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Annals of Orthopedics & Rheumatology

Research Article

The Effects of the Surgical Approach on the Postoperative Gait Mechanics Following Total Hip Arthroplasty

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Submitted: 15 July 2015

Accepted: 12 November 2015

Published: 13 November 2015

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Keywords

- Total hip arthroplasty
- Gait analysis
- WOMAC
- Harris hip score

Abstract

Introduction: Minimally invasive total hip arthroplasty (THA) is advertised to allow improved and faster rehabilitation due to reduced soft-tissue damage compared to THA performed with a standard transmuscular approach. The aim of this prospective Level II study was to analyze gait function after THA using 3 different approaches and 2 different types of prostheses.

Patients and Methods: Ten patients underwent THA through a minimally invasive anterior (n=5) or antero-lateral (n=5) approach using conventional ceramic-on-ceramic prostheses. In comparison, 8 metal-on-metal resurfacing arthroplasties were implanted through a posterior approach. An instrumented three-dimensional gait analysis was performed to evaluate gait function preoperatively, 6-weeks and 6-months postoperatively after implantation. The Harris Hip Score (HHS) and the Western Ontario and McMaster Universities Arthritis Index (WOMAC) were used to evaluate the functional clinical outcome.

Results: The pre- and postoperative gait analyses showed constantly all but one no differences between the three groups for gait parameters. Only the step length was significantly longer in case of anterior and posterior approach compared to the antero-lateral approach (p=0,025). The scoring systems (HHS, WOMAC) resulted in nearly identical pre- and postoperative scores with excellent functional outcome in all groups.

Conclusions: The current study indicates that there are no functional differences at 6-months follow-up for THAs performed through different approaches. The only difference at gait analysis performed 6-months following hip arthroplasty showed to be longer stride length for the anterior and posterior approach in comparison to the THA group performed through an antero-lateral approach.

ABBREVIATIONS

HHS: Harris Hip Score; WOMAC: Western Ontario and McMaster Universities Arthritis Index

INTRODUCTION

Total hip arthroplasty (THA) is known as a cost effective procedure for pain reduction and improvement of joint function especially in older, less active patients with approximately 85% of implant survival after 15- to 20-years. Persistent asymmetric limb loading after THA might lead to an overloading of the non-operated hip joint resulting in osteoarthritis of the contralateral limb or increase the risk of falls [1-3].

Resurfacing hip arthroplasty (RHA) became an accepted and widespread procedure for joint replacement, especially in young and physically active patients. Propagated advantages of this procedure were thought to be less bone resection, less stress shielding, more physiological femoral loading, lower risk of dislocation because of the larger head, less leg-length

discrepancy, higher range of motion, and easier revision [4].

Minimally invasive approaches to the hip are known to reduce soft tissue damages and therefore, they are supposed to provide earlier mobilization and rehabilitation of the patient in the early postoperative phase. Several studies reported functional outcome following THA using gait analysis as one of the most objective tools for postoperative data assessment [1,4-20]. Most of these studies demonstrated slower walking speed and smaller step length following THA. Further, reduced muscle strength (e.g. gluteal muscles) and reduced range of motion in the hip and knee joint, especially in case of extension in the late stance phase, are supposed to cause impairments of gait adaptation. Additionally, due to a more invasive surgical technique in case of RHA in comparison to conventional or minimally invasive THA, it is expected that the range of motion as well as the muscle strength would be more affected in the early postoperative phase.

The purpose of this prospective, Level II study was to investigate pre- and postoperative changes in gait symmetry in patients receiving a THA through a minimally invasive anterior or anterolateral approach or RHA through a posterior approach. We hypothesized functional differences present between patients who had undergone THA with the minimally invasive approaches (anterior and antero-lateral) and patients who had undergone RHA with a posterior approach.

MATERIALS AND METHODS

Patients

In the minimal invasive group five patients underwent THA through antero-lateral approach (modified Watson-Jones). Another five patients got THA through an anterior approach. In all these patients a conventional ceramic-on-ceramic device (Pinnacle/Corail, DePuy, Warsaw, IN) with 36 mm head diameter was used. For comparison, eight metal-on-metal resurfacing arthroplasties (ASR™, DePuy) were implanted through a posterior approach. All arthroplasties of all groups were implanted by one single senior orthopaedic surgeon (RW). Patients' demographics are shown in Table 1. Due to the small number of patients, we observed no statistically significant differences between both groups with respect to demographic data, only the femoral head size was statistically significant different between the groups with regard to the resurfacing device (Table 1).

