1-1-2015

The impact of socioeconomic status on implant selection for patients undergoing hip arthroplasty

Michael Olsen
Saint Michael's Hospital University of Toronto

Michael Neufeld
Saint Michael's Hospital University of Toronto

Michael Sellan
Saint Michael's Hospital University of Toronto

Zachary Morison
Saint Michael's Hospital University of Toronto

Emil H. Schemitsch
Saint Michael's Hospital University of Toronto

The Impact of Socioeconomic Status on Implant Selection for Patients Undergoing Hip Arthroplasty

Michael Olsen, MD, PhD, Martin Orthopaedic Biomechanics Laboratory, St. Michael's Hospital, University of Toronto
Michael Neufeld, BSc, Martin Orthopaedic Biomechanics Laboratory, St. Michael's Hospital, University of Toronto
Michael Sellan, MD, MSc, Martin Orthopaedic Biomechanics Laboratory, St. Michael's Hospital, University of Toronto
Zachary Morison, MSc, Martin Orthopaedic Biomechanics Laboratory, St. Michael's Hospital, University of Toronto
Emil H. Schemitsch, MD, FRCS (C), Division of Orthopaedic Surgery, Department of Surgery, St. Michael's Hospital

Abstract

Hip resurfacing arthroplasty (HRA) is an alternative to total hip arthroplasty (THA) that preserves proximal femoral bone stock. Patient socioeconomic status (SES) has been demonstrated to impact access to care for numerous healthcare interventions but little is known about its impact on HRA when compared to THA. The aim of this study was to investigate whether there are disparities in SES for patients receiving HRA or THA. A retrospective database review was conducted comprising 617 hip arthroplasty patients (310 HRA, 307 THA). Patient postal code was used as a surrogate marker for patients' SES and referenced against Canada Census Tract data to determine patient income. Patients greater than 70 years of age and those who underwent THA as revision or for fractures were excluded from the study. There were 465 patients included in the analysis comprised of 273 HRA and 192 THA patients. HRA patients ($33,240, SD $8,206) had a significantly higher mean income than THA patients ($29,365, SD $7,119, $p<0.001$). The percentage of patients that underwent HRA compared to THA increased as patients' SES increased. Patients with an income greater than $25,000 were significantly more likely to undergo HRA rather than THA (OR ≥1.76), compared to patients with an income less than $25,000 in whom THA was more likely. There appears to be a disparity in SES between patients who receive HRA and THA. Further work is needed to better understand the factors that influence the choice of hip replacement for patients requiring surgical intervention.

Corresponding Author:
Michael Olsen
Martin Orthopaedic Biomechanics Laboratory
St. Michael's Hospital, University of Toronto
5-066 Shuter Wing, 30 Bond Street
Toronto, ON. Canada M5B 1W8
Email: michael.olsen@utoronto.ca

Introduction

The goal of joint replacement is to replace a diseased joint with a fully functional and pain-free joint, re-establishing the patient's quality of life and often improving the patient's overall health. Total hip arthroplasty (THA) has traditionally been indicated for an older patient population with end-stage hip disease, most often osteoarthritis. In this older patient population THA results in good functional outcomes and low rates of revision.[1] However, the demographics for patients receiving THA have been changing in recent years.[2] Younger patients are electing to undergo hip replacement to maintain their active lifestyles rather than accepting the limitations of their hip degeneration,[3] and as a result THA is no longer a procedure exclusively for the elderly. The functional demands and longevity of younger arthroplasty patients are increased compared to their aged counterparts,[4] and consequently younger patients receiving THA have poorer functional outcomes and increased rates of revision.[5] Modern metal-on-metal hip resurfacing arthroplasty (HRA) is a bone-conserving alternative to THA that preserves femoral bone stock in an effort to improve future revision surgery. There has been considerable controversy surrounding the use of metal-on-metal bearings[6-8] with declining use of the procedure in recent years.[9, 10] Currently, hip resurfacing may be indicated for a select patient population[11-14] and outcomes with the surgery appear to be implant specific.[9, 10, 15-17]

