RESEARCH ARTICLE

Magnetic Resonance Imaging Assessment of Hip Abductor after Total Hip Arthroplasty Using a Direct Lateral Approach

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Abstract

Background: Surgical techniques and rehabilitations after total hip arthroplasty (THA) play a significant role in the improvement of pain and limping. This study aimed to assess hip abductor muscle's diameter and its strength after 6 months postoperative THA performed by Hardinge approach.

Methods: After obtaining the patients' demographic characteristics, the preoperative values of patients' hip abductor muscle diameter were measured using magnetic resonance imaging, and were compared with postoperative values 6 months later. Moreover, the hip abductor muscle's strength was assessed using the Trendelenburg test.

Results: A total of 88 patients participated in this study with a mean age of 47.3±1.574 years. It should be noted that 55.7% of the participants were male. Muscle diameter decreased from a mean value of 27.07±7.485 preoperative to mean value of 25.64±7.353 mm postoperative ($P<0.001$). Moreover, the degrees of Trendelenburg test (i.e., mild or severe) decreased after surgery ($P<0.001$). There was no significant difference between the frequencies of different grades of limping according to the studied variables.

Conclusion: A decrease was observed in gluteus medius muscle diameter, and the Trendelenburg test results were improved in this study. Moreover, the difference between pre- and postoperative gluteus medius muscle diameters were measured using MRI. It can be concluded that MRI is not an appropriate diagnostic tool for the assessment of abductor strength after THA in the 6-month postoperative visit. Accordingly, it is suggested to evaluate muscle strength before and after each surgery to schedule the following treatment protocol required for each patient.

Level of evidence: IV

Keywords: Hardinge, Hip Abductor Diameter, Magnetic Resonance Imaging, Trendelenburg test

Introduction

Total hip arthroplasty (THA) can substantially improve patients' health-related quality of life; however, the surgical outcome may depend on several factors (1)from January 1980 to June 2003, to identify relevant studies. Studies were eligible for review if they met the following criteria: (1. In addition to patient-specific factors, including age, gender, body mass index (BMI), comorbidities, and preoperative functions (2), different tools and techniques suggested for surgery and post-surgical care can also affect the surgical

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outcome (3). The main three surgical approaches in THA includes anterior or anterolateral, posterolateral, and direct lateral approaches but the posterior approach, direct lateral approach, and direct anterior approach are by far the most common across the globe (4). This article highlights the history and technique for each of these common approaches. A review of outcomes and complications for each approach are also provided. Each approach has its own unique advantages and disadvantages, but all can be safely and successful utilized for THA. Strong, convincing, high-quality studies comparing the different approaches are lacking at this time. Surgeons are therefore recommended to choose whichever approach they are most comfortable and experienced using. Though not described here, THA can also be done using the anterolateral approach (also known as the Watson Jones approach. Direct lateral approach, which is called "Hardinge approach", is the second most common surgical approach used worldwide for THA (5). However, each approach and prosthesis has its own complications (6).

Abductor muscle weakness resulting from gluteus medius muscle atrophy is an important predictor of postoperative pain and limping (7)and all patients provided informed consent. Two musculoskeletal radiologists blinded to clinical information analyzed triplanar MR images of the greater trochanter obtained in 25 patients without and 39 patients with trochanteric pain and abductor weakness after THA. Tendon defects, diameter, signal intensity, and ossification; fatty atrophy; and bursal fluid collections were assessed. In 14 symptomatic patients, MR imaging and surgical findings were correlated. Differences in the frequencies of findings between the two groups were tested for significance by using chi2 analysis. RESULTS: Tendon defects were uncommon in asymptomatic patients and significantly more frequent in symptomatic patients: Two asymptomatic versus 22 symptomatic patients had gluteus minimus defects (*P<.001*. Therefore, an appropriate preoperative assessment would be useful for comprehensive rehabilitation after THA (8). Magnetic resonance imaging (MRI) is suggested as an appropriate tool for the assessment of gluteus medius muscle's diameter (9, 10)allowing pain relief and restoration of mobility in large numbers of patients; however, pain after hip arthroplasty occurs in as many as 40% of cases, and despite improved longevity, all implants eventually fail with time. Owing to the increasing numbers of hip arthroplasty procedures performed, the demographic factors, and the metal-on-metal arthroplasty systems with their associated risk for the development of adverse local tissue reactions to metal products, there is a growing demand for an accurate diagnosis of symptoms related to hip arthroplasty implants and for a way to monitor patients at risk. Magnetic resonance (MR. The investigation of the factors affecting abductor muscle strength can help improve patient weakness after THA. Therefore, this study aimed to assess the hip gluteus medius muscle's diameter and strength with MRI and Trendelenburg test, respectively, after THA using the Hardinge approach. To this end, the association between these two values was evaluated after 6 months of postoperative rehabilitation.

