



ORIGINAL RESEARCH

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The evaluation of two different surgical approaches in total hip arthroplasty according to the patient satisfaction, plantar pressure distribution and trendelenburg sign

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Abstract

The aim of this prospective study was to analyze the results of two different surgical approaches for total hip arthroplasty as Trendelenburg sign, plantar pressure distribution with the help of dynamic pedobarography and clinical results by Harris Hip Score. A total of 28 patients who underwent unilateral total hip arthroplasty using two different types of lateral approach as conventional lateral Hardinge approach and intermuscular Hardinge approach described by Pai were included in this study. Plantar pressures have measured by EMED-SF pedobarography device and analysed by the help of a commercial software; that separates the foot to the four different parts which are called masks. Trendelenburg's sign has been estimated as grade 1 and grade 2 by the method which was described by Hardcastle and Nade. Clinical outcome was measured by comparing Harris Hip Scores pre-operatively and postoperatively at last clinic visit. In both groups after the two years from the surgery; total contact time has increased at the operation side when the results were compared before the surgery at the same side and at the other side after the surgery. Also when we looked at the first and second masks which show the significant part of the stance phase; contact areas have similarly increased and the changes at the peak pressures were similar as contact areas. In both groups Harris Hip score was increased significantly after the operation. This is the first study to compare two different lateral approaches by pedobarographic analysis, clinical evaluation and functional scoring. The functional and clinical early results are similar in both lateral hip approaches for total hip arthroplasty when superior gluteal nerve protection, conjoint tendon repair and postoperative rehabilitation have done well.

Keywords: Total hip arthroplasty, pedobarography, Trendelenburg's sign, Harris hip score, gait analyses

Introduction

The frequency of total hip arthroplasty treatment for the degenerative hip arthritis increases day by day. The main purpose of surgical treatment; to relieve the pain, provide functions to the joint and create a near normal hip range of motion. Many different surgical approaches have been described due to implant features and reasons of arthritis. Surgeon's experience is the main criteria for selecting the approach type. Partial advantages such as preventing prosthesis dislocation, protecting the adductor muscle function and providing the best view of acetabulum effect the preference [1].

The biomechanics of the hip should be well known to better understanding of the complications as dislocation, corrosion, loosening and creating the anatomical and physiological features as near normal hip [2]. Protecting the strength and function

of the abductor mechanism is extremely important in implant biomechanics. Traditionally isokinetic dynamometer is used in the assessment of quantitative abductor muscle strength. In recent years, gait analysis is said to be a easy and practical method in literature. Dynamic pedobarography may also be an effective method to assessment of abductor muscle strength preoperatively and postoperatively. Stance phase, load distribution between hips and gait speed are based on the pedobarography [3-6]. Biomechanical concepts in hip, generally corresponding to the 16th phase of gait and the 31st phase (mid-stance phase) as described by O. Fischer and Braune in 1889.

Pedobarography (plantar pressure measurement) provides to measure the ground reaction forces very precisely and pointwise during walking. It assess the dynamic pressure which created with contacting the ground. Analyzing plantar pressure has an important role in diagnosis, treatment and follow-up of the diseases which affecting the axial alignment of the lower extremity [7]. Osteoarthritis changes gait pattern of the patients depending on pain, instability, neuromuscular disease, muscle weakness. They adapt in accordance with the current situation. Limited range

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of motion prevents the expected maximum extension during the stance phase. Patients try to tolerate the situation by increasing lumbar lordosis or flexion of the pelvis [8]. Osteoarthritic patients after hip replacement surgery; show significant change in stance phase, especially in the mid stance phase, load distribution, range of motion, gait speed and postoperative gait can not be considered as normal [9,10]. Functional healing process and damage of hip abductor muscles and soft tissue are the most important reasons for these abnormal gait [11].

