Eklem Hastalıkları ve Cerrahisi
Joint Diseases and Related Surgery

Clinical Study / *Klinik Çalışma*

Eklem Hastalık Cerrahisi
2010;21(2):86-90

Gait symmetry in patients with unilateral partial hip arthroplasty

Tek taraflı kısmi kalça artroplastili hastalarda yürüme simetrisi

Ö. Fuad Öken, M.D.,[1] Öznur Öken, M.D.,[2] A. Özgür Yıldırım, M.D.,[1] Güneş Yavuzer, M.D.,[3] Murat Gülçek, M.D.,[1] Vuslat Sema Ünal, M.D.,[1] Ahmet Uçaner, M.D.[1]

[1]Department of 1st Orthopedics and Traumatology, Ankara Numune Training and Research Hospital, Ankara, Turkey;
[2]Department of Physical Medicine and Rehabilitation, Ankara Physical Medicine and Rehabilitation Education and Research Hospital, Ankara, Turkey;
[3] Department of Physical Medicine and Rehabilitation, Medicine Faculty of Ankara University, Ankara, Turkey

Objectives: In this study gait deviations symmetry and asymmetry in patients with unilateral partial hip arthroplasty was determined.

Patients and methods: Gait characteristics and time since operation (11.9±6.1; range 7 to 29 months) of 16 patients (9 females, 7 males; mean age 61.5±16.5 years; range 27 to 86 years) with unilateral partial hip arthroplasty were evaluated. Ten healthy volunteers (3 females, 7 males; mean age 54.1±11.9 years; range 35 to 65 years) were included in the study as control group. Quantitative gait data was collected with the Vicon 370 System (Oxford Metrics, Oxford, UK). Spatio-temporal (walking velocity, cadence, step time, step length, double support time) and kinematic (joint rotation angles of pelvis and hip in sagittal plane) data were processed by using Vicon Clinical Manager software package. Spatio-temporal and kinematic gait symmetry indices of both groups were calculated.

Results: Spatio-temporal and kinematic gait characteristics, but not the symmetry indices, of patients with unilateral partial hip arthroplasty were different from the control group (p>0.05).

Conclusion: Findings of this study reveal that patients with unilateral partial hip arthroplasty had various gait deviations compared to healthy subjects, but that symmetry was preserved.

Key words: Femoral neck fractures; gait characteristics; partial hip artroplasty; symmetry index.

Amaç: Bu çalışmada, tek taraflı kısmi kalça artroplastili hastalarda yürüme bozuklukları, simetri ve asimetri saptandı.

Hastalar ve yöntemler: Tek taraflı kısmi kalça artroplastisi yapılan 16 hastanın (9 kadın, 7 erkek; ort. yaş 61.5±16.5 yıl; dağılım 27-86 yıl) yürüyüş karakteristikleri ve ameliyattan sonra geçen süre (11.9±6.1 ay; dağılım 7-29 ay) değerlendirildi. On sağlıklı gönüllü (3 kadın, 7 erkek; ort. yaş 54.1±11.9; dağılım 35-65 yıl) kontrol grubu olarak çalışmaya dahil edildi. Kantitatif yürüyüş verileri, Vicon 370 System (Oxford Metrics, Oxford, UK) kullanılarak toplandı. Spatio-temporal (yürüme hızı, kadans, adım zamanı, adım uzunluğu, çift destek zamanı) ve kinematik (sagittal planda pelvis ve kalçanın eklem rotasyon açıları) veriler, Vicon Clinical Manager yazılımı kullanılarak değerlendirildi. Her iki gruptaki hastalarda, spatio-temporal ve kinematik yürüme simetri indeksleri hesaplandı.

Bulgular: Tek taraflı kısmi kalça artroplastili hastaların spatio-temporal ve kinematik yürüme karakteristikleri kontrol grubundakinlerden farklıydı ancak simetri indeksleri açısından fark yoktu (p>0.05).

Sonuç: Bu çalışmanın sonuçları, tek taraflı kısmi kalça artroplastili hastaların sağlıklı bireylerle karşılaştırıldığında çeşitli yürüme bozukluklarına sahip olduklarını, ancak yürüme simetrilerinin korunduğunu göstermiştir.

Anahtar sözcükler: Femur boyun kırığı; yürüme özellikleri; kısmi kalça artroplastisi; simetri indeksi.