Patients with pain or degenerative disease in the contralateral hip, previous arthroplasty in the lower extremity or any history of neurologic disease were excluded from the study.

All patients underwent the same rehabilitation protocol with a hospital therapist starting the day after surgery. The patients were allowed to walk with full weight bearing using crutches from the day after surgery. After discharge, all patients underwent a further outpatient rehabilitation program until their sixth week of follow-up.

In order to assess a subjective and an objective functional status, The Western Ontario and McMaster University Osteoarthritis Index (WOMAC) and Harris Hip Score (HHS) were completed pre- and postoperatively. An instrumented three-dimensional gait analysis was performed to evaluate gait function.

Gait analysis

Gait analysis was performed using a ten-camera motion capturing system (VICON MX; Oxford Metrics, Oxford, UK) and four force plates mounted under the walkway (AMTI) at four separate occasions: preoperatively, and 6 weeks, 3 and 6 months after hip arthroplasty. Marker arrangement, the calculation methods and model assumptions were applied according to Kadaba et al. [7]. A minimum of 15 walking trials along a 10-meter walkway were accomplished with a self-selected speed. For each patient a minimum of five valid trials, providing a clear foot force plate contact, were captured per limb. Calculations of kinematic parameters for the pelvis, hip, knee, and ankle joints as well as kinetic parameter calculations for the hip, knee, and ankle joint were performed using the Vicon Clinical Manager (VICON, Oxford Metrics). Moment and power parameters were normalized to the weight of the patients. Power generation and absorption patterns in the sagittal plane were calculated and labeled according to the method described by Winter et al. [21]. Pelvic kinematics, sagittal, frontal and transversal plane kinematics, and kinetic parameters of the hip, knee, and ankle joints, as well as time-distance parameters were set as outcome measurements in this study.

Statistical analysis

Statistical data analysis was performed with ANOVA analyses in order to compare the data between the different approaches regarding gait analysis parameters and scoring systems using PASW Statistics 16.0 program (SPSS Inc., Chicago, IL). A p-value less than 0,05 was considered to be statistically significant with a calculated power of 0.8. We performed post-hoc power analysis according to Hoenig and Heisey in case of significant differences [22]. All data are presented with mean ± standard deviation (SD).

The study was approved by the local ethics committee and fulfilled the Helsinki Declaration.

RESULTS

Comparing the MIS groups with the RHA group pre- and postoperative gait analyses at 6-weeks and 6-months follow-up showed all but one no statistical significant differences for gait function parameters (Figure 1, Table 2). Only the step length was statistically shorter in the antero-lateral group compared to the anterior and posterior approach group 6-months postoperatively (p=0,025, Table 2). Unsurprising in all three approach groups the postoperative function improved compared to the preoperative status (Figure 1).

In almost the same manner the scoring systems (HHS and WOMAC) resulted in identical advancement from pre- to postoperative findings within the different groups. Overall, there was an excellent functional outcome in all groups without any statistically significant difference (Table 3).

DISCUSSION

The current study showed that there is all but one no significant difference concerning gait function parameters 6-months postoperatively following THA using three different

Table 1: Demographic analysis of patients receiving total hip arthroplasty (THA) with a conventional, minimal invasive (1) antero-lateral or (2) anterior approach and patients receiving resurfacing hip arthroplasty (RHA) through a (3) posterior approach. All values are presented as mean results with their range. We observed no statistically significant differences at preoperative analysis.

	THA ant.-lat.	THA ant.	RHA post.	p-value
Number of patients	5	5	8	
Sex ratio (m:f)	2:3	4:1	5:3	
Mean age at operation	55 (46 to 67)	57 (49 to 68)	46 (35 to 61)	0.078
Mean BMI	27 (23 to 31)	25 (20 to 31)	26 (20 to 30)	0.765
Mean size cup	50 (48 to 52)	50 (48 to 54)	57 (50 to 64)	0.983
Mean size femoral head	34 (32 to 36)	34 (32 to 36)	50 (45 to 57)	<0.001

Abbreviations: THA: Total Hip Arthroplasty; RHA: Resurfacing Hip Arthroplasty; Ant: Anterior; Lat: Lateral; Post: Posterior

