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Osteointegration analysis with serial radiography as a predictor of successful cementless bipolar hemiarthroplasty at surabaya orthopaedic and traumatology hospital

Imilda Rizqi
Radiology Department, Medical Faculty, Universitas Airlangga, Surabaya, Indonesia

Rosy Setiawati
Radiology Department, Medical Faculty, Universitas Airlangga, Surabaya, Indonesia
Corresponding authors email: rosy-s@fk.unair.ac.id

Komang Agung Irianto S.
Orthopedic Surgeon of Orthopedy Department, Medical Faculty, Universitas Airlangga, Surabaya, Indonesia

***Abstract*---**Osteointegration is a direct structural relationship between the bone and the implant surface, a properly osseointegration implant can function without mobility. We aim to evaluate this process using serial radiological examinations, where characteristics such as bone sclerosis and cortical-periosteal thickening will be investigated. A retrospective analytic-observational study was conducted on 96 patients after cementless bipolar hemiarthroplasty operation from January 2012 to January 2021, examined for standing pelvic or hip anterior-posterior radiographs after six weeks, six months, and a year post-procedure at Surabaya Orthopaedic and Traumatology Hospital. Two musculoskeletal radiology consultants blindly evaluated for bone sclerosis, femoral stem positioning or stem angulation, cortical-periosteal thickening, and leg length discrepancy. The study was conducted on 24 male subjects (25%) and 72 female subjects (75%). Bone sclerosis significantly appeared in the six-month evaluation. There was no difference in femoral stem positioning. Cortical-periosteal thickening was found on the medial side according to the valgus position of the stem and began to appear in the 6-month evaluation and became more prominent after one year. No significant leg length discrepancy was found. Optimal osteointegration is the critical factor

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in predicting the result of cementless bipolar hemiarthroplasty, in which serial radiography supports the analysis of this process in a non-invasive manner.

***Keywords*---**bipolar hemiarthroplasty cementless, osteointegration, bone pedestal, stem subsidence, pelvic or hip radiography.

Introduction

A femoral neck fracture is a global health problem which mainly occurs among the elderly, with an annual incidence of 0.2 to 3.8 to 1000 individuals worldwide (Cheng et al., 2011). This number is constantly growing as the population ageing, exaggerated by deteriorating reflex and vision (Johansson et al., 2011), and most importantly, a high prevalence of osteoporosis in older people (Mak et al., 2010). The fracture of the femoral neck entails severe haemorrhage, excruciating pain, risk of thromboembolism, avascular necrosis, and nonunion (Sauvé et al., 2007), with one-year-death after the occurrence of 8% in women and 18% in men.

Hip hemiarthroplasty is a popular modality in treating femoral neck fractures nowadays. Compared to total hip arthroplasty, hemiarthroplasty is faster and easier with minor bleeding, yielding early mobilisation and weight-bearing ability (Smektala et al., 2008). In this approach, the acetabulum is preserved while replacing the head and neck of the femur, indicated in cases in which the acetabulum is unaffected. Unipolar hemiarthroplasty comprises the femoral shaft with a fixed head articulating with the natural acetabulum, as opposed to the bipolar hemiarthroplasty in which the femoral shaft with polyethene-coated metal head and cup supports the motion between the artificial cup and head and the original cup and acetabulum (Vanrusselt et al., 2015).

The role of radiology imaging in evaluating the post-procedure of hip hemiarthroplasty is mandatory (Mulcahy & Chew, 2012b). The prosthetic component must be appropriately placed consistent with the expected anatomical site. It is recommended that the pelvic radiograph in an erect position is conducted after the patient is able to stand. Serial radiograph offers timely prosthetic assessment; consequently, detection of minor changes will be feasible (Mushtaq et al., 2019).

Osteointegration refers to the structural binding between the bone and the implant surface; hence, a proper osteointegration of an implant will provide stable and functional anatomy, which a series of radiographs may analyses, such as bone sclerosis/spot welding and cortical-periosteal thickening (Vanrusselt et al., 2015). Usually osteointegration is achieved in early 4-12 weeks on patient with walking exercise with early partial weight bearing (A et al., 2021). Based on the references, we seek to investigate the effectiveness of serial radiograph examination for detecting osteointegration after hip hemiarthroplasty surgery in a statistical manner, utility historical data, to impart the possible changes that may take place.