Materials and Methods

Study design

This descriptive cross-sectional study was conducted in Imam Hossein Hospital, Tehran, Iran, from October 2017 to August 2018. The patients who needed THA were included in this study.

The study protocol was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (ir.sbmu.msp.rec.1396.159).

The sample size was obtained at 117 patients who met the inclusion criteria using a convenient sampling method. Patients were scheduled by a chief orthopedic specialist based on the hip primary osteoarthritis (OA) (diagnosed by tonnis criteria), femoral head necrosis (diagnosed by Ficat and arlet classification), and femoral neck fracture (diagnosed by plain radiologic x-ray radiography). On the other hand, the patients with the congenital hip-joint disease, ankylosing spondylitis, thalassemia, and rheumatoid arthritis, as well as those who underwent revision surgery were not included in the study. Moreover, the patients who were unwilling to participate in the study or those who died during the research procedure were excluded from the study.

Demographic characteristics of the patients, including age, gender, and BMI were recorded in this study. It should be noted that no limitation was observed in these values. Subsequently, all patients underwent MRI assessment for recording the preoperative values of patients' gluteus medius diameter. The assessment of hip gluteus medius muscle diameter was performed by T system (Symphony; Siemens medical solutions, Erlangen Co., Germany) according to the axial T2 sequence. Moreover, the gluteus medius diameter was assessed near its origin which was aligned with greater sciatic notch upper than replacement cup components to minimize the prosthesis artifact [Figure 1].

Trendelenburg test was performed by standing on a non-operated limb for 5 and 20 seconds. If the patient was not able to stand on one leg at these times, the test was positive. This test assesses the abductor muscle strength which represents normal, mild, and severe degrees. The normal degree is characterized by negative results at 5 and 20 seconds. Moreover, the mild level is the negative and positive Trendelenburg test at 5th and 20th seconds, respectively, and the severe level is the positive Trendelenburg test at both 5thand 20th seconds.

All procedures were performed by one orthopedic surgeon with conventional uncemented hemispherical cup and standard uncemented stem (Zimmer and Striker Co.) using the Hardinge approach. The day after surgery, postoperative care instructions were given to all patients for walking by a crutch or walker, and Clexane was prescribed following discharge. After 2 weeks, in the first visit, the patients were trained by an abduct plaster on the operated limb and could stand on an opposite limb with protection as long as 10 seconds. At follow-up visit (i.e., six months later) the MRI parameters and physical examination were repeated and compared with the

