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FUNCTIONAL AND CLINICAL OUTCOMES FOLLOWING ANTERIOR HIP REPLACEMENT – A 5 YEAR COMPARITIVE STUDY VERSUS POSTERIOR APPROACH

Running Head: FUNCTIONAL AND CLINICAL OUTCOMES FOLLOWING ANTERIOR HIP REPLACEMT

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Abstract

Introduction

With the evolution of Total Hip Joint Replacement (THJR) techniques, there has been a trend towards minimally invasive surgery. The anterior approach (AA) to THA has been widely associated with less soft tissue damage. The aim of our study was to compare clinical and 1 year functional outcomes for AA hip arthroplasty versus a posterior approach (PA)

Method

We retrospectively reviewed 92 (50 anterior, 42 posterior) total hip replacements performed at our centre between 2006-2011. Clinical outcomes were recorded from hospital medical records and clinical audit system. Range of Motion (ROM) analysis, Harris hip score (HHS) and SF-12 score were recorded pre-operatively and at the 12 month follow up marks. Additionally, we reviewed; operative time, length of stay, discharge destination, complications, return to theatre and readmission rates Results

The results of our study revealed significantly shorter average hospital length of stay for the AA vs PA (4.2 vs 6.0 days respectively p-value 0.004). Interestingly, our study also showed significantly shorter operating time with the AA (83.0 vs 91.8 mins, P- Value 0.048) and lower return to theatre rates (0 vs 9.5% p-value 0.026). Finally, multi-variate analysis showed AA to be associated with higher HHS and pre-op Body Mass Index (BMI) to be associated with lower HHS at 12 months post op (P-value 0.02 and <0.001 respectively)

Conclusions

Our study showed improved HHS at 12 months as well as reduced hospital length of stay, operating time and return to theatre with an AA when compared with a PA.

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Introduction:

The minimally invasive anterior approach to total hip arthroplasty (Hueter approach) is a true internervous and inter-muscular approach. This approach is said to be less injurious to soft tissue with less post-operative pain[1]. Furthermore the literature has shown a potential for reduced blood loss, shorter hospital stay and reduced post-operative pain[2 3].

While recent research has focused on comparing outcomes of anterior hip replacement with the lateral Hardinge approach[6 9 10], studies comparing an anterior approach to a posterior one are scarce. The main advantage of the posterior approach is that it provides a better view of the entire hip and surrounding structures. It is also highly extensile and can be used for difficult primary and complex revision cases. Moreover, the posterior approach to the hip remains one of the most widely used approaches today.

The aim of this study was to compare the clinical and one year post operative functional outcomes of total hip arthroplasty performed via an anterior and a conventional posterior approach.

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Method:

Patients

This study was conducted at a 460-bed university affiliated tertiary referral central metropolitan hospital. We retrospectively reviewed a total of 92 cementless (50 anterior, 42 posterior) total hip replacements performed between January 2006 to December 2011 for osteoarthritis. The study was approved by the Human Research Ethics Committee of St. Vincent's Hospital Melbourne.

Data included patient age, gender, Body Mass Index (BMI), American Society of Anaesthesiologists (ASA) score, anaesthetic type, operating time, length of stay, discharge destination, complications as well as pre and one year post-operative range of motion, HHS and SF-12 score, which was extracted from the St. Vincent's Melbourne Arthroplasty Outcomes (SMART) Registry. In brief the SMART Registry prospectively collects detailed information on all patients undergoing hip and knee TJA at the study center, including patient demographics, co-morbidities, as well as information about their surgery, their postoperative course and complications. A minimum of twelve months follow up data

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is recorded for >98% of patients in this database. HHS and the SF12 score were completed by patients at their pre-admission clinic for surgery and at the one year follow up period.

Surgical Technique/Implants

Anterior approach

Patients were positioned using the Medacta© Traction table with the operated leg in 10 -20 degrees of internal rotation. An intermuscular approach between tensor fascia lata and sartorius was then made. The technique utilised has been previously described by Fredrick Laude[11]. Anterior hip replacements were conducted by two surgeons during the time period using a *Quadra®-H (Medacta)* cementless stem in Titanium-Niobium alloy with hydroxyapatite *coating.* A Versafit (Medacta) cementless acetabular component was utilised for all anterior hips. A metal on polyethylene bearing surface was used.