Material and Methods

This project was a retrospective study using an analytic-observational design from January 2012 to January 2021, involving patients who underwent cementless bipolar hemiarthroplasty and had been evaluated for pelvic and hip radiography six weeks, six months, and a year post-procedure at Orthopedic and Traumatology Hospital in Surabaya. All samples met the inclusion and exclusion criteria. The radiographs were blindly assessed for bone sclerosis, femoral shaft position/stem angulation, cortical-periosteal thickening, and leg length discrepancies by two musculoskeletal radiologists. Data analysis was done using MS Excel and SPSS software version 25.0 and illustrated in tables.

Results and Discussion

We gathered 96 samples using a consecutive sampling fashion.

Table 1
Agreement test result (Kappa coefficient) of two observers

Observed variables	n	Period	p-Kappa	r-Kappa
Bone Sclerosis	87	6 weeks	0,003	0,787
	59	6 months	0,011	0,82
	37	12 months	0,001	0,745
Stem angulation	87	6 weeks	0,000	0,781
	59	6 months	0,000	0,932
	37	12 months	0,000	1
Cortical-periosteal thickening	87	6 weeks	0,000	0,77
	59	6 months	0,000	0,892
	37	12 months	0,000	0,735
Leg Length Discrepancy	24	6 weeks	0,000	0,909
	18	6 months	0,000	1
	8	12 months	0,005	1

For consistent and valid results, the researcher recruited comparing observers, each dependently reviewed the follow-up radiograph and clinical progression at three timestamps, six weeks, six months, and twelve months. The interobserver reliability test among two reviewers was done using kappa agreement analysis in every observed variable.

The calculated mean p-kappa value was 0.001 (<0.05), meaning there was an agreement between the observers. We determined the r-kappa to discover the strength of reliability, which yielded a mean of 0.841, signifying an excellent agreement between the reviewers. Furthermore, we compared the significance of progression in each parameter of observation periods (six weeks, six months, and twelve months). Kolmogorov-Smirnov test was used to assess the normality of data distribution for qualitative parameters, for instance, cortical-periosteal thickening and leg length discrepancy, which resulted in a p-value of <0.05 in most parameters, denoting the data were not normally distributed. Only the leg length discrepancy in the sixth and twelfth months provided normally distributed data, with p-values of 0.135 and 0.153, respectively. We did not do the normality test on categorical data, such as bone sclerosis and cortical-periosteal thickening; instead, the binominal distribution justification method was applied. All normality test results of three parameters are shown in the table below.

Table 2
Normality test results of three parameters

Tested parameters	p-value		
	6 week	6 month	12 month
Cortical-periosteal thickening	0,025	0,006	0,038
Leg Length Discrepancy	0,048	0,134	0,153

After the normality test produced the pattern of our data distribution, we decided on the statistical analysis method to investigate the significance of clinical changes and improvement following the surgery, which results are given in Table 3, together with their p-values.

Table 3
The significance test result of each parameter and timestamp

Parameter	6 week vs 6 month	6 week vs 12 month	6 month vs 12 month
Bone sclerosis	0,000	0,000	0,000
Stem angulation	0,125	1,000	1,000
Cortical-periosteal thickening	0,170	0,001	0,002
Leg Length Discrepancy	0,925 -	- 0,116	- 0,142

For the quantitative data, including cortical-periosteal thickening and leg length discrepancy, the analysis was done using Wilcoxon Signed Ranks Test and T-test for the skewed and normally distributed data, respectively. The significance of development was found in comparing the cortical thickening of six weeks versus twelve months and six months versus twelve months, which yielded all p-values of <0.05. Aside from the mentioned variables, we did not find any significant difference in the compared data.

Our samples in this project involved the patients with femoral neck fractures undergoing cementless bipolar hemiarthroplasty in Orthopedic and Traumatology Hospital in Surabaya from January 2012 until January 2021. We applied the inclusion and exclusion criteria and gathered 96 samples, comprising 72 female (75%) and 24 male (25%). The predominating age group of the samples was between 71 and 80 years old, with a mean age of 71.6 years old. Dunn et al. conducted a project on hip hemiarthroplasty entailing 62 females and 59 males with a mean age of 62.5. Moreover, a study by Longo et al. included 50 samples of 27 males and 23 females, averaging 73.2 years old (Dunn et al., 2020),(Longo et al., 2021).