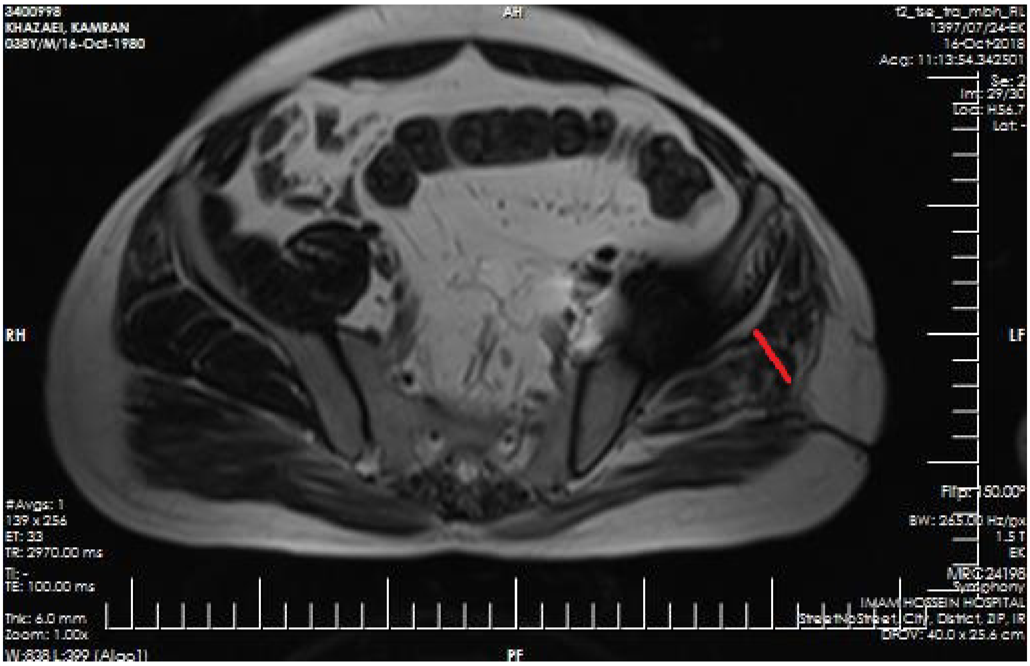

Figure 1. Post operative gluteus medius diameter.

postoperative values.

Statistical analysis

Continuous and categorical variables were compared using the paired t-test or Wilcoxon test and McNemar's test, respectively. The data were analyzed in the IBM SPSS software (Version 25.0, IBM Corp. 2016. Armonk, NY: IBM Corp). A p-value less than 0.05 was considered statistically significant.

Results

According to the results, 88 patients participated in this study with a mean age of 47.3±1.574 (age range: 22-85) years. Moreover, 55.7% of the participants were male. Most patients (70.5%) had a BMI of <30 kg/m^2. The causes of THA were primary OA (63.6%), avascular necrosis (33%), and fracture (3.4%). In addition, the values of postoperative muscle diameters decreased significantly, compared to preoperative values (25.64±7.353 mm vs. 27.07±7.485 mm, respectively, *P<0.001*) [Table 1]. The frequency of different grades of the Trendelenburg test is demonstrated in Figure 2. Logistic regression analysis showed that patients had an 85% chance of reduction in Trendelenburg degrees after surgery (OR=0.159; 95%CI: 0.088 to 0.282). Table 1 summarizes the comparison between the results of muscle diameter assessment

Table 1. Comparison of pre- and post-operative parameters in the studied patients

	Preoperative value	Postoperative value	*P-value*
Leg length discrepancy (mm), Mean±SD	41.07±1.327	16.74±6.737	<0.001
Muscle diameter(mm), Mean±SD	27.07±7.485	25.64±7.353	<0.001
Muscle atrophy>50%, No. (frequency)	43(48.9%)	41(46.6%)	0.625
Heterotopic ossification, No. (frequency)	28(31.8%)	13(14.8%)	0.020
Pretrochanteric bursa fluid, No. (frequency)	38(43.2%)	6(6.8%)	<0.001
Positive 5 seconds muscle force, No. (frequency)	34(38.6%)	4(4.5%)	<0.001
Positive 20 seconds muscle force, No. (frequency)	80(90.9%)	65(73.9%)	<0.001
Normal Trendelenburg, No. (frequency)	8(9.1%)	23(26.1%)	<0.001
Mild Trendelenburg, No. (frequency)	48(54.5%)	61(69.3%)	<0.001
Severe Trendelenburg, No. (frequency)	32(36.4%)	4(4.5%)	<0.001