Anterior hip replacements were first conducted at our institution in July 2008 and our results incorporated the learning curve of one of our surgeons. The second surgeon was trained in an overseas institute where anterior hips were performed routinely, and as such their results did not incorporate a learning curve.

Posterior approach

The posterior approach to total hip arthroplasty was done with the patient in a lateral position via an incision 7cm above and posterior to the greater trochanter (GT) which curved down the shaft of the femur posterior to the GT. The fascia lata was incised to uncover vastus lateralis distally. The fibres of gluteus maximus were split, with piriformis, obturator internus and the short external rotators

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detached close to the femoral insertion. These muscles were collectively reflected to expose the hip capsule.

We included posterior hip replacements conducted by 6 surgeons with similar operating experience to that of our surgeons from the anterior hip replacement cohort. In this group, an Alloclassic-SL (Zimmer) cementless femoral component with an Allofit (Zimmer) cementless acetabular cup was used. A metal on polyethylene bearing surface was used. We utilised this prosthesis for comparison as it provided a cementless prosthesis which had the largest usage at our institution and thus a conservative comparison to the anterior approach. Moreover by using this prosthesis for comparison we were able to include a larger number of operations performed by a consultant surgeon as opposed to junior members of staff.

Post Operative Treatment

A standardised post-operative medical, nursing and allied health rehabilitation regimen was utilised amongst both groups. Post operatively patients were allowed to weight bear as tolerated and administered parenteral opiate analgesia via patient controlled analgesia device and then converted to oral long acting analgesia with breakthrough short acting analgesia as required. Anti-emetic medication was also prescribed as required. Patients in both groups were mobilised on day 1 post operatively with a view to discharge home on Day 4. An indwelling urinary catheter was inserted in all patients in theatre, under sterile conditions, and was removed on Day 2 or once patients were safely mobilising, whichever came first. Furthermore each patient received 24hrs of IV cephazolin. For patients with a penicillin allergy Vancomycin was given. Each patient received low molecular weight heparin as well as anti-embolic stockings for deep vein thrombosis prophylaxis during hospitalisation.

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Statistical Analysis

Variables were summarized as mean and standard deviation [mean (SD)] for continuous variables, and proportions (percentages) for categorical variables. Associations between the outcome of interest (HHS at 12 months) and predictor variable (surgical approach) were initially examined in univariate analyses. Analysis of covariates included: age, gender, body mass index (BMI) ASA Score, aetiology (OA versus AVN), femoral head size and baseline general health was measured by the SF-12 physical composite scale (PCS) and mental composite scale (MCS). Covariates with $p<0.1$ (in the univariate analyses) were entered into each multiple linear regression model to evaluate the relationship between surgical approach and HHS, SF-12 PCS and MCS at 12 months. Non-significant variables were removed sequentially from individual regression models, leaving significant predictors for each outcome. In addition to approach, all models were adjusted for baseline HHS, age and gender. Results of linear regression were presented as a coefficient (parameter estimate) for each independent variable, with corresponding 95% confidence interval (95% CI) and p value. P values ≤ 0.05 were deemed statistically significant. Analyses were performed using SPSS for Windows version 21.0 (SPSS Inc., Chicago, Illinois)

Results

In total, 1610 primary total hip replacements were performed at our institution between January 2006 and December 2011. Of these 646 were performed via a posterior approach. From this group there were a large number of exclusions from this study. These were:

I. patients who had bilateral hip replacements,

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II. post-operative diagnosis of anything other than osteoarthritis or AVN

III. surgery completed by a someone other than a consultant orthopaedic surgeon (i.e. registrar or junior medical staff)

IV. patients where a prosthesis other than those pre-selected was used

This left a total of 42 patients in our posterior group. Of the 51 patients who had anterior hip replacements during our study period only one patient was excluded for a pre-operative diagnosis of rheumatoid arthritis.

Consequently a total of 50 patients in the anterior group and 42 patients in the posterior group were included in our final analysis.

Baseline demographic data and clinical characteristics of the two groups are presented in Table 1. There was no statistically significant differences in BMI, ASA score, type of anaesthetic used, pre-op HHS and SF-12 Mental scores. Importantly however, the anterior group had a statistically significant older population 62.5 (9.0) vs 57.0 (12.8), p-value: 0.018 but with higher pre-op SF-12 Physical scores (28.48 (5.6) vs 25.0 (5.1) vs, p-value: 0.003).