The number of hip replacement procedures performed in Canada increased by 59% from 1997 to 2007.[18] Over this same period, disparity in socioeconomic status for Canadians continued to grow.[19] Rahman et al. conducted a cohort study using British Columbia's population-based administrative data from 1991 to 2004 investigating the association between demographic variables and SES on surgical consultation and total joint arthroplasty rates among patients with osteoarthritis.[20] They demonstrated that independent of age, severity of osteoarthritis, or comorbidity, patients with higher SES consulted orthopaedic surgeons more frequently and received THA surgery more often than those with low SES. Numerous additional studies have demonstrated that SES has an effect on accessing healthcare in orthopaedics[21, 22] as well as other healthcare disciplines.[23, 24] Furthermore, low income has been demonstrated to be an independent predictor for the choice of less aggressive, modern, and efficacious surgical treatment for patients with various illnesses including appendicitis,[25] end-stage renal disease,[26] rectal cancer,[27] benign ovarian disease,[28] and breast cancer.[29]

With the recent advent of bone-conserving alternatives to traditional total hip replacement, patients are presented with a number of surgical treatment options for their hip pain. There has been little in the way of investigation into the factors that may predict the choice of implant the patient ultimately receives. To our knowledge, no study has demonstrated whether SES influences the choice between HRA and THA in patients with end-stage hip disease, and there has been no Canadian study investigating if there are disparities in SES for patients receiving HRA or THA. Therefore, the aim of the current study was to investigate within a single surgeon's practice if SES influences whether patients receive HRA versus THA and if there are disparities in SES for patients receiving HRA or THA.

Methods

Study Design and Population

We conducted a retrospective cohort study using a hip replacement database of hip arthroplasties performed by the senior surgeon. The database review was conducted on 617 hip arthroplasty patients (310 HRA, 307 THA) performed between February 2005 and July 2010. Patients' postal code was used as a surrogate marker for patients' SES and was referenced against a Statistics Canada 2006 Census Tract (CT) Profile to determine patients' CT Median Income ($CAD) - Persons 15 years and over.[30]

Patients with postal codes incompatible with a Statistics Canada 2006 Census Tract Profile were excluded from the analysis, as were patients who underwent THA as revision or for fractures, thus eliminating HRA as an option. Patients 70 years of age and older receiving THA were also excluded from the study. Although being 70 years of age and older is not an absolute contraindication to HRA, patients in this age range are much more likely to receive THA as a consequence of their age alone. Ethics approval for this study was obtained through the Research Ethics Board at St. Michael's Hospital.

Variables and Outcomes

The data variables collected included type of hip arthroplasty surgery (HRA or THA), primary etiology for surgery, date of surgery, postal code at the time of surgery, gender, age, and body mass index (BMI). Outcomes of interest were differences in CT median income, age, BMI, and gender between HRA and THA patients, as well as differences in CT median income, age, and BMI between male and female patients that underwent the same surgery.

The primary outcome of interest was the probability of undergoing HRA or THA. The primary predictor variable was patient CT median income. Patients' SES classification for this analysis was established by segregating patients into one of four categories based on the patient's CT median income. Patients were divided into (1) $24,999 or less, (2) $25,000 to $34,999, (3) $35,000 to $44,999, and (4) $45,000 and above.