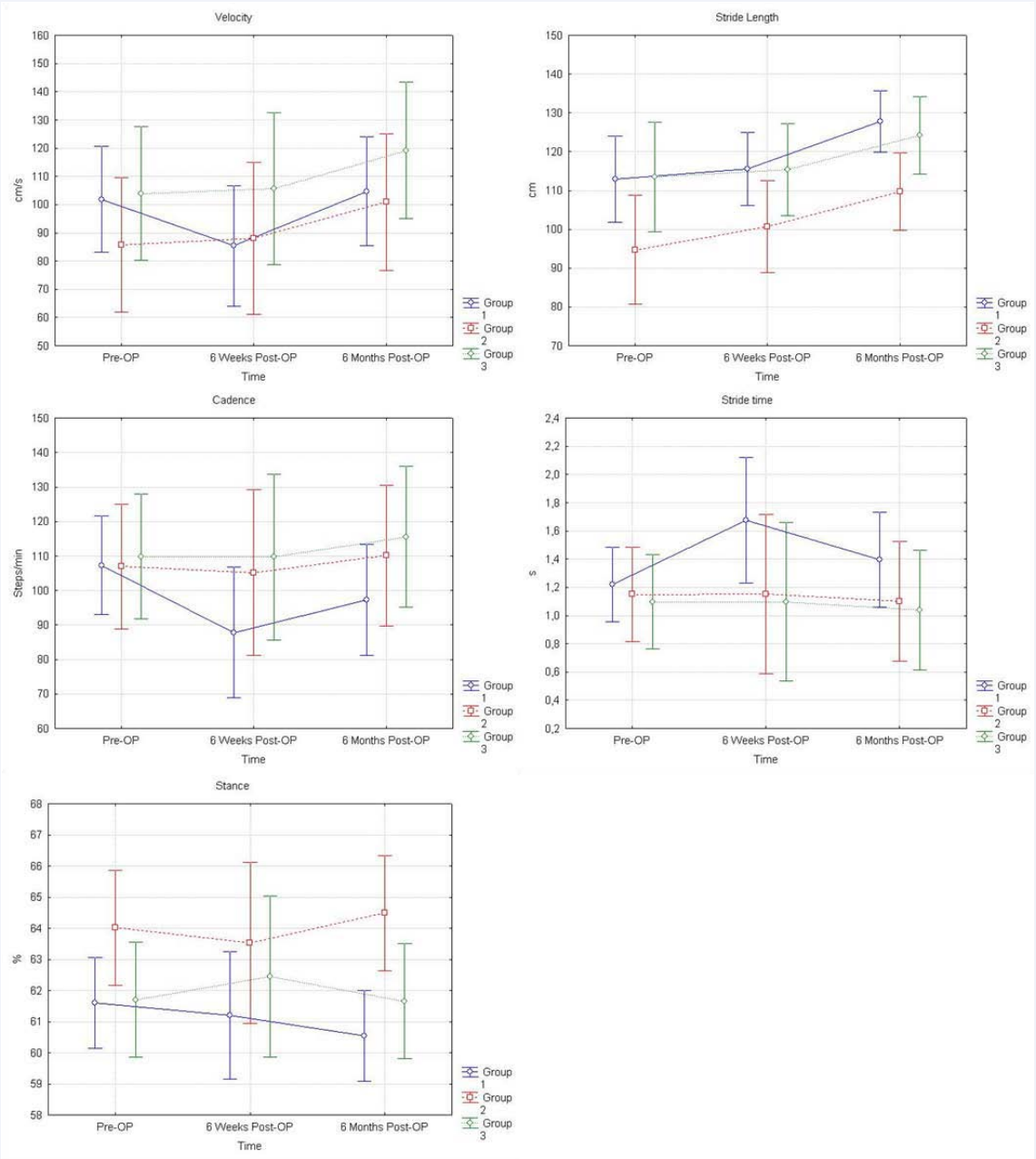

Figure 1 Graphics showing the results for the different gait function parameters (velocity, cadence, stride length, stride time and stance) preoperatively, 6-weeks as well as 6 months postoperatively, divided by approaches (group 1: RHA post.; group 2: THA ant.-lat.; group 3: THA ant.).

approaches. Only the stride length was significantly shorter in the antero-lateral approach conventional THA group compared to the anterior and the posterior group (Table 2). Nevertheless, there was an excellent functional outcome in all groups at a follow-up of 6-months.