Clinical outcomes

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Table 2 highlights the differences in clinical outcomes between total hip replacement via an anterior and posterior approach. There was a statistically significant difference in length of stay; with those patients in the anterior group having an average length of hospital stay of 4.2 (1.4) days compared with 6.0(4.0) days in the posterior group (p-value= 0.004). Of note, there also a small difference in operating time between the anterior and posterior groups (83.0 mins (17.53) vs 91.8mins (24.44) respectively, p-value= 0.048). In addition, there was a lower rate of return to theatre in the anterior group 0% vs 9.5% (p-value 0.026). The reasons for return to theatre in the posterior group included joint infection, haematoma, prosthetic dislocation and superficial wound infection.

Functional outcomes (Unadjusted)

At 12 months HHS were 87.5 (16.1) for the anterior Group and 78.0 (19.9) for the posterior Group, (p=0.051). SF-12 Physical Scores were 44.7 (11.) for the anterior Group compared to 39.6 (13.9) for the posterior Group, (p=0.061). There was no significant difference in 12 month SF-12 Mental Health Scores at 12 months (Table 2). Regression analysis demonstrated that an anterior approach was associated with superior HHS (coefficient 8.5; p=0.020) at 12 months, when adjusted for baseline scores, age and gender (Table 3). In contrast, a higher BMI was associated with inferior HHS (coefficient -1.07, p<0.001) at 12 months.

Discussion

The results of our study showed the anterior approach to have significantly shorter length of stay, operating time and reduced return to theatre rates than the posterior group. This study was a retrospective review of clinical and functional outcomes comparing anterior and posterior approaches to total hip arthroplasty and as such has limitations, including the relatively small sample size of our cohort. Moreover, while we attempted to match surgeon experience between the

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groups, only one surgeon had patients in both groups which introduces a potential source of bias. There was greater potential for variance in surgical technique in the posterior group given there was 6 surgeons performed the surgeries in this group. This included the fact that there were screws utilised for the acetabulum only in the posterior group which may reflect a more conservative approach by this cohort, given the statistically older age group in the anterior group. Furthermore, our study did not include any measure of leg length discrepancy between the two groups, one of the most common reasons for litigation post hip arthroplasty [23] [24] [25]. An inherent difficulty with the nature of retrospective studies is lack of blinding and as such patient outcomes may be influenced by knowledge of their treatment modality. This potential bias also importantly extends into the data collectors who were also unblinded to the approach utilised. This was due to the fact that parts of the data were collected by physiotherapy staff who were required to look at post-operative notes to ensure any potential restrictions were observed. The two groups were not matched and consequently the anterior group were older with worse pre-operative SF-12 physical scores, potentially under-representing the benefit of the anterior approach. Lastly, retrospective based cohort studies are vulnerable to selection bias and thus future research will require suitably large randomised control trials before any definitive conclusions may be reached.

Prior research has been centred on comparisons with a minimally invasive direct lateral approach, given its limited muscular trauma. Berend et al.[6] revealed a significant increase in patient's being discharged directly home compared to a direct lateral approach. The lower extremity score and the HHS were significantly higher in the anterior approach at 6 weeks post operatively. Similarly Wayne et al.[10] revealed shorter hospital stay and lower operative site infection rates with the anterior group. However, the anterior group did have significantly longer operative times, higher bleeding rates, nerve damage and greater percentage of malpositioned acetabular components. To our

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knowledge, Ilchmann et al.[12] is the only study to compare longer term functional outcomes of anterior versus lateral approaches to hip replacement. This was a prospective cohort study which included a total of 255 patients (142 lateral, 113 anterior). The study highlighted superior HHS scores and patient satisfaction at 6 weeks, 12 weeks and 1 year for the anterior group (which incorporated the surgeon's learning curve), however results did not reach statistical significance at the 2 year follow up. Furthermore, in keeping with prior research utilising HHS, the minimal clinically significant difference of this score has been suggested as between 4 and 10 points, [26 27]suggesting the 7.5 point increase in HHS for the anterior group to be clinically significant.