Replacement of the femoral head in displaced femoral neck fractures and unstable intertrochanteric fractures has best been accomplished with partial hip arthroplasty (PHA) in elderly patients. To allow immediate postoperative weight-bearing, we have advocated the use of prosthetic arthroplasty.[1,2] Development of a technique for minimally invasive surgery in hip arthroplasty

• *Received: December 22, 2009 Accepted: March 29, 2010*

• Correspondence: Ö. Fuad Öken, M.D. Serdar Sok., No: 70/3, 06170 Yenimahalle, Ankara, Turkey.
Tel: +90 312 - 508 51 01 Fax: +90 312 - 312 68 76 e-mail: fuadoken@yahoo.com

has evolution over the past decades.[3] In addition to a smaller skin incision, the advantages of this approach include a minimized need for soft-tissue dissection and decreased surgical exposure necessary to obtain accurate and reproducible femoral preparation.[4,5] The minimally invasive procedure involves not only a smaller cosmetic skin incision, but also preservation of the abductor muscle. The aim of care after surgery for hip fracture is to get people safely back on their feet and walking again.

Normal gait is an important indicator of functional recovery. After hip arthroplasty, many patients continue to exhibit abnormal gait patterns including decreased hip movements in sagittal and frontal planes as well as shorter stance time and step length than that of the non-operated limb.[6] It has been reported that patients with total hip arthroplasty (THA) showed great asymmetry in ground reaction forces.[6] Previous studies reported gait asymmetry following hip arthroplasty due to habitual antalgic movement patterns, leg length discrepancy or weakness of the hip muscles.[7-9] The ability to maintain single-limb support is an important determinant of gait stability. Antalgic gait is assumed to be related to a decreased ability to bear weight on the operated side.

Gait asymmetry leads to increased energy expenditure and risk of falls. Consequently, improvement in symmetry provides an important clinical marker of functionality. In spite of reports on gait asymmetry after THA, PHA is often neglected regarding gait asymmetry. The aim of this study was to determine gait symmetry in patients with partial hip arthroplasty who were operated on by using a minimally invasive anterolateral technique.

PATIENTS AND METHODS

Subjects

Sixteen patients (9 females, 7 males; mean age 61.5±15.6 years; range 27 to 86 years) with PHA using a minimally invasive antero-lateral technique were enrolled in the study. Mean ± standart deviation (SD) of time since operation was 11.9±6.1 (range 7-29) months. They had an unstable comminuted intertrochanteric fracture (AO/OTA type 31-A2), unstable and displaced femoral neck fractures, and non-union of femoral neck fracture (AO/OTA type 31-B3; Table I). Inclusion criteria for the study were: *(i)* more than six months since operation; *(ii)* ability to walk at least 10 m barefoot without a walking aid; *(iii)* no leg length discrepancy; *(iv)* no pain.

Minimally invasive antero-lateral (A-L) technique, in which abductor muscles and posterior capsule functions are preserved, was used for all patients. Gait characteristics of 16 patients (9 females, 7 males) with PHA were evaluated by quantitative gait analysis. The clinical characteristics of the patients were recorded from the medical charts.

Age and sex-matched 10 healthy volunteers (3 females, 7 males; mean age 54.1±11.9 range 35 to 65 years) were included as control group. The protocol was approved by the Hospital Ethics Committee.

Quantitative gait analysis

Quantitative gait data was collected with the Vicon 370 System (Oxford Metrics, Oxford, UK). Spatio-temporal (walking velocity, cadence, step time, step length, double support time) and kinematic (joint rotation angles of pelvis and hip in sagittal plane) data were processed using Vicon Clinical Manager software package. A typical gait trial was selected for each limb on the basis of consistency of spatio-temporal characteristics for assessments. Spatio-temporal and kinematic gait symmetry indices of both groups were calculated.

To quantify the extent of the spatio-temporal and kinematic asymmetry of gait pattern, the single-support time and the step length asymmetry ratio were calculated, as well as the maximum pelvic tilt degree associated with maximum flexion and extension values of the hip at stance and swing, as follows (6, 13, 15): asymmetry ratio = [1-(affected/unaffected)]. The greater these ratios, the greater the asymmetry.

Statistical analysis

Wilcoxon signed-rank test was used for comparison of operated and non-operated leg whereas non-operated leg and control group compared with Mann-Whitney U-test. Also, because our asymmetry ratio values were not homogenously distributed, groups were compared using the Mann-Whitney U-test for age, time-distance and kinematic parameters of the groups. Asymmetry ratio values are presented as mean ± SD. The significance level was set at 0.05. We analyzed the data using SPSS (Statistical