Table 1. Patient demographics by surgical procedure

Variable	HRA* n=273	THA† n=192	*p* value
Gender, no. (%)			<0.001
Male	222 (81.3)	101 (52.6)	
Female	51 (18.7)	91 (47.4)	
Age, yr, mean (SD‡, range)			
Total	51.4 (8.6, 24-74)	50.2 (12.7, 19-69)	0.238§
Males	51.5 (8.8)	49.7 (11.9)	0.118§
Females	50.5 (7.6)	50.8 (13.5)	0.916§
BMI¶, kg/m^2, mean (SD)			
Total	29.3 (4.7)	28.4 (6.0)	0.097
Males	29.2 (4.6)	29.3 (5.9)	0.975
Females	29.3 (5.3)	27.5 (6.0)	0.073
Median Income, $CAD, mean (SD)			
Total	33,240 (8,206)	29,365 (7,119)	<0.001
Males	33,652 (8,243)	29,932 (7,762)	<0.001
Females	31,448 (7,875)	28,736 (6,312)	0.026
Primary Diagnosis, no. (%)			
Osteoarthritis	257 (94.1)	173 (90.1)	0.104

**HRA = hip resurfacing arthroplasty*
†THA = total hip arthroplasty
‡SD = standard deviation
§Excluding THA patients 70 years of age and older
¶BMI = body mass index

Table 2. A comparison of patient demographics by gender for patients that underwent the same surgical procedure

Variable	Male	Female	*p* value
HRA*			
Age, yr, mean (SD†)	51.5 (8.8)	50.5 (7.6)	0.417
Median Income, $CAD, mean (SD)	33,652 (8,243)	31,448 (7,875)	0.084
BMI‡, kg/m^2, mean (SD)	29.2 (4.6)	29.3 (5.3)	0.904
THA§			
Age, yr, mean (SD)	49.7 (11.9)	50.8 (13.5)	0.562
Median Income, $CAD, mean (SD)	29,932 (7,762)	28,736 (6,312)	0.246
BMI, kg/m^2, mean (SD)	29.3 (5.9)	27.5 (6.0)	0.043

**HRA = hip resurfacing arthroplasty*
†SD = standard deviation
‡BMI = body mass index
§THA = total hip arthroplasty

Statistical Analysis

Statistical analysis was performed using Microsoft Excel (Microsoft Corp. Redmond, WA, USA) and the statistical software package SPSS (SPSS Inc., Chicago, IL). Independent-Samples t-tests were used to compare differences in CT median income, age, and BMI between surgical groups, as well as differences in these parameters between genders within the same surgical group. The Pearson Chi-Square test was used to compare differences in gender and dominant primary diagnosis between surgical groups. We used univariate binomial logistic regression to examine the association between patients' SES and the type of arthroplasty performed, computing odds ratios (ORs) and their 95% confidence intervals (CIs). We considered all p values to be significant at 0.05.

Results

Baseline Characteristics

There were 465 patients included in the analysis, of whom 273 (58.7%) underwent HRA and 192 (41.3%) underwent THA. HRA and THA patient demographics are shown in Table 1. There were significant gender differences between HRA (81.3% male, 18.7% female) and THA (52.6% male, 47.4% female) patients (p<0.001). There was no significant difference in age between HRA and THA patients, with mean ages of 51.4 years (SD 8.6) and 50.2 years (SD 12.7) respectively (p=0.238). Similarly, there was no significant difference in the dominant etiology between HRA and THA patients (p=0.104), as the primary diagnosis of osteoarthritis of the hip joint was present in 94.1% of HRA patients and 90.1% of THA patients included in the analysis.

Age and BMI differences between male and female patients that underwent the same surgery are shown in Table 2. In spite of significant gender differences between HRA and THA, there was no significant difference in age between male and female HRA patients (p=0.417) or male and female THA patients (p=0.562). Likewise, there was no significant difference in BMI between male and female HRA patients (0.904). There was a statistically significant, although clinically insignificant, difference in BMI between male and female THA patients (p=0.043).

Outcomes

HRA patients ($33,240, SD $8,206) had a significantly higher mean income than THA patients ($29,365, SD $7,119, p<0.001, Table 1). HRA males had a significantly higher mean income than THA males (p<0.001), as did HRA females compared to THA females (p=0.026, Table 1). In spite of significant gender differences between HRA and THA, there was no significant income difference between male and female HRA patients (p=0.084) or male and female THA patients (p=0.246, Table 2).