One of the unique aspects of our research was the analysis of medium term functional outcomes between anterior and posterior approaches to total hip replacement surgery. Our results showed that at the one year follow up period an anterior approach correlated with superior HHS compared to a posterior approach. We suggest that this improvement is a consequence of less soft tissue and muscle trauma. Bremer et al[9]. conducted a retrospective MRI study at 1 year post operatively to reveal significantly less frequent detachment of the abductor insertion, partial tears and tendonitis of gluteus medius and minimus, lower presence of peri-trochanteric bursal fluid and fatty atrophy of gluteus medius and minimus with an anterior approach when compared to a standard transgluteal one. Future research utilising gait analysis, may provide an insight into the earlier recovery associated with an anterior approach, as previously explored by Lugade et al.[13] This research revealed improved internal and external rotation with an anterior approach compared to a posterior one.

Whilst the Australian National Joint Replacement Registry lacks data about approach utilised, the posterior total hip replacement is still the most common approach performed at our institution.

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However, research comparing this method of hip arthroplasty with an anterior approach is scarce. A recent retrospective study by Martin et al.[14] examined short term post-operative outcomes and showed a significant reduction in hospital stay and days to mobilisation with an anterior approach. In contrast to our results, this approach was associated with a higher lateral femoral cutaneous nerve neuropraxia and longer operative time in comparison with a conventional posterior approach, reasons for which we will discuss subsequently. One of the major limitations of the study by Martin et.al was a considerably higher BMI in the posterior group, compared to the anterior group (34.1 vs 28.5 P<0.001), raising the distinct possibility of selection bias within the trial. In our study, BMI was comparable between the two groups and we found that a higher BMI was an independent predictor of inferior functional outcome at 12 months.

In keeping with the study by Martin et al.[14] our study did find a significantly shorter length of hospital stay with the anterior approach when compared to a posterior approach. This improvement in post operative hospital duration has also been shown in comparisons with a direct lateral approach [10 12]. We believe that this reduction is due to the smaller incision site, as well as the aforementioned reduction in soft tissue and muscle trauma, aiding in patients mobilising earlier. Field et al.[15] also reported quicker recovery of independent walking, distance walking, balance control and better stance phase stability with an anterior approach than with a posterior one. In addition, Alecci et al.[16] highlighted that reduced post-operative pain and blood loss with an anterior approach may have contributed to significantly shorter length of hospital stay when comparing anterior to lateral total hip replacements.

Contrary to previous research[17,], our study revealed a shorter operative time and return to theatre within the anterior approach cohort. This difference may be attributed to the fact that there is less

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layers to close with the anterior approach, and possibly due to the fact there is no muscular repair via transosseous sutures. In addition screws were commonly used in fixation of the acetabular component in our posterior group whereas this did not occur in the anterior group and this may have further contributed to the time difference.

Our research incorporated the "learning curve" associated with this new minimally invasive approach for one of our surgeons. Previous research has highlighted higher complication rates and longer theatre time in a low volume setting during the so called "learning curve" period[18 19] and therefore our results may well be a conservative estimate of the benefits of this new approach. Research by De Steiger et al. has shown the learning curve for anterior hip replacement to be approximately 50 cases[20]. Significantly, there were no cases of lateral femoral cutaneous nerve neuropraxia and only 1 case of iatrogenic femoral fracture (greater trochanter – non operative management) in the study group which has been a previously well-documented complication of anterior approach hip replacement [21 22]

Conclusions

Our study showed improved HHS at 12 months as well as reduced hospital length of stay, operating time and fewer complications requiring return to theatre with an anterior approach to total hip replacement when compared with a posterior approach. The anterior approach appears to be a safe and comparable alternative to a posterior approach when performing routine elective total hip replacement.