Mont et al. [14] showed that hip kinematics and functionality returned to normal mostly in patients following RHA in comparison to patients receiving a conventional device. On the other hand, Peterson et al. [15] reported no statistically significant difference between a conventional THA group and RHA group concerning kinetic, kinematic, and temporal-spatial gait parameters 6 and 12 weeks following surgery. Only the peak abductor moments changed more in the conventional THA group, which might be explained due to the less invasive surgical procedure in this group [15]. Gore et al. [6] observed an advantage in muscle strength and velocity in the resurfacing group pre- and postoperatively in comparison to conventional THA due to younger and physically more active patients. Furthermore, Chen et al. [4] related similar outcomes following RHA and large head metal-on-metal THA implanted through a posterolateral approach 1 year postoperatively. Only the range of motion in patients following RHA was significantly better compared to the other group [4].

In the current series we could not find significant differences for the temporal-spatial gait function parameters between the different surgical approaches as reported by Queen et al. [20]. Only the stride length was statistically significant shorter in the antero-lateral THA group at 6-months of follow-up (Table 2). Several mechanisms could play a role to explain these results. Regardless of surgical approach, patients who suffer from osteoarthritis of the hip develop gait adaptations to relieve the pain. These adaptations causing weakness and atrophy of the surrounding muscles of the hip could persist postoperatively resulting in abnormal gait patterns. Consequently, the atrophic muscles are not able to produce same moments as the muscles of the not affected side. On the other hand, the differences between the groups could be explained by a selection bias due to the lack of randomization.

Abductor strength weakness has been shown to be responsible for step length asymmetry and reduced leg progression [1]. Klausmeier et al. [8] observed a continuous increase in hip abductor strength following THA through an anterior approach, while the anterolateral group dropped below preoperative levels at 6-weeks postoperatively. This could also be an explanation for the results of the current series. Krych et al. [9, 10] related an advantage in hip muscle strength for patients who had a mini-posterior THA over patients who had a two-incision THA two months and one year postoperatively. Rasch et al. [17] also showed a progressive recovery of muscular weakness and function 2 years following standard THA. We could also observe improvements for all gait function parameters in all groups postoperatively compared to the preoperative status (Table 2). This observation has also been proven by using the clinical scoring systems (Table 3).

Like in the current series, Lugade et al. [1], Lamontagne et al. [11] and Queen et al. [20] revealed that THA after three different approaches (anterior, anterolateral and lateralor posterior) reached the level of controls by several weeks postoperatively up to one year with reduced asymmetries between operated and non-operated limb. Only the anteriorly implanted group demonstrated improvements in symmetry at 6 weeks as well as 1 year after surgery when compared to pre-surgery [1,11]. On

Table 2: Temporal-spatial gait parameters following antero-lateral, anterior and posterior approach to the hip at 6 weeks, and 6 months postoperatively. Data are presented as means and standard deviation. The *p-values* indicate statistical differences between the groups at time of evaluation.

	THA ant.-lat. (n=5)	THA ant. (n=5)	RHA post. (n=8)	6 weeks	THA ant.-lat. (n=5)	THA ant. (n=5)	RHA post. (n=8)	6 months
Temporal-spatial variables	**mean (SD)**	**mean (SD)**	**mean (SD)**	**p-value**	**mean (SD)**	**mean (SD)**	**mean (SD)**	**p-value**
Velocity (cm/sec)	88.09 (9.98)	105.60 (20.05)	85.38 (37.74)	0.449	100.90 (12.49)	119.23 (12.97)	104.71 (34.73)	0.492
Cadence (steps/min)	105.20 (13.66)	109.70 (4.26)	87.85 (35.35)	0.282	110.16 (12.13)	115.56 (6.34)	97.28 (29.57)	0.313
Stride length (cm)	100.74 (5.29)	115.36 (20.62)	115.59 (8.54)	0.112	109.68 (2.07)	124.19 (16.13)	127.77 (9.14)	0.025
Stride time (sec)	1.15 (0.15)	1.09 (0.04)	1.67 (0.85)	0.740	1.10 (0.13)	1.03 (0.05)	1.39 (0.64)	0.566
Stance (% gait cycle)	63.52 (3.37)	62.44 (2.42)	61.20 (2.44)	0.385	64.49 (1.89)	61.65 (2.21)	60.54 (1.79)	0.084

Abbreviations: THA: Total Hip Arthroplasty; RHA: Resurfacing Hip Arthroplasty; Ant: Anterior; Lat: Lateral; Post: Posterior; SD: Standard Deviation

Table 3: Pre- and postoperative results of the Harris Hip Score (HHS) and the WOMAC Score. Statistical analysis revealed that there were no differences between the groups.