Univariate binomial logistic regression showed that patients with an income greater than $45,000 (OR 4.32, 95% CI 1.86-10.03), of $35,000 to $44,999 (OR 3.42, 95% CI 1.82-6.41), and of $25,000 to $34,999 (OR 1.76, 95% CI 1.10-2.80) had significantly higher odds of undergoing HRA rather than THA, compared to patients with an income less than $25,000 (reference category) (Table 3). The percentage of patients that underwent HRA compared to THA increased as patient SES increased (Figure 1). The percentage of patients that underwent HRA increased sequentially from 43.6% in the lowest income category (<$25,000) to 76.9% in the highest income category (≥$45,000). Conversely, the percentage of patients that underwent THA decreased sequentially from 56.4% in the lowest income category (<$25,000) to 23.1% in the highest income category (≥$45,000).

Table 3. Odds ratios* of undergoing HRA† compared to THA‡

	Odds ratio	
Median Income Category, $CAD	(95% confidence interval)	*p* value
<25,000	1.00 (reference category)	–
25,000-34,999	1.76 (1.10-2.80)	0.018
35,000-44,999	3.42 (1.82-6.41)	<0.001
≥45,000	4.32 (1.86-10.03)	0.001

**Determined by univariate binomial logistic regression*
†HRA = hip resurfacing arthroplasty
‡THA = total hip arthroplasty

Discussion

To our knowledge, this represents the only orthopaedic study that analyzes whether SES influences the choice between HRA and THA in patients with end-stage hip disease, as well as the only Canadian study investigating if there are disparities in SES for patients receiving HRA or THA. The current work demonstrated that patients with higher SES were more likely to receive HRA than THA. The percentage of patients that underwent HRA compared to THA increased as patient SES increased. Furthermore, HRA patients had a higher mean income than THA patients.

Similar findings have been demonstrated for surgical procedures in non-orthopaedic specialties. In a study of 8837 male patients with prostate cancer, Hu et al. demonstrated that patients living in areas of higher educational graduation rates and higher median incomes were more likely to undergo minimally invasive versus open retropubic radical prostatectomy.[31] Likewise, Stitzenberg et al. analyzed 5489 patients with early-stage lung cancer and found that patients with lower median incomes were less likely to undergo video-assisted surgical lobectomy compared to open lobectomy.[32]

Within the orthopaedics community there have been numerous accounts citing disparities in access to care for patients receiving joint replacement surgery. Examining patients receiving hip and knee replacements within the British National Health Service, Neuburger et al.[33] showed that patients of lower SES tended to have longer standing joint disease as well as more severe disease progression before receiving surgical intervention. Investigating patients receiving THA in Italy, a country that like Canada has universal health care, Agabiti et al. demonstrated that high-income individuals were more likely than low-income counterparts to receive hip replacement.[34] With respect to HRA, Olsen and Schemitsch demonstrated that for patients in Toronto, Canada, there was a propensity for individuals of higher SES to undergo HRA.[35] The current study expands upon this earlier finding, extending the research to include patients receiving THA, by demonstrating that patients of higher SES are more likely to receive HRA than THA and that HRA patients have a higher mean income than THA patients.

