

Objective. This study evaluated and quantified the interprosthetic joint motion (motion between the outer and inner articulations) of bipolar prostheses one year after partial hip arthroplasty for proximal femoral fractures in a tertiary hospital. We also investigated the effect of adding the hip measurement in adduction.

Methodology. This retrospective cohort study measured the motion of the outer and inner articulations of locally available bipolar prostheses and the interprosthetic joint movement using one-year postoperative radiographs of patients who underwent bipolar partial hip arthroplasty for femoral fractures in a tertiary hospital from 2019 to 2021. Immediate and one-year post-operative AP radiographs in neutral, maximum hip abduction, and maximum hip adduction were measured and compared. The interprosthetic joint motion was calculated from the difference in pelvic-head angles and pelvic-shaft angles.

Results. Twelve patients were included in the study. The interprosthetic joint in bipolar prosthesis was still mobile even after one year in 75% of patients (p = 0.0001). Adding hip adduction measurements resulted in a significantly higher mean of 74.69 degrees as compared to only 34.67 degrees (p = 0.0006).

Conclusion. Most patients retained a mobile interprosthetic joint at one year post-op. Hip adduction radiographs gave additional information on the total interprosthetic joint motion. At both time points studied, the inner head articulation contributed more to the interprosthetic joint motion. All five locally available implant systems used showed good motion after one year.

Keywords. partial hip arthroplasty, hemiarthroplasty, femoral neck fracture, hip fracture, interprosthetic joint motion, bipolar prosthesis

INTRODUCTION

Partial hip arthroplasty is the treatment of choice for completely displaced femoral neck fractures and special cases of intertrochanteric fractures in elderly patients. James Bateman developed a bipolar prosthesis in 1974 to solve issues that arose with the unipolar prosthesis.[1] The bipolar prosthesis is a modular system with two articulations and a moveable intermediate shell between the head of the femoral prosthesis and the acetabulum. This allows motion to occur between the articulations, lessening shear stresses between the metal shell on the acetabulum, decreasing erosion, and avoiding protrusion.[2-4] This has been demonstrated radiographically by Bochner et al. and others.[5,6]

ISSN 0118-3362 (Print)
eISSN 2012-3264 (Online)
Printed in the Philippines.

Received: October 3, 2024
Accepted: December 2, 2024
Published Online: January 21, 2025.
https://doi.org/10.69472/poai.2025.08

Corresponding author: Noreen Joyce L. Yeo, MD. DPBO
Department of Orthopaedics, Makati Medical Center,
2 Amorsolo Street, Legazpi Village
Makati, Philippines, 1229
Tel. No: +632-8888-8999
E-mail: noreenyeo@yahoo.com
ORCiD: https://orcid.org/0009-0001-5969-7856

Randomized control studies and observational studies showed conflicting outcomes between the two prostheses.[7-9] The bipolar prosthesis has been reported to either result in fewer dislocations, better hip range of motion, and improved quality of life,[2,10-16] or have no significant effect, in addition to yielding similar pain scores, functional hip scores, acetabular erosion incidence, and reoperation rate.[17] The bipolar prosthesis has been reported to lose motion at either the inner or outer articulation, behaving like a unipolar prosthesis by three months postoperatively.[18-20] This may selectively occur depending on the size of the outer femoral head and the duration of follow-up.[21]

OBJECTIVE

This study aimed to radiographically evaluate the motion of the outer and inner articulations of the locally available bipolar prosthesis and quantify the interprosthetic joint movement using radiographs over a one-year follow-up period in patients who underwent partial hip arthroplasty for proximal femoral fractures in a tertiary hospital. This study included a new measurement: maximum hip adduction.

METHODOLOGY

Research design

This retrospective cohort study monitored the motion of the outer and inner articulations of the locally available bipolar prosthesis and the interprosthetic joint movement using radiographs over a one-year follow-up period in patients who underwent bipolar partial hip arthroplasty for proximal femoral fractures in a tertiary hospital from 2019 to 2021.