Our post-cementless bipolar hemiarthroplasty patient showed 14.9% distal bone sclerosis characteristics at the sixth-week follow-up, 71.2% distal bone sclerosis at the sixth month, and 62.2% bone sclerosis at the twelfth month. The mineralisation process of osteoblasts usually takes three to six months, secreting matrix vesicles that generate favourable surroundings for the mineralisation by increasing the calcium and phosphor ion concentrations. During the process, several osteoblasts are trapped and converted to osteocytes, or in other words, new bone formation (Mulcahy & Chew, 2012a). The well-fixed ingrowth component bone extend to femoral stem, depicted as bone sclerosis in the plain radiograph (Miller, 2012). There is usually some cortical or endosteal sclerosis of the distal femoral stem due to normal transfer of load stressing along the femoral stem (Agathangelidis et al., n.d.). Inward bony growths can also be seen, most commonly along the medial and lateral femoral shaft as depicted by a thin linear lucencies, less than 2 mm wide (Kaplan et al., 1988).

Our samples demonstrated the stem angulation characters of 90.7% in the valgus position and 9.3% in the varus position in the sixth-week evaluation, 86.7% and 13.3% in the valgus and varus position, respectively in the sixth month, and finally, in the twelfth-month follow-up, 86.8% in the valgus position and 13.2% in the varus position. One per cent showed the conversion from the valgus to varus formation. Stem angulation > 3 degrees was significant with both Full Weight Bearing (FWB) and Partial Weight Bearing (PWB) therapy and no significant change in position was found in subsequent evaluations (Leiss et al., 2021). In this study sample, all patients underwent medical rehabilitation therapy with PWB, none were treated with FWB, but none of the samples showed stem angulation > 3 degrees, with a mean of 0.49 degrees valgus. In the AP projection, the femoral shaft should appear in line with the longitudinal axis and the tip should be centered. Many studies have shown that failure of the hip arthroplasty, is associated with malposition of the varus that with the tip against the lateral cortex (Mulcahy & Chew, 2012a), (Mushtaq et al., 2019). Aseptic loosening can affect the migration of the femoral stem causing the tip of the stem to be laterally (Raut et al., 1995).

The mean of the periosteal thickening value at the sixth week was 0.50 mm (SD ± 0,067), 0.49 mm (SD ± 0,062) at the sixth month, and 0.48 mm (SD ± 0,058) at the twelfth month. Periosteal thickening tends to occur at the medial side according to its valgus stem angulation and lateral with varus angulation. Cortical thickening and periosteal reaction emerge as a result of tension changes at the femoral shaft at the distal site, representing the success of the shaft fixation and osteointegration process, which will usually be visible in the second-month post-procedure (Mulcahy & Chew, 2012a). This study was in accordance with this concept due to the development of the periosteal thickening at the distal of the prosthetic shaft, which was visible in the twelfth month, with an incidence of 6.2%. Younger patients with a higher canal flare index have a greater incidence of cortical-periosteal thickening. Nevertheless, periosteal thickening does not influence clinical results or femoral shaft stability (Agathangelidis et al., n.d.). In other research say that periosteal thickening indicating abnormal transfer of load stresses and lucency, that evaluation with multiplanar reconstructions shows radiolucent thickness more than 2 mm (Blum et al., 2016), but this study none of the sample showed periosteal thickening with radiolucent around stem femoris.

The leg length discrepancy's mean value was 4.45 mm (SD ± 4,89) in the sixth week, 4.69 mm (SD ± 6,37) in the sixth month, and 7.70 mm (SD ± 9,05) in the twelfth month. There was a 4.1% difference in leg length discrepancy in this study. This discrepancy typically happens after the hip hemiarthroplasty procedure, with a tolerable variance up to 10 mm (Morsi et al., 2016). Moderate leg length discrepancy usually may be corrected using orthosis boots (Vanrusselt et al., 2015). Nonetheless, we discovered more than 10 mm leg length discrepancy without any history of orthosis boot therapy in the medical records. Some research known that leg length discrepancy is assessed if there is a difference of 5 mm thought non clinical effect (Di Schino et al., 2009). Apparent leg length discrepancy must be measured, any pelvic obliquity and any scoliosis must be identified (Pietrzak et al., 2018). On clinical evaluation before pelvis radiograph, important to evaluate the level of pain, because it is possible can affect the tilt of the pelvis (Pietrzak et al., 2018). This is retrospective study, so we assume that the samples is in good condition for pelvic radiograph.