There are several possible explanations for the findings of the current study. Firstly, there may be reduced need for HRA among lower SES classes. This is unlikely, however, as individuals of lower SES not only have an age-matched increased severity of hip disease and worse disability,[36] but also an increased need for and similar willingness to undergo hip replacement surgery compared to those of higher SES.[37] Secondly, as indications for HRA tend to be narrower than for THA,[13] preoperative characteristics such as activity level, functional status, and general health status of the average HRA patient tend to be more favourable than that of the average THA patient.[38] Patients of lower SES tend to have increased comorbidities relative to patients of higher SES[36, 38] and this may in part explain the increased likelihood of patients with higher SES to undergo HRA rather than THA in the current study. Thirdly, it is plausible that there is a greater lack of knowledge about HRA among individuals of lower SES, specifically with HRA in its infancy in Canada in the early 2000's. The propensity for individuals of higher rather than lower SES to undergo HRA versus THA suggests the possibility that perhaps better educated patients are further inclined and better able to utilize more extensive resources, and thus ardently seek out new and emergent health care alternatives. The impact of modern information sources, particularly the internet, on patient preferences and the allocation of health care resources is a compelling area of future research.

There are a number of limitations to the current study. Firstly, patient data specifically detailing a patient's income and education is not collected by St. Michael's Hospital. As a result, postal code at the time of surgery was used as a surrogate marker for SES and may not directly represent a patient's social or economic background. Secondly, the patient cohort used in the current study was drawn from a single surgeon's practice in a large academic center and may not be generalizable to the full spectrum of patients receiving hip arthroplasty. However, this is the first study analyzing whether SES is associated with the choice between HRA and THA in patients with end-stage hip disease and the only Canadian study investigating if there are disparities in SES for patients receiving HRA or THA. Thus, while patient selection bias is a potential source of error within this study, the work provides a strong foundation for future work in the area. Lastly, data on patient related factors such as comorbidity, hip disease severity and anatomical considerations was not collected in this study. As these factors influence a patient`s suitability for HRA and THA, future analysis including these confounding variables is necessary to determine if SES is an independent predictor of the choice of hip arthroplasty procedure or if the observed disparities in SES are exclusively a consequence of surgical and patient related factors.

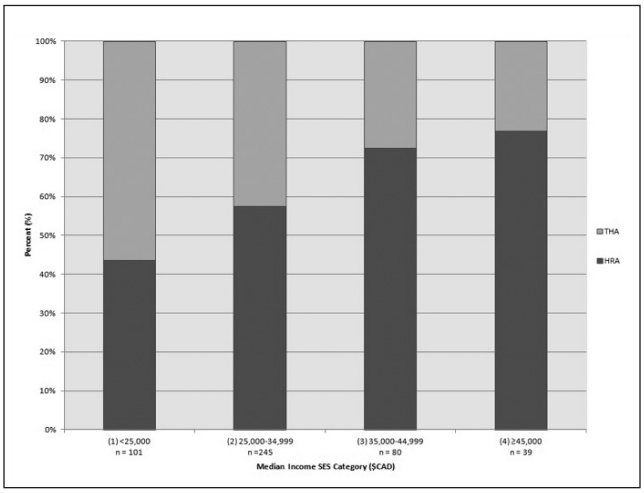

Figure 1. Percentage of patients that underwent HRA or THA in each median income SES category. Patients' SES classification was established by segregating arthroplasty patients into one of four categories based on the patient's Statistics Canada 2006 Census Tract Median Income ($CAD) - Persons 15 years and over. Patients were stratified into income categories (1) $24,999 or less, (2) $25,000 to $34,999, (3) $35,000 to $44,999, and (4) $45,000 and above.
HRA = hip resurfacing arthroplasty, THA = total hip arthroplasty, SES = socioeconomic status, $CAD = Canadian dollars.

Conclusion

The current study demonstrated that patients with higher SES were more likely to receive HRA than THA. The percentage of patients that underwent HRA compared to THA increased as patient SES increased. HRA patients had a higher mean income than THA patients. There appears to be a disparity in SES between patients who receive HRA and THA, but further research is required to better understand the factors that influence the choice of hip replacement intervention.