Data collection methods

Routine immediate and one-year post-operative hip radiographs were taken in supine anteroposterior (AP) views in neutral, maximum hip abduction, and maximum hip adduction. True neutral AP views were taken with both legs 15 degrees internally rotated. Maximum hip abduction views were taken with the maximum tolerated abduction done by the patient. Maximum hip adduction views, not included in Bochner's original study, were taken with the maximum tolerated adduction done by the patient. All radiographic images used a computerized radiography system and were stored digitally in the Picture Archiving and Communication System (PACS). Consent was secured from the chairman of the Department of Radiology of the involved tertiary hospital and the chairman of the orthopaedic specialty clinic before accessing the images digitally.

Data was encoded using Microsoft Excel on a password-encrypted computer accessed only by the primary investigator. All measurements and encoding was done by the primary investigator.

Outcome

Interprosthetic joint motion in bipolar partial hip arthroplasty was assessed radiologically as originally described by Bochner.[6] Measurements were taken from hip AP radiographic views in neutral, maximum hip abduction, and maximum hip adduction.

The pelvic-head angle was the angle formed between the pelvic line and a line drawn along the center of the long axis of the femoral stem. The pelvic-shaft angle was the angle formed between the pelvic line (drawn tangential to the inferior margin of the ischial tuberosities) and a line drawn tangential to the inferior margin of the outer head. Angle A was the difference in the pelvic-head angle between the hip AP neutral (A1) and maximum hip abduction (A2) radiographs. Angle B was the difference in the pelvic-shaft angle between the hip AP neutral (B1) and maximum hip abduction (B2) radiographs. Angle C was the difference in the pelvic-head angle between the hip AP neutral and maximum hip adduction (B1) radiographs. Angle D was the difference in the pelvic-shaft angle between the hip AP neutral and maximum hip adduction (B3) radiographs (Figures 1, 2 & 3).

Interprosthetic motion in abduction (X) was calculated as the difference between Angle A and B. Interprosthetic motion in adduction (Y) was calculated as the difference between Angles C and D. The total interprosthetic joint motion (W) was the sum of X and Y.[22]

Angles A & C (AC) pertained to the total motion contributed by the outer head articulating with the acetabulum. Angles B & D (BD) pertained to the total motion of the prosthesis relative to the acetabulum (Figures 1, 2 & 3). The % interprosthetic motion (W%) was calculated as W ÷ Angle BD, representing the contribution of the inner head articulating with the outer shell to total prosthetic motion.

Measurement	Calculation	Interpretation
Angle A	A1–A2	outer shell motion in abduction
Angle B	B1–B2	shaft motion in abduction
Angle C	A1–A3	outer shell motion in adduction
Angle D	B1–B3	shaft motion in adduction
X	B–A	interprosthetic motion in abduction
Y	C–D	interprosthetic motion in adduction
W	X + Y	total interprosthetic motion
Angle AC	A + C	total outer shell motion relative to the pelvis
Angle BD	B + D	total shaft and prosthetic motion relative to the pelvis
W%	W ÷ Angle BD	the proportion of interprosthetic motion of total prosthetic motion or % interprosthetic motion

Sample size

The study included 12 patients. At a 95% confidence level and an 80% test power, the minimum detectable difference at one year was set at 30%.

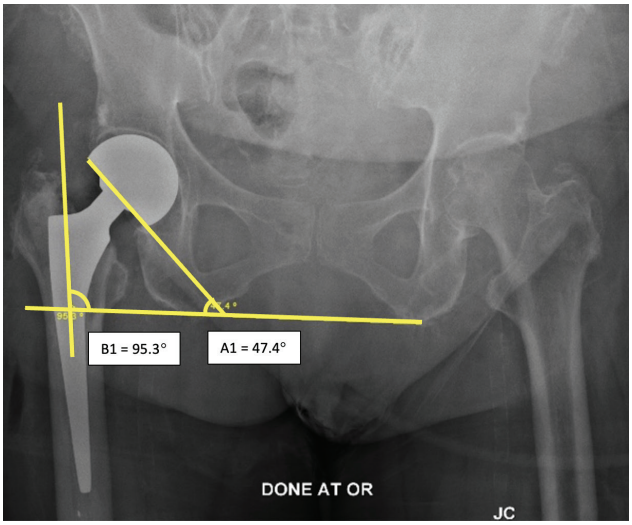

Figure 1. Hip neutral AP xray.