Conclusion

Serial plain radiographs in the sixth-week, sixth-month, and twelfth-month follow-ups were able to depict the progression of osteointegration in the patients after the bipolar hemiarthroplasty procedure, which is the key parameter in predicting the satisfying results of the surgery. The main component of osteointegration consists of bone sclerosis, femoral stem angulation, cortical-periosteal thickening, and leg length discrepancy. We recommend that future research in this field use a prospective approach with larger samples.

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Declaration of Interest
The authors declare no conflict of interest that might influence the outcome of this project.

References

A, G., KA, I., & R, S. (2021). Femoral Stem Subsidence and its Associated Factors after Cementless Bipolar Hemiarthroplasty in Geriatric Patients. *Malaysian Orthopaedic Journal*, *15*(1), 63–71. https://doi.org/10.5704/MOJ.2103.010

Agathangelidis, F., Boutsiadis, A., & Petsatodis, G. (n.d.). Pedestal sign in cementless total hip replacement. *Hippokratia*, *18*(4), 378. http://www.ncbi.nlm.nih.gov/pubmed/26052214

Blum, A., Meyer, J. B., Raymond, A., Louis, M., Bakour, O., Kechidi, R., Chanson, A., & Gondim-Teixeira, P. (2016). CT of hip prosthesis: New techniques and new paradigms. *Diagnostic and Interventional Imaging*, *97*(7–8), 725–733. https://doi.org/10.1016/j.diii.2016.07.002

Cheng, S. Y., Levy, A. R., Lefaivre, K. A., Guy, P., Kuramoto, L., & Sobolev, B. (2011). Geographic trends in incidence of hip fractures: A comprehensive literature review. *Osteoporosis International*, *22*(10), 2575–2586.