References

1. Shimmin AJ, Bare JV. Comparison of functional results of hip resurfacing and total hip replacement: a review of the literature. Orthop Clin North Am. Apr;42(2):143-151, vii.
2. Bozic KJ, Kurtz S, Lau E, et al. The epidemiology of bearing surface usage in total hip arthroplasty in the United States. J Bone Joint Surg Am. Jul 2009;91(7):1614-1620.
3. Amanatullah DF, Cheung Y, Di Cesare PE. Hip resurfacing arthroplasty: a review of the evidence for surgical technique, outcome, and complications. Orthop Clin North Am. Apr;41(2):263-272.
4. Schmalzried TP. Why total hip resurfacing. J Arthroplasty. Oct 2007;22(7 Suppl 3):57-60.
5. Australian Orthopaedic Association (AOA) National Joint Replacement Registry 2009 Annual Report. Adelaide: AOA; 2009.
6. Hartmann A, Lutzner J, Kirschner S, Witzleb WC, Gunther KP. Do survival rate and serum ion concentrations 10 years after metal-on-metal hip resurfacing provide evidence for continued use? Clin Orthop Relat Res. Nov 2012;470(11):3118-3126.
7. Smith AJ, Dieppe P, Howard PW, Blom AW. Failure rates of metal-on-metal hip resurfacings: analysis of data from the National Joint Registry for England and Wales. Lancet. Nov 17 2012;380(9855):1759-1766.
8. Spencer RF. Where do we stand with metal-on-metal bearings. Hip Int. Feb 15 2013:0.
9. Australian Orthopaedic Association (AOA) National Joint Replacement Registry 2012 Annual Report. Adelaide: AOA; 2012.
10. National Joint Replacement Registry of England and Wales 2012 Annual Report. London: National Joint Replacement Centre; 2012.
11. Coulter G, Young DA, Dalziel RE, Shimmin AJ. Birmingham hip resurfacing at a mean of ten years: results from an independent centre. J Bone Joint Surg Br. Mar 2012;94(3):315-321.
12. Holland JP, Langton DJ, Hashmi M. Ten-year clinical, radiological and metal ion analysis of the Birmingham Hip Resurfacing: from a single, non-designer surgeon. J Bone Joint Surg Br. Apr 2012;94(4):471-476.
13. Johnson AJ, Zywiel MG, Hooper H, Mont MA. Narrowed indications improve outcomes for hip resurfacing arthroplasty. Bull NYU Hosp Jt Dis.69 Suppl 1:S27-29.
14. Murray DW, Grammatopoulos G, Pandit H, Gundle R, Gill HS, McLardy-Smith P. The ten-year survival of the Birmingham hip resurfacing: an independent series. J Bone Joint Surg Br. Sep 2012;94(9):1180-1186.
15. Agency MaHpR. Medical Device Alert: All metal-on-metal hip replacements2012.
16. de Steiger RN, Hang JR, Miller LN, Graves SE, Davidson DC. Five-year results of the ASR XL Acetabular System and the ASR Hip Resurfacing System: an analysis from the Australian Orthopaedic Association National Joint Replacement Registry. J Bone Joint Surg Am. Dec 21 2011;93(24):2287-2293.
17. Hug KT, Watters TS, Vail TP, Bolognesi MP. The Withdrawn ASR THA and Hip Resurfacing Systems: How Have Our Patients Fared Over 1 to 6 Years? Clin Orthop Relat Res. Feb 2013;471(2):430-438.
18. Canadian Institute for Health Information (CIHI). Hip and Knee Replacements in Canada-Canadian Joint Replacement Registry (CJRR) 2008-2009 Annual Report. Ottawa: CIHI; 2009.
19. Canadian Broadcasting Corporation (CBC) News. www.cbc.ca/news/business/story/2011/12/05/oecd-rich-poor-gap.html. Last accessed April 2015.
20. Rahman MM, Kopec JA, Sayre EC, et al. Effect of sociodemographic factors on surgical consultations and hip or knee replacements among patients with osteoarthritis in British Columbia, Canada. J Rheumatol. Mar;38(3):503-509.