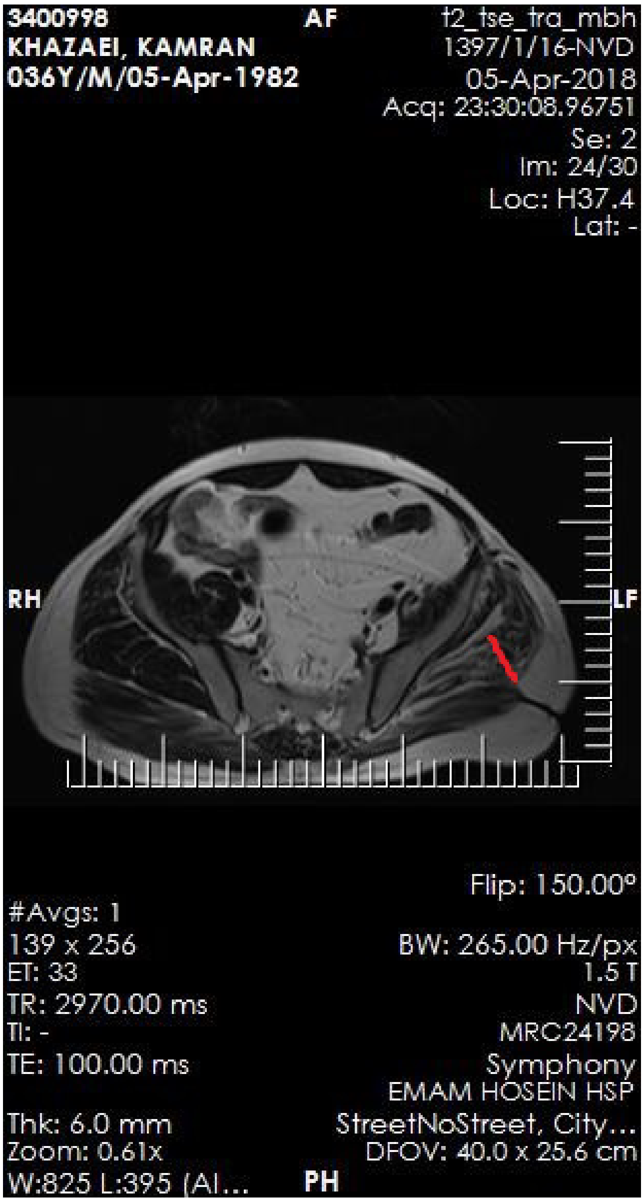

Figure 2. Pre operative gluteus medius diamer.

and Trendelenburg test results before and after surgery. In addition, the frequency of different degrees of Trendelenburg test is depicted according to patients' gender, BMI, mean age, and muscle diameter in Table 2.

Discussion

This study included 88 patients who underwent the assessment of the gluteus medius muscle diameter and the muscle strength using MRI and Trendelenburg test, respectively. The limb length discrepancy in all of the operated patients was estimated at maximum 2 cm by C-Arm assessment in the operation time. aligning with lesser trochanter by each other that in this range not influenced on post operating limp.

Similarly, the results of the present study showed that muscle diameter could be successfully measured by MRI. Moreover, the results of the measurements showed a significant decrease in muscle diameter from 27.07±7.485 to 25.64±7.353 mm after surgery. Furthermore, the positive results of the Trendelenburg test reduced from 38.6% to 4.5% and from 90.9% to 73.9% at 5th and 20th seconds, respectively. These reductions indicate improvements in muscle strength despite a decrease in muscle diameter. Other patient characteristics have also been described in this study.

Pfirrmann et al. investigated the tri-planar MRI of the greater trochanter in patients following THA and compared the frequency of defects of abductor muscles (i.e., gluteus minimus and gluteus medius) and fatty atrophy among patients with and without symptoms. The results revealed that symptomatic patients had a higher frequency of tendon and muscle defects and all patients provided informed consent (7). Two musculoskeletal radiologists blinded to clinical information analyzed triplanar MR images of the greater trochanter obtained in 25 patients without and 39 patients with trochanteric pain and abductor weakness after THA. Tendon defects, diameter, signal intensity, and ossification; fatty atrophy; and bursal fluid collections were assessed. In 14 symptomatic patients, MR imaging and surgical findings were correlated. Differences in the frequencies of findings between the two groups were tested for significance by using chi2 analysis. RESULTS: Tendon defects were uncommon in asymptomatic patients and significantly more frequent in symptomatic patients: Two asymptomatic versus 22 symptomatic patients had gluteus minimus defects

Table 2. Frequency of different grades of Trendelenburg test according to the study variables

		Trendelenburg Test Grades			*P-value*
		Normal	Mild	Severe	
Gender	Male	11(22.4%)	36(73.5%)	2(4.1%)	0.478
	Female	12(30.8%)	25(64.1%)	2(5.1%)	
Body Mass Index Category	<30 kg/m^2	8(30.8%)	17(65.4%)	1(3.8%)	0.527
	>30 kg/m^2	15(24.2%)	44(71.0%)	3(4.8%)	
Age (years), Mean±SD		44.78±1.052	47.21±1.697	57.25±2.084	0.245