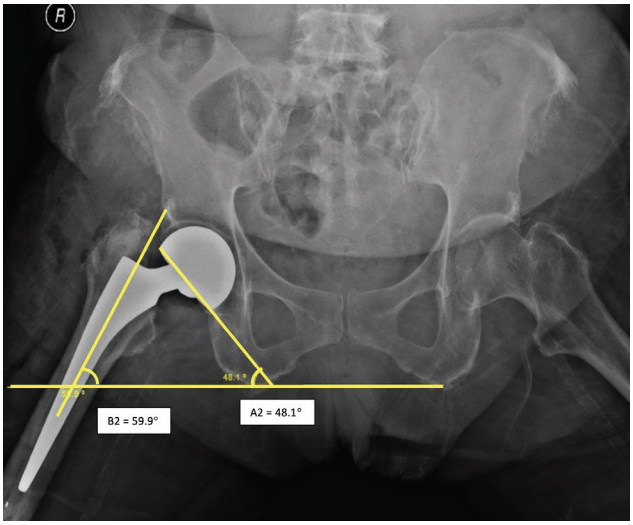

Figure 2. Hip maximum abduction AP xray.

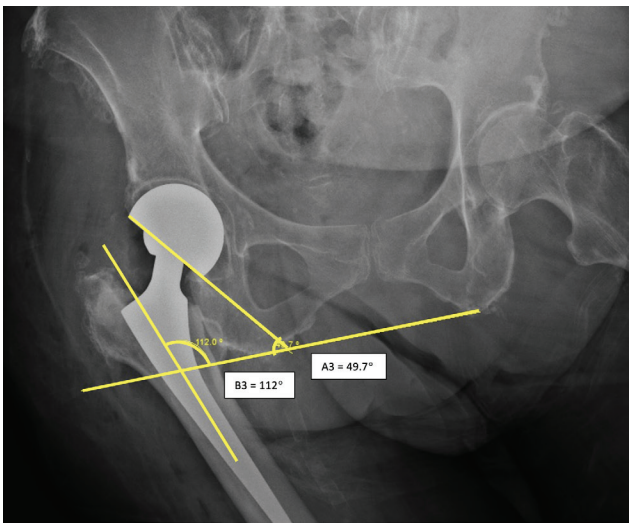

Figure 3. Hip maximum adduction AP xray.

In Figure 1, the Pelvic-head angle (A1) is 47.4°and the Pelvic-shaft angle (B1) is 95.3°. In Figure 2, the Pelvic-head angle (A2) is 48.1° and the Pelvic-shaft angle (B2) is 59.9°. In Figure 3, the Pelvic-head angle (A3) is 49.7° and the Pelvic-shaft angle (B3) is 112°. Angle A = 0.7°, difference between A1 and A2. Angle B = 35.4°, difference between B1 and B2. Angle C = 2.3°, difference between A1 and A3. Angle D = 16.7°, difference between B1 and B3. Angle BD is 52.1°. The interprosthetic joint motion in abduction (X) is 34.7°. The interprosthetic joint motion in adduction (Y) is 14.4°. The total interprosthetic joint motion (W) is 49.1° which is 94% of 62.1°. These radiographs were taken from actual patients of the co-author; this specific patient was not included in the study.

Statistical analysis

Data were encoded in Microsoft Excel, and then edited and analyzed using STATA15. Categorical data were presented in frequencies and percentages, and compared using Paired Student's T-test and Mcnemar's Test. The rate of interprosthetic joint motion was presented using means and standard deviations. A z-test was used to compare the proportion of patients with bipolar motion to those with unipolar motion at one year post-operatively.

Ethical considerations

The study adhered to the ethical considerations and principles set out in relevant guidelines, including the Declaration of Helsinki, WHO guidelines, International Conference on Harmonization-Good Clinical Practice, and National Ethics Guidelines for Health Research.

This study was reviewed and approved by the Makati Medical Center Institutional Review Board (IRB). The IRB also stated that no informed consent from patients were needed since the radiographs were routinely done even before the study was started. However, we asked for consent from the chairmen of the Department of Radiology of the involved tertiary hospital and the orthopaedic specialty clinic for access to the imaging.

RESULTS

From 2019 to 2021, 48 patients underwent bipolar partial hip arthroplasty in the selected tertiary hospital. Thirty-six patients were excluded from the study: nine patients had concomitant injuries, one patient had a peri-implant femoral fracture, two patients expired due to medical reasons, and 24 patients were lost to follow-up (went home to their provinces, refused follow-up during the COVID-19 lockdown, etc.). Only 12 patients met the criteria and were included in our study.