TABLE I

Demographic and etiologic data of the patients with partial hip arthroplasty

Case	Age/gender	Side	Pathology	Fracture classification (AO/OTA)	Time to gait analysis (months)
1	38/F	L	Non-union of femoral neck fracture	B3.2	12
2	54/F	R	Non-union of femoral neck fracture	B3.3	12
3	27/F	R	Non-union of femoral neck fracture	B3.2	11
4	57/M	R	Non-union of femoral neck fracture	B3.1	15
5	74/M	L	Femoral neck fracture	B2.2	29
6	42/F	R	Non-union of femoral neck fracture	B3.2	12
7	63/F	R	Femoral neck fracture	B2.2	29
8	74/M	R	Femoral neck fracture	B2.1	15
9	67/M	R	Femoral neck fracture	B2.2	18
10	63/F	R	Unstable intertrochanteric fracture	A2.2	19
11	86/F	L	Unstable intertrochanteric fracture	A2.1	7
12	67/F	L	Unstable intertrochanteric fracture	A2.1	18
13	73/M	R	Unstable intertrochanteric fracture	A2.1	28
14	75/M	R	Unstable intertrochanteric fracture	A2.1	27
15	74/M	R	Unstable intertrochanteric fracture	A2.1	26
16	67/F	R	Unstable intertrochanteric fracture	A2.2	27

AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen (Association for the Study of Internal Fixation)/Orthopaedic Trauma Association.

Package for Social Sciences) for Windows version 11.5 (SPSS Inc., Chicago, Illinois, USA).

RESULTS

There were no difference between operated and non-operated legs in terms of time-distance and kinematic parameters ($p<0.05$; Table II). However, patients with PHA had significantly slower walking speed, less cadence, shorter step length, a greater pelvic tilt and a smaller hip extension at stance phase than the healthy subjects.

In addition, asymmetry ratio of time-distance and kinematic parameters in patients with PHA were no different from the control group ($p>0.05$; Table II).

DISCUSSION

Most of the previous studies on gait after THA reported that gait symmetry was impaired. In contrast, findings of the current study reveal that although the patients with PHA had a slower walking velocity and less cadence than healthy subjects and walked with a bilaterally shortened step length, an increased pelvic tilt and an insufficient hip extension at stance phase, gait asymmetry was not observed.

These results were inconsistent with the limited number of previous studies. McCrory et al.[7] found greater asymmetry index of ground reaction forces than normal individuals.

TABLE II

Comparison of spatio-temporal and kinematic variables of pelvis and hip in both groups

	Operated leg (n=16)	Non-operated leg (n=16)	*p**	Control (n=10)	*p***
Walking velocity (m/s)	0.5±0.2	0.5±0.2	0.228	1±0.3	0.001
Step length (°)	0.3±0.1	0.3±0.1	0.797	0.6±0.1	0.001
Single support time (°)	0.4±0.1	0.4±0.1	0.964	0.4±0.1	0.212
Pelvic tilt (°)	20.3±10.8	20.0±10.7	0.875	5.2±4.7	0.001
Hip initial contact (°)	33.2±14.8	36.1±15.8	0.379	26.5±7.3	0.246
Hip extension (°)	9.9±12.5	7.1±12.7	0.179	1.3±0.7	0.001
Hip flexion at swing (°)	34.0±11.9	36.8±14.5	0.408	26.6±7.3	0.126

*: Wilcoxon test between operated and non-operated side; **: Mann Whitney U-test between operated leg and control group.

Notwithstanding, the type of the surgical procedure might have affected the outcome. Among the THA procedures, the A-L approach could affect the function of the gluteus minimus, gluteus medius, tensor fasciae latae, and vastus lateralis muscles, where the gluteus medius and gluteus minimus are responsible for control of pelvic obliquity during gait.[8] The posterolateral (P-L) approach affects the posterior joint capsule and external rotator muscle group, which is predominantly responsible for posterior and lateral stability of the hip joint.[8]

Madsen et al.[6] reported that at six months postoperatively, almost all of the patients with THA using an A-L approach showed an increased trunk inclination, reduced sagittal plane range of motion, and greater loading asymmetry. In contrast, several of the P-L patients exhibited a better gait pattern than the A-L approach.

Although we used the A-L approach, presumably due to the minimally invasive surgery procedure we didn't observe gait asymmetry.

In patients with unilateral hip OA, both pre- and post-THA surgery, gait dysfunctions and asymmetries have been seen.[10] Patients with hip OA preoperatively walk as antalgic pattern because of pain during the weight acceptance phase of walking and this habitual antalgic gait can be continued postoperatively. It has been reported that asymmetry of the range of hip motion persists 12 months after THA in patients with unilateral coxoarthropathy during free level walking.[11] One of the reasons why we didn't observe asymmetric gait pattern in the our study population could be that because our patients had undergone PHA following femoral fracture, they didn't acquire antalgic gait patterns.