	THA ant.-lat.	THA ant.	RHA post.	p-value
Harris Hip Score				
- Preoperatively	46 (24 to 74)	57 (29 to 85)	46 (38 to 52)	0,422
- 6 weeks postoperatively	87 (70 to 93)	90 (84 to 99)	94 (84 to 100)	0,216
- 6 months postoperatively	98 (92 to 100)	98 (93 to 100)	99 (96 to 100)	0,630
WOMAC				
- Preoperatively	113 (75 to 137)	143 (60 to 228)	133 (96 to 154)	0,442
- 6 weeks postoperatively	19 (12 to 41)	11 (0 to 26)	13 (0 to 44)	0,715
- 6 months postoperatively	5 (0 to 14)	1 (0 to 5)	4 (0 to 12)	0,445

the other hand, Madsen et al. [12] and Beaulieu et al. [2] found that the majority of patients following THA had not returned to normal gait symmetry between 6 to 15 months postoperatively. Controversially, Chiu et al. [3] related a continuous recovery of inter-joint coordination pattern following THA and Queen et al. [20] suggested that restoration of gait is minimally affected by the approach itself.

Meneghini et al. [13], Pospischill et al. [16], Sander et al. [18], Ward et al. [19]and Queen et al. [20] reported no significant differences between minimally invasive and standard approaches as well as three different minimally invasive approaches with regard to the temporo-spatial gait parameters 6 and 12 weeks as well as 3 and 6 months following surgery. This could also be observed in the current study. Bennett et al. [5] and Dorr et al. [23] found no improvement in a minimally invasive group compared to a standard incision group. In both groups of each study, a posterior approach with different length of the skin incision was used. Therefore, no different functional outcomes should have been expected [5,23].

One limitation of the study could be the small group of patients included, which is split into three subpopulations. Nevertheless, we ruled out this limitation as statistical analysis showed significant differences between the patient groups and therefore reached adequate post-hoc power according to Hoenig and Heisey [22]. Furthermore, we compared three different surgical approaches with two different arthroplasty systems. This was chosen because the ceramic-on-ceramic THA was more suitable for the anterior and the antero-lateral approach and the metal-on-metal RHA more suitable for the posterior approach. Last we want to underline the significant benefit, that this is a single surgeon study, which elevates its scientific value.

CONCLUSION

For conclusion, gait analysis 6-months after THA showed not significant better gait function parameters for conventional THA implanted through a minimally invasive anterior or antero-lateral approach in comparison to metal-on-metal RHA performed through a posterior approach. Further, the current study indicates that there is no functional benefit at 6-months follow- up for resurfacing devices implanted through a posterior approach.