Most were females (91.67%). Ages ranged from 67 to 95 years old, with a mean age of 77.4 ± 7.8 years old. All patients included in the study had femoral neck fractures (Table 2).

There were significant differences (p <0.05) between immediate and one-year post-operative values of pelvic-shaft angle in hip abduction (B2; p = 0.0020), pelvic-head angle in hip adduction (A3; p = 0.0437), A1 and A2 (angle A; p = 0.0189), B1 and B2 (angle B; p = 0.0037), interprosthetic joint motion in abduction (X; p = 0.0029), total interprosthetic joint motion (W; p = 0.0066), and percentage of total interprosthetic joint motion (Z%; p = 0.0055).

A functioning bipolar joint must demonstrate % interprosthetic joint motion (W%) of 25% or more, demonstrating a mobile inner shell relative to the outer shell. Nine (75%) of our patients demonstrated this at one-year post-op, significantly more than the number of patients with W% <25% (z = 259.79, p = 0.0001). No significant difference was seen when comparing the two time points (immediate vs. one-year post-op, p = 0.3173) (Table 4). When comparing our new measurement (measuring both abduction and adduction) with the original measurement (abduction only), we found a significant increase in the mobility recorded (p = 0.0006) (Table 5).

One year post-operatively, seven out of 12 patients (58.3%) demonstrated more total prosthetic motion than interprosthetic motion (Table 6). Five different implant systems were documented. While all systems had cases retaining bipolar interprosthetic motion at one year post-op, the three cases with unipolar motion were attributed to AK Medical (n = 2, 17%) and U2 Hip (n = 1, 8%).

Most (75%) patients still had mobile bipolar interprosthetic joints even after one year. Half (50%) also retained interprosthetic movement on abduction and 58.3% retained movement on adduction. Small amounts of motion, less than 5 degrees, would have been missed in seven patients if adduction had not been documented. These results show that hip adduction radiographs can give additional information on the total interprosthetic joint motion in bipolar prostheses.

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
• 60 years old and above • Male and female • Femoral neck and intertrochanteric fractures • All patients of the department who had bipolar partial hip arthroplasty from 2019–2021 (multi-surgeon) • With records of radiographic images at a tertiary hospital Picture Archiving and Communication System (PACS) and/or Philippine Orthopaedic Institute (POI) Radiology Department • Previous community ambulator	• Younger than 60 years old • Episode of hip dislocation postoperatively • Mental disability • Osteoarthritis • Other hip injuries besides femoral neck and intertrochanteric fractures • Lost to follow-up

Table 2. Patient characteristics

Variables	n	Mean ± SD; Frequency %
Total number of patients	12	
Male	1	8.33%
Female	11	91.67%
Type of fracture		
Femoral neck	12	100%
Intertrochanteric	0	0
Age		77.4 ± 7.8 years (Range 67–95)

DISCUSSION

Bochner initially determined interprosthetic joint motion from neutral pelvic AP and maximum hip abduction radiographs.[6] But on this study, we included hip adduction. There was a significant difference in the number of patients (75%) whose bipolar interprosthetic joints were still mobile (W% ≥25%) compared with those whose joints were static (W% <25%) even after one year (p = 0.0001). This contrasts with the varying outcomes in the literature. Verberne found that mobility was already lost at three months (interprosthetic joint motion was 16.9%).[18] Rai reported that interprosthetic joint motion was 33.74% at three months, 25.66% at 1.5 years, and was steady at 20% for six years.[5]

Table 3. Comparison of immediate and one-year post-operative radiographic parameters