Several studies[12-14] compared THA outcome between minimally invasive and standard incision techniques and reported no differences regarding the improvement in the gait kinematics with a step length asymmetry and abnormal gait pattern. They suggested that residual muscle weakness and atrophy due to arthritic pain prior to surgery could be as a possible reason of this. We didn't find gait asymmetry in our patients, and muscle weakness was minimal because of the minimally invasive PHA procedure which had a very small incision and very good exposure for the acetabulum and femur.[15] Also, minimally invasive surgical procedures involve less tissue disruption and therefore, less intraoperative bleeding as well as less postoperative pain.[16] In addition, by using the anterior minimally invasive technique, preserving the posterior capsule which is important for proprioception could have contributed to a more symmetrical gait.

None of the patients in the current study had leg length discrepancy which is the other factor contributing to asymmetric gait patterns following surgery.

This study is associated with several limitations. The study population was small and preoperative gait assessments of the patients were absent. Also, the patients included in the study already had no pain and leg length discrepancy, and so, symmetry could not be impaired in our patients.

In conclusion, findings of this study reveal that although patients with PHA had various deviations compared to healthy subjects, gait symmetry has been preserved. The absence of habitual antalgic gait patterns prior to surgery and leg length discrepancy as well as type of surgical procedure may have contributed to preserving gait symmetry following hip arthroplasty. Partial hip arthroplasty using minimally invasive procedures can be preferred in order to provide a symmetric gait pattern, but studies with more patients are needed.

REFERENCES

1. Sener M, Onar V, Kazlmoğlu C, Yağdi S. Mortality and morbidity in elderly patients who underwent partial prosthesis replacement for proximal femoral fractures. [Article in Turkish] Eklem Hastalik Cerrahisi 2009;20:11-7.
2. Harwin SF, Stern RE, Kulick RG. Primary Bateman-Leinbach bipolar prosthetic replacement of the hip in the treatment of unstable intertrochanteric fractures in the elderly. Orthopedics 1990;13:1131-6.
3. Hartzband MA. Posterolateral minimal incision for total hip replacement: technique and early results. Orthop Clin North Am 2004;35:119-29.
4. Sherry E, Egan M, Henderson A, Warnke PH. Minimally invasive techniques for total hip arthroplasty. J Bone Joint Surg [Am] 2002;84-A:1481.
5. Howell JR, Garbuz DS, Duncan CP. Minimally invasive hip replacement: rationale, applied anatomy, and instrumentation. Orthop Clin North Am 2004;35:107-18.
6. 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.
7. McCrory JL, White SC, Lifeso RM. Vertical ground reaction forces: objective measures of gait following

hip arthroplasty. Gait Posture 2001;14:104-9.
8. Long WT, Dorr LD, Healy B, Perry J. Functional recovery of noncemented total hip arthroplasty. Clin Orthop Relat Res 1993;288:73-7.
9. Bassey EJ, Littlewood JJ, Taylor SJ. Relations between compressive axial forces in an instrumented massive femoral implant, ground reaction forces, and integrated electromyographs from vastus lateralis during various 'osteogenic' exercises. J Biomech 1997;30:213-23.
10. Galea MP, Levinger P, Lythgo N, Cimoli C, Weller R, Tully E, et al. A targeted home- and center-based exercise program for people after total hip replacement: a randomized clinical trial. Arch Phys Med Rehabil 2008;89:1442-7.
11. Miki H, Sugano N, Hagio K, Nishii T, Kawakami H, Kakimoto A, et al. Recovery of walking speed and symmetrical movement of the pelvis and lower extremity joints after unilateral THA. J Biomech 2004; 37:443-55.
12. Bennett D, Ogonda L, Elliott D, Humphreys L, Lawlor M, Beverland D. Comparison of immediate postoperative walking ability in patients receiving minimally invasive and standard-incision hip arthroplasty: a prospective blinded study. J Arthroplasty 2007;22:490-5.
13. 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;23:374-82.
14. Lin DH, Jan MH, Liu TK, Lin YF, Hou SM. Effects of anterolateral minimally invasive surgery in total hip arthroplasty on hip muscle strength, walking speed, and functional score. J Arthroplasty 2007;22:1187-92.
15. Bertin KC, Röttinger H. Anterolateral mini-incision hip replacement surgery: a modified Watson-Jones approach. Clin Orthop Relat Res 2004;429:248-55.
16. Jerosch J, Theising C, Fadel ME. Antero-lateral minimal invasive (ALMI) approach for total hip arthroplasty technique and early results. Arch Orthop Trauma Surg 2006;126:164-73.