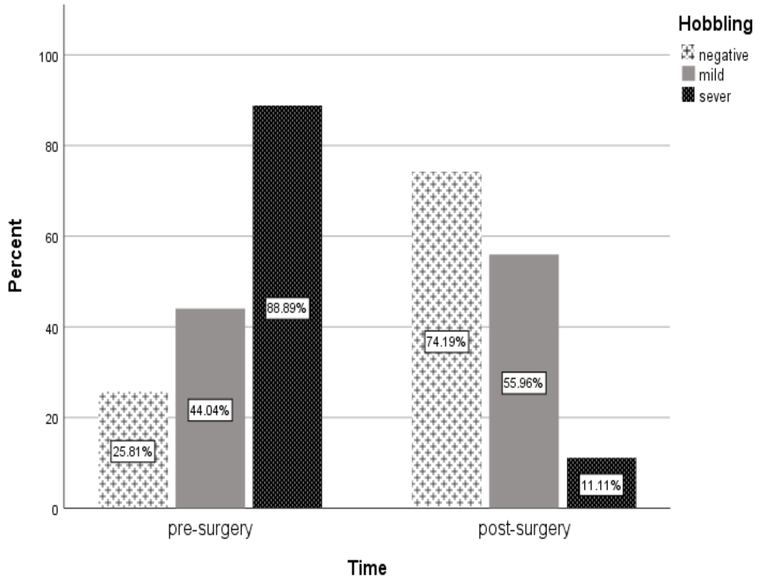

Figure 3. Frequency of different degrees of Trendelenburg test before and after surgery in the studied patients.

(*P<.001*. In the present study, the patients' reported outcomes were not investigated and it was not clear how many were symptomatic. In addition, according to a study conducted by Horstmann et al., the association between postoperative limping severity and pain was stronger for the hip extensor and flexor muscles, compared to that between hip adductor and abductor muscles (11).

Another important factor evaluated in the present study was the frequency of each grade of Trendelenburg test before and after surgery and the association between the studied variables and Trendelenburg test results. According to the findings of the Trendelenburg test, 4.5% of patients had severe hip dysfunction before surgery and none of them had a positive Trendelenburg test after surgery. On the other hand, 28.4% of the patients had severe and mild hip dysfunction before and after surgery, respectively. Additionally, 12.5% of the patients were normal before surgery and had mild hip dysfunction after surgery. In the same line, 1.1% of the cases had mild hip dysfunction before surgery and severe hip dysfunction after surgery. Furthermore, 9.1% of the patients were normal before or after surgery [Figure 3]. Logistic regression analysis showed that the patients had an 85% chance of reduction in the degrees of Trendelenburg test after surgery (OR=0.159; 95%CI: 0.088 to 0.282).

These results indicate the success of surgical and rehabilitation techniques. According to the results of the present study, there was no significant association between age and Trendelenburg test results. This finding is contrary to the results of previous research in which age of >70 associated with walking ability after THA (12). In the same line, Gordon et al. revealed that surgical outcomes were only affected by age in patients who were in their late 60s (13).

Nankaku et al. also reported a higher mean age in patients with limping, compared to those without limping; however, they declared the uncertain predictive value of age (14). Accordingly, the lack of association between age and Trendelenburg test results in the present study could be due to the low frequency of aged patients.

Regarding the frequency of different degrees of Trendelenburg test results, there was no difference between patients who were <30 and >30kg/m^2. However, previous studies indicated the effect of obesity on postoperative limping and unfavorable outcomes following THA (12, 15, 16). In the present study, less than 30% of the patients had a BMI >30kg/m^2 and were considered obese. Although the preoperative weight was considered in this study, the patients' weight may change after THA (17).

One of the limitations of this study was the cross-sectional nature of the research procedure. Therefore, there was no control group to compare the results, and there was a chance of the confounders' effect on the findings. However, several demographic and radiographic factors were investigated to minimize the effect of confounders. In addition, MRI scans were evaluated by a chief orthopedic specialist which may lead to bias in accuracy estimates; nevertheless, the chief orthopedic specialist was an expert in this field.