		Immediate, degrees (mean ± SD)	One year, degrees (mean ± SD)	*P*-value
AP neutral xray	**A1** *(Pelvic-head angle)*	37.5 ± 9.9	30.4 ± 20.3	0.1745
	B1 *(Pelvic-shaft angle)*	92.0 ± 2.3	92.2 ± 3.3	0.8391
Maximum abduction xrays	**A2** *(Pelvic-head angle)*	44.2 ± 10.9	46.3 ± 26.8	0.7586
	B2 *(Pelvic-shaft angle)*	66.6 ± 9.8	75.2 ± 9.5	**0.0020**
Maximum adduction xrays	**A3** *(Pelvic-head angle)*	33.8 ± 10.9	22.8 ± 19.8	**0.0437**
	B3 *(Pelvic-shaft angle)*	99.3 ± 6.6	100.2 ± 4.6	0.5599
	Angle A *(A1–A2)*	6.7 ± 7.6	15.9 ± 10.6	**0.0189**
	Angle B *(B1–B2)*	25.3 ± 10.6	17.0 ± 8.3	**0.0037**
	Angle C *(A1–A3)*	5.2 ± 3.6	7.6 ± 4.2	0.1573
	Angle D *(B1–B3)*	7.6 ± 5.3	8.1 ± 2.8	0.7401
	X *(neutral-abduction)*	18.8 ± 9.7	6.5 ± 6.0	**0.0029**
	Y *(neutral-adduction)*	4.8 ± 4.9	3.9 ± 2.9	0.6320
	W *(shaft movement)*	23.6 ± 12.4	10.4 ± 6.0	**0.0066**
	W% *(interprosthetic joint motion)*	67.1 ± 24.2	36.1 ± 19.3	**0.0055**

* Bold p-values showed a significant difference between the immediate and one-year follow-up.

Table 4. Proportion of interprosthetic joint motion immediately and one year post-operatively

	The proportion of interprosthetic joint motion of total prosthetic motion one year post-operative			Comparing immediate vs one-year postoperative		
	Values	Z value	*p*-value	Immediate Post Op	1 Year Post Op	*p*-value
<25%	3 (25%)	259.79	**0.0001**	1 (8.3%)	3 (25%)	0.3173
≥25%	9 (75%)			11 (91.7%)	9 (75%)	

* Bold p-values showed significant difference between patients with <25% and those with >25%

We recorded more patients with % interprosthetic motion ≥25% when hip adduction measurements were included (58.3%) as compared to when excluded (50%, $p = 0.0006$) (Table 5). This is the first study to include hip adduction. We did this to measure a bigger plane of motion, to determine if including adduction makes a significant difference, and to mitigate errors in radiologic measurement. According to Brady, there is a 3 to 5% rate of error and discrepancies in radiologic measurements, consisting of both human and system errors.[23] This error rate may mask small values, leading to erroneous measurements in interprosthetic joint motion.

We also compared the changes in interprosthetic motion over time. The inner head articulation was found to contribute more to overall motion in 91.67% of patients immediately post-op, and 58.3% one year post-op.

This is also the first study to report on the interprosthetic joint motion of locally available bipolar implants. Implant systems were chosen based on surgeon preference. According to our data, all five systems had cases with good interprosthetic joint motion at one year post-op. The three cases with W% <25% were attributed to two systems. One possible reason is that hip abduction and adduction radiographs were only performed as tolerated by the patient.

The proposed advantage of bipolar over unipolar prostheses is reduced acetabular erosion, attributed to less motion between the metal shell and the acetabulum.[2-4,10,12] This is effective as long as motion is maintained in both articulations during the patient's lifetime.

Table 5. Value of adding Y (hip adduction measurements)

	Mean	SD	Difference	*p*-value
X only	34.67	33.84	40.03	**0.0006**
X+Y	74.69	37.06		

* Bold p-value shows a significant difference between measurements using hip abduction measurements only compared to using hip abduction and adduction measurements

Scope and limitations

Our sample size was small due to the paucity of patients who met the inclusion criteria. This was due to the unavailability of radiographs and poor follow-up during the two years of lockdown related to the COVID-19 pandemic. The length of follow-up was limited to one year. Long-term outcomes would be beneficial in assessing the longevity of bipolar interprosthetic motion.

This study only measured the interprosthetic joint motion of bipolar hip prostheses. We also recommend assessing other outcomes and consequences of the amount of joint motion. Measurements were done on 2D plain radiographs which may be affected by positioning and radiologist technique. Radiographs were static and non-weight bearing, which could also have affected motion and measurements. Only one investigator performed the measurements and no intraclass correlation was done.