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Table 1: Baseline characteristics of two groups (mean results where applicable)

	Anterior (n=50)	Posterior (n= 42)	P-value
Age	62.5, (9.01)	57.0 (12.84)	0.02
Male : Female	30:30	14:28	0.01
Body Mass Index (Kg/m^2)	31.3 (5.2)	29.9 (6.7)	0.27
ASA Score	2.2 (0.7)	2.2 (0.7)	0.99

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Anaesthetic Spinal General Combined	 39 7 4	 37 3 2	 0.24
Pre-op HHS	38.2 (11.5)	35.2 (12.3)	0.23
Pre-op SF-12 PCS	28.5 (5.59)	25.0 (5.1)	0.01
Pre-op SF-12 MCS	44.9 (10.9)	44.3 (12.5)	0.40

Table 2: Post-operative clinical and patient outcomes (mean results where applicable)(Unadjusted)

	Anterior	Posterior	P-value
Operating Time (mins)	83.0 (17.5)	91.79 (24.4)	0.05
Length of stay (days)	4.2 (1.4)	6.0 (4.0)	0.01
Discharge destination Home Rehabilitation	 40 10	 33 9	 0.87

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Significant complication (%) ***	16.0	19.0	0.70
Readmission to hospital (%)	4.0	9.5	0.295
Return to theatre (%)	0	9.5	0.03
12m HHS	87.5 (16.1)	79.95 (19.9)	0.05
12m SF-12 PCS	44.7 (11.4)	39.6 (13.9)	0.06
12m SF-12 MCS	53.5 (11.4)	51.6 (10.0)	0.43

*** Significant complication is defined as a complication which required treatment, readmission to hospital, return to theatre or delayed discharge

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Table 3: Multivariable-adjusted association of 12 month Harris Hip Scores

	Univariate Analysis		Multivariate Analysis	
Variable	**Beta coefficient (95% CI)**	**P value**	**Beta coefficient (95% CI)**	**P Value**
Age	-0.1 (-0.5, 0.2)	0.49	-0.1 (-0.4, 0.2)	0.48
Female	-4.9 (-12.5, 2.7)	0.21	2.0 (-5.1, 9.0)	0.58

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BMI	-1.2 (-1.8, -0.6)	<0.01	-1.07 (-1.62, – 0.51)	<0.01
Etiology	1.8 (-4.9, 8.5)	0.60	Removed	
Anterior Approach	7.5 (-0.2, 15.1)	0.05	8.49 (1.38, 15.60)	0.02
ASA Score	-6.5 (-11.8, – 1.3)	0.02		NS
Femoral Head Size	-0.9 (-2.2, 0.4)	0.16	Removed	
Pre Harris Hip Score	0.7 (0.4, 1.0)	<0.01	0.51 (0.22, 0.80)	0.01
Pre SF12 PCS	0.8 (0.2, 1.5)	0.01		NS
Pre SF12 MCS	0.5 (0.2, 0.8)	0.01		NS

*Beta Coefficient represents the magnitude of change in 12month HHS with each unit increase of BMI and for anterior compared to posterior approach (when adjusted for baseline HHS)

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Conflict of Interest

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Mr. Anthony Dunin has received consultancy fees from Medacta in carrying out cadaver workshops.

References

[1] Pfirrmann CW, Nötzli 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;235:969-76.

[2] Chimento GF, Pavone V, Sharrock N, Kahn B, Cahill J, Sculco TP. Minimally invasive total hip arthroplasty: a prospective randomized study. J Arthroplasty. 2005;20:139-44.

[3] Kennon RE, Keggi JM, Wetmore RS, Zatorski LE, Huo MH, Keggi KJ. Total hip arthroplasty through a minimally invasive anterior surgical approach. J Bone Joint Surg Am. 2003;85 Suppl 4:39-48.

[4] Berger RA. Total hip arthroplasty using the minimally invasive two-incision approach. Clin Orthop Relat Res. 2003;417:232-41.

[5] Kim YH. Comparison of primary total hip arthroplasties performed with a minimally invasive technique or standard technique: a prospective and randomized study. J Arthroplasty. 2006;21:1092-8.

[6] Berend K, Lombardi A, Seng B, Adams J. Enhanced early outcomes with the anterior supine intermuscular approach in primary total hip arthroplasty. *The Journal Of Bone And Joint Surgery. American Volume* [serial online]. November 2009;91 Suppl 6:107-120

[7] Matta JM, Shahrdar C, Ferguson T. Single-incision anterior approach for total hip arthroplasty on an orthopaedic table. Clin Orthop Relat Res. 2005;441:115-24.

[8] Siguier T, Siguier M, Brumpt B. Mini-incision anterior approach does not increase dislocation rate: a study of 1037 total hip replacements. Clin Orthop Relat Res. 2004;426:164-73.