https://doi.org/10.1007/s00198-011-1596-z
Di Schino, M., Baudart, F., Zilber, S., Poignard, A., & Allain, J. (2009). Anterior dislocation of a total hip replacement. Radiographic and CT-scan assessment. Behavior following conservative management. *Orthopaedics & Traumatology, Surgery & Research: OTSR*, *95*(8), 573–578. https://doi.org/10.1016/j.otsr.2009.08.003
Dunn, H., Rohlfing, G., & Kollmorgen, R. (2020). A comparison of leg length discrepancy between direct anterior and anterolateral approaches in total hip arthroplasty. *Arthroplasty*, *2*(1), 2–7. https://doi.org/10.1186/s42836-020-00051-7
Gemini, S., Lolo, L. L., Sumiati, S., Ezdha, A. U. A., & Susanti, N. Y. (2022). Correlation of fiber intakes with incidence of constipation in the elderly. International Journal of Social Sciences and Humanities, 6(1), 58–65. https://doi.org/10.53730/ijssh.v6n1.3528
Johansson, H., Clark, P., Carlos, F., Oden, A., McCloskey, E. V., & Kanis, J. A. (2011). Increasing age- and sex-specific rates of hip fracture in Mexico: A survey of the Mexican institute of social security. *Osteoporosis International*, *22*(8), 2359–2364. https://doi.org/10.1007/s00198-010-1475-z
Kaplan, P. A., Montesi, S. A., Jardon, O. M., & Gregory, P. R. (1988). Bone-ingrowth hip prostheses in asymptomatic patients: radiographic features. *Radiology*, *169*(1), 221–227. https://doi.org/10.1148/radiology.169.1.3420262
Khidoyatova, M. R., Kayumov, U. K., Inoyatova, F. K., Fozilov, K. G., Khamidullaeva, G. A., & Eshpulatov, A. S. (2022). Clinical status of patients with coronary artery disease post COVID-19. International Journal of Health & Medical Sciences, 5(1), 137-144. https://doi.org/10.21744/ijhms.v5n1.1858
Leiss, F., Götz, J. S., Meyer, M., Maderbacher, G., Reinhard, J., Parik, L., Grifka, J., & Greimel, F. (2021). Differences in femoral component subsidence rate after THA using an uncemented collarless femoral stem: full weight-bearing with an enhanced recovery rehabilitation versus partial weight-bearing. *Archives of Orthopaedic and Trauma Surgery*, *0123456789*. https://doi.org/10.1007/s00402-021-03913-0
Longo, U. G., Salvatore, S. De, Piergentili, I., Indiveri, A., Di Naro, C., Santamaria, G., Marchetti, A., De Marinis, M. G., & Denaro, V. (2021). Total hip arthroplasty: Minimal clinically important difference and patient acceptable symptom state for the forgotten joint score 12. *International Journal of Environmental Research and Public Health*, *18*(5), 1–11. https://doi.org/10.3390/ijerph18052267
Mak, J. C. S., Cameron, I. D., & March, L. M. (2010). Evidence-based guidelines for the management of hip fractures in older persons: An update. *Medical Journal of Australia*, *192*(1), 37–41. https://doi.org/10.5694/j.1326-5377.2010.tb03400.x
Miller, T. T. (2012). Imaging of hip arthroplasty. *European Journal of Radiology*, *81*(12), 3802–3812. https://doi.org/10.1016/j.ejrad.2011.03.103
Morsi, E., Habib, M. E., Elseedy, A., & Eid, T. (2016). Revision of failed hip hemiarthroplasty: Classification, management, and follow-up. *Journal of Orthopaedics*, *13*(2), 63–68. https://doi.org/10.1016/j.jor.2016.01.003
Mulcahy, H., & Chew, F. S. (2012a). Current concepts of hip arthroplasty for radiologists: Part 1, features and radiographic assessment. *American Journal of Roentgenology*, *199*(3), 559–569. https://doi.org/10.2214/AJR.12.8843

Mulcahy, H., & Chew, F. S. (2012b). Current concepts of hip arthroplasty for radiologists: Part 2, revisions and complications. *American Journal of Roentgenology*, *199*(3), 570–580. https://doi.org/10.2214/AJR.12.8844
Mushtaq, N., To, K., Gooding, C., & Khan, W. (2019). Radiological imaging evaluation of the failing total hip replacement. *Frontiers in Surgery*, *6*(June), 1–13. https://doi.org/10.3389/fsurg.2019.00035
Pietrzak, J. R., Donaldson, M. J., Kayani, B., & Haddad, F. S. (2018). Painful total hip arthroplasty. *Orthopaedics and Trauma*, *32*(1), 38–44. https://doi.org/10.1016/j.mporth.2017.11.008
Raut, V. V., Siney, P. D., & Wroblewski, B. M. (1995). Revision for aseptic stem: Loosening using the cemented Charnley prosthesis. A review of 351 hips. *Journal of Bone and Joint Surgery - Series B*, *77*(1), 23–27. https://doi.org/10.1302/0301-620x.77b1.7822390
Sauvé, P., Mountney, J., Khan, T., De Beer, J., Higgins, B., & Grover, M. (2007). Metal ion levels after metal-on-metal Ring total hip replacement: a 30-year follow-up study. *The Journal of Bone and Joint Surgery. British Volume*, *89*(5), 586–590. https://doi.org/10.1302/0301-620X.89B5.18457
Smektala, R., Endres, H. G., Dasch, B., Maier, C., Trampisch, H. J., Bonnaire, F., & Pientka, L. (2008). The effect of time-to-surgery on outcome in elderly patients with proximal femoral fractures. *BMC Musculoskeletal Disorders*, *9*, 171. https://doi.org/10.1186/1471-2474-9-171
Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. International Journal of Health Sciences, 6(1), i-v. https://doi.org/10.53730/ijhs.v6n1.5949
Vanrusselt, J., Vansevenant, M., Vanderschueren, G., & Vanhoenacker, F. (2015). Postoperative radiograph of the hip arthroplasty: what the radiologist should know. *Insights into Imaging*, *6*(6), 591–600. https://doi.org/10.1007/s13244-015-0438-5