Table 6. Comparison of inner and outer head articulation immediate post-operative and at least 1 year post-operative

Patient Initials	System	Immediate post-op		One year post-op			
		Angle AC	Angle BD	X%	Y%	Angle AC	Angle BD
AC	AK Medical	38	52.3	24	**60**†	**43.7**††	43.6
AS	**AK Medical***	6.8	34.5	2.1	8.4	**21**††	20.7
SO	AK Medical	3	52.1	**48**†	8	**50**††	31.1
LA	Chunli	6.5	27.4	**72**†	**40**†	**21.5**††	13.5
ES	AK Medical	6.6	36.1	11.3	55	24.4	**28.3**††
MB	U2 Hip	6.9	21	**27**†	**78**†	**20**††	17
RD	**AK Medical***	14.7	37.7	5.5	9.2	34.7	**37.1**††
HC	LCU	16.2	23.8	**83**†	0	9	**19**††
FA	AK Medical	9.8	31.1	**37.5**†	**83**†	11	**22**††
EM	Just Medical	19	19	7	**54.5**†	19	**24**††
LL	**U2 Hip***	5.5	42.3	0	**62.5**†	16	**21**††
MF	Chunli	3.4	18.5	**98.6**†	21.7	12.2	**23.7**††

* Highlighted in bold are the implant systems with a % interprosthetic joint motion of <25% at one-year post-op.
† Bold values represent interprosthetic joint motion in abduction (X%) and adduction (Y%) ≥25%.
†† Bold values represent whether total outer shell motion (Angle AC) or total prosthetic motion (Angle BD) was higher for each case.

CONCLUSION

Most patients retained a mobile interprosthetic joint at one year post-op. Hip adduction radiographs gave additional information on the total interprosthetic joint motion. At both time points studied, the inner head articulation contributed more to the interprosthetic joint motion.

This is also the first study to report on locally available bipolar implants. All five implant systems had cases that showed good motion after one year, despite three cases of <25% interprosthetic joint motion being attributed to two of these systems.

ACKNOWLEDGMENTS

This study has been successful and we want to thank the consultants in the orthopaedics department of Makati Medical Center for allowing their patients to be included in the study. Special mention is given to Dr. Czar Gaston, our previous department research head, for his continued guidance. We also want to thank Dr. Charles Cabus and Reginald Arimado for helping us finalize and interpret our data.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

FUNDING SOURCE

None.