[9] Bremer AK; Kalberer F; Pfirrmann CW; Dora C, Standard Transgluteal *versus* Minimal Invasive Anterior Approach in hip Arthroplasty: A Prospective, Consecutive Cohort Study**,** The Journal Of Bone And Joint Surgery. British Volume [J Bone Joint Surg Br], ISSN: 0301-620X, 2011 Jul; Vol. 93 (7), pp. 886-9;

[10] Wayne N, Stoewe R. Primary total hip arthroplasty: a comparison of the lateral Hardinge approach to an anterior mini-invasive approach. *Orthopedic Reviews* [serial online]. January 2009;1:79-84

[11] Laude F, Dora C. Anterior Minimally Invasive Surgery Surgical Technique Handbook Medacta. www.medacta.com

[12] Ilchmann T, Gersbach S, Zwicky L, Clauss M. Standard transgluteal versus minimal invasive anterior approach in hip arthroplasty: a prospective, consecutive cohort study. *Orthopedic Reviews* [serial online]. October 2013;5(4):133-137

[13] Lugade V, Wu A, Jewett B, Collis D, Chou L. Gait asymmetry following an anterior and anterolateral approach to total hip arthroplasty. Clinical Biomechanics. 2010;(7):675.

[14] Martin, C., Pugely, A., Gao, Y., & Clark, C. A Comparison of Hospital Length of Stay and Short-term Morbidity Between the Anterior and the Posterior Approaches to Total Hip Arthroplasty. *Journal Of Arthroplasty*, *28*(5), 849-854.

[15] Field, R. *Prospective randomised trial comparing anterior versus posterior approach for total hip arthroplasty. BHS Manchester 2012*

[16] *Alecci V, Valente j. Comparison of primary total hip replacements performed with a direct anterior approach versus the standard lateral approach: perioperative findings. Orthop Traumatol. 2011 Sep; 12(3):123-9.*

This article is protected by copyright. All rights reserved.

[17] Spaans AJ, van den Hout JA, Bolder SB. High complication rate in the early experience of minimally invasive total hip arthroplasty by the direct anterior approach. Acta Orthop. 2012;83:342–346.
[18] Woolson ST, Pouliot MA, Huddleston JI. Primary total hip arthroplasty using an anterior approach and a fracture table: short-term results from a community hospital. J Arthroplasty. 2009;24:999–1005.
[19] Pogliacomi F, Paraskevopoulos A, Costantino C, Marenghi P, Ceccarelli F. Influence of surgical experience in the learning curve of a new approach in hip replacement: anterior mini-invasive vs. standard lateral. Hip International: The Journal Of Clinical And Experimental Research On Hip Pathology And Therapy. September 2012;22(5):555-561.
[20] Bhargava T, Goytia RN, Jones LC, et al. Lateral femoral cutaneous nerve impairment after direct anterior approach for total hip arthroplasty. Orthopedics 2010;33(7):472.
[21] de Steiger R, Lorimer M, Solomon M. What Is the Learning Curve for the Anterior Approach for Total Hip Arthroplasty?. Clinical Orthopaedics And Related Research [serial online]. September 22, 2015
[22]Seng BE, Berend KR, Ajluni AF, et al. Anterior-supine minimally invasive total hip arthroplasty: defining the learning curve. Orthop Clin North Am 2009; 40(3):343.
[23] Bose W. Accurate limb-length equalization during total hip arthroplasty. Orthopedics 2000; 23: 433-6.
[24] White T, Dougall T. Arthroplasty of the hip. Leg length is not important. J Bone Joint Surg Br 2002; 84: 335-8.
[25] Hofmann A, Skrzynski M. Leg-length inequality and nerve palsy in total hip arthroplasty: A lawyer awaits! Orthopedics 2000; 23: 943-4.
[26] Costa M, Achten J, Griffin D, et al. Total hip arthroplasty versus resurfacing arthroplasty in the treatment of patients with arthritis of the hip joint: single centre, parallel group, assessor blinded, randomised controlled trial. *BMJ: British Medical Journal* 2012:15
[27] Hoeksma H, Van den Ende C, Ronday H, Heering A, Breedveld F, Dekker J. Comparison of the responsiveness of the Harris Hip Score with generic measures for hip function in osteoarthritis of the hip. *Annals of the Rheumatic Diseases* 2003:935

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