According to the results, a decrease was observed in gluteus medius muscle diameter, and the Trendelenburg test results were improved in this study. Moreover, the difference between pre- and postoperative gluteus medius muscle diameters were measured using MRI. With this background in mind, it can be concluded that MRI is not an appropriate diagnostic tool for the assessment of abductor strength after THA in the 6-month postoperative visit. Accordingly, it is suggested to evaluate muscle strength before and after each surgery to schedule the following treatment protocol required for each patient. In addition, future studies are recommended to focuse on patients' follow-ups for a longer period (i.e., 18 months).

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References

1. Ethgen O, Bruyere O, Richy F, Dardennes C, Reginster JY. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. J Bone Joint Surg Am. 2004; 86(5):963-74.
2. Hofstede SN, Gademan MG, Vliet Vlieland TP, Nelissen RG, Marang-van de Mheen PJ. Preoperative predictors for outcomes after total hip replacement in patients with osteoarthritis: a systematic review. BMC Musculoskelet Disord. 2016; 17(1):212.
3. Malviya A, Abdul N, Khanduja V. Outcomes following total hip arthroplasty: a review of the registry data. Indian J Orthop. 2017; 51(4):405-13.
4. Moretti VM, Post ZD. Surgical approaches for total hip arthroplasty. Indian J Orthop. 2017; 51(4):368-76.
5. Chechik O, Khashan M, Lador R, Salai M, Amar E. Surgical approach and prosthesis fixation in hip arthroplasty world wide. Arch Orthop Trauma Surg. 2013; 133(11):1595-600.
6. Petis S, Howard JL, Lanting BL, Vasarhelyi EM. Surgical approach in primary total hip arthroplasty: anatomy, technique and clinical outcomes. Can J Surg. 2015; 58(2):128-39.
7. Pfirrmann CW, Notzli HP, Dora C, Hodler J, Zanetti M. Abductor tendons and muscles assessed at MR imaging after total hip arthroplasty in asymptomatic and symptomatic patients. Radiology. 2005; 235(3): 969-76.
8. Healy WL, Iorio R, Pellegrini VD, Della Valle CJ, Berend KR. Complications of total hip arthroplasty: standardized list, definitions, and stratification developed by the hip society. Clin Orthop Relat Res. 2016; 474(6):1528-9.
9. Fritz J, Lurie B, Miller TT, Potter HG. MR imaging of hip arthroplasty implants. Radiographics. 2014; 34(4):E106-32.
10. Kovalak E, Ozdemir H, Ermutlu C, Obut A. Assessment of hip abductors by MRI after total hip arthroplasty and effect of fatty atrophy on functional outcome. Acta Orthop Traumatol Turc. 2018; 52(3):196-200.
11. Horstmann T, Listringhaus R, Brauner T, Grau S, Mundermann A. Minimizing preoperative and postoperative limping in patients after total hip arthroplasty: relevance of hip muscle strength and endurance. Am J Phys Med Rehabil. 2013; 92(12):1060-9.
12. Singh JA, Lewallen DG. Predictors of activity limitation and dependence on walking aids after primary total hip arthroplasty. J Am Geriatr Soc. 2010; 58(12):2387-93.
13. Gordon M, Greene M, Frumento P, Rolfson O, Garellick G, Stark A. Age- and health-related quality of life after total hip replacement: decreasing gains in patients above 70 years of age. Acta Orthop. 2014; 85(3):244-9.
14. Nankaku MP, Tsuboyama TP, Aoyama TP, Kuroda YP, Ikeguchi RP, Matsuda SP. Preoperative gluteus medius muscle atrophy as a predictor of walking ability after total hip arthroplasty. Phys Ther Res. 2016; 19(1):8-12.
15. Vincent HK, Horodyski M, Gearen P, Vlasak R, Seay AN, Conrad BP, et al. Obesity and long term functional outcomes following elective total hip replacement. J Orthop Surg Res. 2012; 7(1):16.
16. Huddleston JI, Wang Y, Uquillas C, Herndon JH, Maloney WJ. Age and obesity are risk factors for adverse events after total hip arthroplasty. Clin Orthop Relat Res. 2012; 470(2):490-6.
17. Aderinto J, Brenkel IJ, Chan P. Weight change following total hip replacement: a comparison of obese and non-obese patients. Surgeon. 2005; 3(4):269-72.