REFERENCES

1. Bateman JE. Single-assembly total hip prosthesis—preliminary report. Orthop Digest. 1974;2:15–22.
2. Hedbeck CJ, Blomfeldt R, Lapidus G, Törnkvist H, Ponzer S, Tidermark J. Unipolar hemiarthroplasty versus bipolar hemiarthroplasty in the most elderly patients with displaced femoral neck fractures: a randomized, controlled trial. Int Orthop. 2011:35(11):1703-11. PMID: 21301830 PMCID: PMC3193971 DOI: 10.1007/s00264-011-1213-y
3. Ng ZD, Krishna L. Cemented versus cementless hemiarthroplasty for femoral neck fractures in the elderly. J Orthop Surg (Hong Kong) 2014;22(2):186–9. PMID: 25163952 DOI: 10.1177/230949901402200214
4. Iamthanaporn K, Chareancholvanich K, Pornrattanamaneewong C. Reasons for revision of failed hemiarthroplasty: Are there any differences between unipolar and bipolar? Eur J Orthop Surg Traumatol. 2018;28(6):1117-23. PMID: 29549451 DOI: 10.1007/s00590-018-2176-0
5. Rai AK, Singh S, Kumaraswamy V, Khare G, Yadav V, Agarwal R. Bicentric bipolar hip prosthesis: A radiological study of movement at the interprosthetic joint. Indian J Orthop. 2011;45(6):508-13. PMID: 22144743 PMCID: PMC3227354 DOI: 10.4103/0019-5413.87120
6. Bochner RM, Pellicci PM, Lyden JP. Bipolar hemiarthroplasty for fracture of the femoral neck. Clinical review with special emphasis on prosthetic motion. J Bone Joint Surg Am. 1988;70(7):1001-10. PMID: 3403568.
7. Long JW, Knight W. Bateman UPF prosthesis in fractures of the femoral neck. Clin Orthop Relat Res. 1980;(152):198-201. PMID: 7438604.
8. Cornell CN, Levine D, O'Doherty J, Lyden J. Unipolar versus bipolar hemiarthroplasty for the treatment of femoral neck fractures in the elderly. Clin Orthop Relat Res. 1998;(348):67-71. PMID: 9553535.
9. Ong BC, Maurer SG, Aharonoff GB, Zuckerman JD, Koval KJ. Unipolar versus bipolar hemiarthroplasty: functional outcome after femoral neck fracture at a minimum of thirty-six months of follow-up. J Orthop Trauma. 2002;16(5):317-22. PMID: 11972074 DOI: 10.1097/00005131-200205000-00005
10. Rogmark C, Leonardsson O. Hip arthroplasty for the treatment of displaced fractures of the femoral neck in elderly patients. Bone Joint J. 2016;98-B(3):291-7. PMID: 26920951 DOI: 10.1302/0301-620X.98B3.36515
11. Gebhard JS, Amstutz HC, Zinar DM, Dorey FJ. A comparison of total hip arthroplasty and hemiarthroplasty for treatment of acute fracture of the femoral neck. Clin Orthop Relat Res. 1992;(282):123-31. PMID: 1516303.
12. Wang F, Zhang H, Zhang Z, Ma C, Feng X. Comparison of bipolar hemiarthroplasty and total hip arthroplasty for displaced femoral neck fractures in the healthy elderly: a meta-analysis. BMC Musculoskelet Disord. 2015;16:229. PMID: 26316274 PMCID: PMC4552391 DOI: 10.1186/s12891-015-0696-x
13. Lestrange NR. Bipolar arthroplasty for 496 hip fractures. Clin Orthop Relat Res. 1990;(251):7-19. PMID: 2403876.
14. LaBelle LW, Colwill JC, Swanson AB. Bateman bipolar hip arthroplasty for femoral neck fractures. A five- to ten-year follow-up study. Clin Orthop Relat Res. 1990;(251):20-5. PMID: 2295175.
15. Wetherell RG, Hinves BL. The Hastings bipolar hemiarthroplasty for subcapital fractures of the femoral neck. A 10-year prospective study. J Bone Joint Surg Br. 1990;72(5):788-93. PMID: 2211757 DOI: 10.1302/0301-620X.72B5.2211757
16. Kanto K, Sihvonen R, Eskelinen A, Laitinen M. Uni- and bipolar hemiarthroplasty with a modern cemented femoral component provides elderly patients with displaced femoral neck fractures with equal functional outcome and survivorship at medium-term follow-up. Arch Orthop Trauma Surg. 2014;134(9):1251-9. PMID: 25055754 DOI: 10.1007/s00402-014-2053-1
17. Parker MJ, Gurusamy KS, Azegami S. Arthroplasties (with and without bone cement) for proximal femoral fractures in adults. Cochrane Database Syst Rev. 2010;(6):CD001706. PMID: 20556753 DOI: 10.1002/14651858.CD001706.pub4
18. Verberne GH. A femoral head prosthesis with a built-in joint. A radiological study of the movements of the two components. J Bone Joint Surg Br. 1983;65(5):544-7. PMID: 6643555 DOI: 10.1302/0301-620X.65B5.6643555
19. Eiskjaer S, Boll K, Gelineck J. Component motion in bipolar cemented hemiarthroplasty. J Orthop Trauma. 1989;3(4):313-6. PMID: 2600699 DOI: 10.1097/00005131-198912000-00010
20. Phillips TW. The Bateman bipolar femoral head replacement. A fluoroscopic study of movement over a four-year period. J Bone Joint Surg Br. 1987;69(5):761-4. PMID: 3680337 DOI: 10.1302/0301-620X.69B5.3680337
21. Brueton RN, Craig JS, Hinves BL, Heatley FW. Effect of femoral component head size on movement of the two-component hemi-arthroplasty. Injury. 1993;24(4):231-5. PMID: 8325679 DOI: 10.1016/0020-1383(93)90175-6
22. Hodgkinson JP, Meadows TH, Davies DR, Hargadon EJ. A radiological assessment of interprosthetic movement in the Charnley-Hastings hemiarthroplasty. Injury. 1988;19(1):18-20. PMID: 3169971 DOI: 10.1016/0020-1383(88)90167-2
23. Brady AP. Error and discrepancy in radiology: inevitable or avoidable? Insights Imaging. 2017;8(1):171-82. PMID: 27928712 PMCID: PMC5265198 DOI: 10.1007/s13244-016-0534-1