21. Dixon T, Shaw M, Ebrahim S, Dieppe P. Trends in hip and knee joint replacement: socioeconomic inequalities and projections of need. Ann Rheum Dis. Jul 2004;63(7):825-830.
22. Hollowell J, Grocott MP, Hardy R, Haddad FS, Mythen MG, Raine R. Major elective joint replacement surgery: socioeconomic variations in surgical risk, postoperative morbidity and length of stay. J Eval Clin Pract. Jun;16(3):529-538.
23. Berglund A, Garmo H, Robinson D, et al. Differences according to socioeconomic status in the management and mortality in men with high risk prostate cancer. Eur J Cancer. Jan;48(1):75-84.
24. Lee SL, Yaghoubian A, Stark R, Shekherdimian S. Equal access to healthcare does not eliminate disparities in the management of adults with appendicitis. J Surg Res. Oct;170(2):209-213.
25. Lee SL, Shekherdimian S, Chiu VY. Effect of race and socioeconomic status in the treatment of appendicitis in patients with equal health care access. Arch Surg. Feb 2011;146(2):156-161.
26. Gore JL, Danovitch GM, Litwin MS, Pham PT, Singer JS. Disparities in the utilization of live donor renal transplantation. Am J Transplant. May 2009;9(5):1124-1133.
27. Olsson LI, Granstrom F, Pahlman L. Sphincter preservation in rectal cancer is associated with patients' socioeconomic status. Br J Surg. Oct;97(10):1572-1581.
28. Abenhaim HA, Azziz R, Hu J, Bartolucci A, Tulandi T. Socioeconomic and racial predictors of undergoing laparoscopic hysterectomy for selected benign diseases: analysis of 341487 hysterectomies. J Minim Invasive Gynecol. Jan-Feb 2008;15(1):11-15.
29. Cyran EM, Crane LA, Palmer L. Physician sex and other factors associated with type of breast cancer surgery in older women. Arch Surg. Feb 2001;136(2):185-191.
30. Statistics Canada. 2006 Census: Data Products - Census Tract (CT) Profiles. Ottawa: Statistics Canada; 2006.
31. Hu JC, Gu X, Lipsitz SR, et al. Comparative effectiveness of minimally invasive vs open radical prostatectomy. JAMA. Oct 14 2009;302(14):1557-1564.
32. Stitzenberg KB, Shah PC, Snyder JA, Scott WJ. Disparities in access to video-assisted thoracic surgical lobectomy for treatment of early-stage lung cancer. J Laparoendosc Adv Surg Tech A. Oct;22(8):753-757.
33. Neuburger J, Hutchings A, Allwood D, Black N, van der Meulen JH. Sociodemographic differences in the severity and duration of disease amongst patients undergoing hip or knee replacement surgery. J Public Health (Oxf). Aug;34(3):421-429.
34. Agabiti N, Picciotto S, Cesaroni G, et al. The influence of socioeconomic status on utilization and outcomes of elective total hip replacement: a multicity population-based longitudinal study. Int J Qual Health Care. Feb 2007;19(1):37-44.
35. Olsen M, Schemitsch EH. The Impact of Gender and Socioeconomic Status on Patient Outcomes in Hip Resurfacing Arthroplasty. University of Toronto Medical Journal. 2012; 89(2):82-87.
36. Eachus J, Chan P, Pearson N, Propper C, Davey Smith G. An additional dimension to health inequalities: disease severity and socioeconomic position. J Epidemiol Community Health. Oct 1999;53(10):603-611.
37. Hawker GA, Wright JG, Glazier RH, et al. The effect of education and income on need and willingness to undergo total joint arthroplasty. Arthritis Rheum. Dec 2002;46(12):3331-3339.
38. Fowble VA, dela Rosa MA, Schmalzried TP. A comparison of total hip resurfacing and total hip arthroplasty - patients and outcomes. Bull NYU Hosp Jt Dis. 2009;67(2):108-112.