REFERENCES

1. Lugade V, Wu A, Jewett B, Collis D, Chou LS. Gait asymmetry following an anterior and anterolateral approach to total hip arthroplasty. Clin Biomech (Bristol, Avon). 2010; 25: 675-680.
2. Beaulieu ML, Lamontagne M, Beaulé PE. Lower limb biomechanics during gait do not return to normal following total hip arthroplasty. Gait Posture. 2010; 32: 269-273.
3. Chiu SL, Lu TW, Chou LS. Altered inter-joint coordination during walking in patients with total hip arthroplasty. Gait Posture. 2010; 32: 656-660.
4. Chen YS, Zhao S, Cao L, Zhang XL. Gait analysis of patients with metal-on-metal resurfacing hip arthroplasty compared with big-femoral-head total hip arthroplasty. Saudi Med J. 2011; 32: 394-399.
5. Bennett D, Ogonda L, Elliott D, Humphreys L, Beverland DE. Comparison of gait kinematics in patients receiving minimally invasive and traditional hip replacement surgery: a prospective blinded study. Gait Posture. 2006; 23: 374-382.
6. Gore DR, Murray MP, Gardner GM, Sepic SB. Hip function after total vs. surface replacement. Acta Orthop Scand. 1985; 56: 386-390.
7. Kadaba MP, Ramakrishnan HK, Wootten ME. Measurement of lower extremity kinematics during level walking. J Orthop Res. 1990; 8: 383-392.
8. Klausmeier V, Lugade V, Jewett BA, Collis DK, Chou LS. Is there faster recovery with an anterior or anterolateral THA? A pilot study. Clin Orthop Relat Res. 2010; 468: 533-541.
9. Krych AJ, Pagnano MW, Coleman Wood K, Meneghini RM, Kaufman K. No strength or gait benefit of two-incision THA: a brief followup at 1 year. Clin Orthop Relat Res. 2011; 469: 1110-1118.
10. Krych AJ, Pagnano MW, Wood KC, Meneghini RM, Kaufmann K. No benefit of the two-incision THA over mini-posterior THA: a pilot study of strength and gait. Clin Orthop Relat Res. 2010; 468: 565-570.
11. Lamontagne M, Varin D, Beaulé PE. Does the anterior approach for total hip arthroplasty better restore stair climbing gait mechanics? J Orthop Res. 2011; 29: 1412-1417.
12. Madsen MS, Ritter MA, Morris HH, Meding JB, Berend ME, Faris PM, et al. The effect of total hip arthroplasty surgical approach on gait. J Orthop Res. 2004; 22: 44-50.
13. Meneghini RM, Smits SA, Swinford RR, Bahamonde RE. A randomized, prospective study of 3 minimally invasive surgical approaches in total hip arthroplasty: comprehensive gait analysis. J Arthroplasty. 2008; 23: 68-73.
14. Mont MA, Seyler TM, Ragland PS, Starr R, Erhart J, Bhave A. Gait analysis of patients with resurfacing hip arthroplasty compared with hip osteoarthritis and standard total hip arthroplasty. J Arthroplasty. 2007; 22: 100-108.
15. Petersen MK, Andersen NT, Mogensen P, Voight M, Søballe K. Gait analysis after total hip replacement with hip resurfacing implant or Mallory-head Exeter prosthesis: a randomised controlled trial. Int Orthop. 2011; 35: 667-674.
16. Pospischill M, Kranzl A, Attwenger B, Knahr K. Minimally invasive compared with traditional transgluteal approach for total hip arthroplasty: a comparative gait analysis. J Bone Joint Surg Am. 2010; 92: 328-337.
17. Rasch A, Dalén N, Berg HE. Muscle strength, gait, and balance in 20 patients with hip osteoarthritis followed for 2 years after THA. Acta Orthop. 2010; 81: 183-188.
18. Sander K, Layher F, Babisch J, Roth A. [Evaluation of results after total hip replacement using a minimally invasive and a conventional approach. Clinical scores and gait analysis]. Z Orthop Unfall. 2011; 149: 191-199.
19. Ward SR, Jones RE, Long WT, Thomas DJ, Dorr LD. Functional recovery of muscles after minimally invasive total hip arthroplasty. Instr Course Lect. 2008; 57: 249-254.
20. Queen RM, Butler RJ, Watters TS, Kelley SS, Attarian DE, Bolognesi MP. The effect of total hip arthroplasty surgical approach on postoperative gait mechanics. J Arthroplasty. 2011; 26: 66-71.

21. Winter DA. Energy generation and absorption at the ankle and knee during fast, natural, and slow cadences. Clin Orthop Relat Res. 1983; 147-154.

22. Hoenig JM, Heisey DM. The Abuse of Power. The Pervasive Fallacy of Power Calculations for Data Analysis. The American Statistician. 2001; 55: 19-24.

23. Dorr LD, Maheshwari AV, Long WT, Wan Z, Sirianni LE. Early pain relief and function after posterior minimally invasive and conventional total hip arthroplasty. A prospective, randomized, blinded study. J Bone Joint Surg Am. 2007; 89: 1153-1160.

Cite this article

Maurer-Ertl W, Friesenbichler J, Svehlik M, Holzer L, Sadoghi P, et al. (2015) The Effects of the Surgical Approach on the Postoperative Gait Mechanics Following Total Hip Arthroplasty. Ann Orthop Rheumatol 3(4): 1056.