The forms of changes in foot-ground pressure are generally valuable to any pathological changes in gait, such as those characteristics of pain ("antalgic" or "painful" gait), loss of balance, disturbances in neuromuscular control. The pedobarography may be the easiest and cheapest way to understand the characteristic changes after total hip arthroplasty.

Abduction deficiency or Trendelenburg gait pattern (or gluteus medius) is an abnormal gait caused by weakness of the abductor muscles of the lower limb, gluteus medius and gluteus minimus. During the stance phase, the weakened abductor muscles allow the pelvis to tilt down on the opposite side. To compensate, the trunk lurches to the weakened side to attempt to maintain pelvis throughout the gait cycle. And pelvic balance can be ensured with this way. Asymmetry in double assistance, decrease in gait speed and hip abductor moment in the stance phase and can be seen after total hip arthroplasty [12].

In the literature, there are few many reported articles about the gait analyses, Trendelenburg's sign, and hip abductor muscle function after the total hip arthroplasty with the lateral approach. This is the first study to compare two different lateral approaches by pedobarographic analysis, clinical evaluation and functional scoring.

In our study, we analyzed that the clinical results and the differences at the patients who had unilateral total hip arthroplasty surgery with two different surgical approaches as classical lateral Hardinge approach and modification of lateral intermuscular approach. The aim of this study was to assess the Trendelenburg sign, plantar pressure distribution with the help of dynamic pedobarography and clinical results by Harris Hip Score after two different surgical approaches.

Materials and Methods

This study protocol was approved by the Gazi University Faculty of Medicine Ethics Committee. (September 29 2010 / 167)

We selected 28 patients (7 male, 21 female) who had been operated in our clinic because of the unilateral degenerative hip arthritis. Total hip arthroplasty was performed by the same surgeon to the patient. The cementless, standard off-set stem was used for whole the patients. The patients had been separated by the block randomisation technique. The preferred approach for the first group is classical lateral Hardinge approach and 13 patients had been selected for this group. In the second group there were 15 patients and the preferred approach was modification of lateral intermuscular approach (Pai).

The patients who had advanced stage of foot deformity, pes planus,

achilles tendon strain, generalized joint laxity, neuromuscular disease, peripheral neuropathy, spine problems that may lead to pelvic instability and surgical history of lower extremity were excluded from the study.

Gait analysis was made preoperatively to the patients who planned total hip arthroplasty by the same researcher. Plantar pressures were measured by EMED-SF pedobarography device and analysed by the help of a commercial software (Novel H, Munich, Germany). While patients were walking on a 7 meter treadmill, a static and two dynamic measurements are made for each feet. We requested each patient to step as minimum 3 phase on the board and the results were recorded 71 Hz sample velocity for square. All patients were assessed with Harris Hip Score system to evaluate the patients satisfaction. According to this assessment, the patients were evaluated with pain score, function score (gait, stairs be able to walk up and down, to wear socks-shoes, sitting, to ride on public transport), the deformity score and move scores. Two years after the surgery, patients were called away control. And they were analyzed using the same technique. Trendelenburg's sign of was investigated with physical examination and Harris hip score was applied.

Patients were operated by the same surgeon, under general anesthesia and combined spinal and epidural anesthesia, in the supine position.

In patients undergoing conventional Hardinge approach; incision was started from the spina iliaca anterior superior, 1/2 anterior part of gluteus medius fibers were removed from sticking area and has been reached to the joint; tendon-tendon repair was performed with 1.0 Vycril (Figure 3). In patients undergoing modified intermuscular Hardinge approach, direct lateral incision was passed from tip of trochanter major. 1/3 anterior part of muscle fibers were removed from sticking area with blunt approach. The surgeon has been reached to the joint by entering from cleavage which formed by tensor fascia lata, gluteus medius and minimus. After surgery tendon-bone repair was performed with 5.0 Ethibond (Figure 4).

Pedobarographic measurements were recorded with EMED-SF (44.4*22.5cm active area, 71 Hz sampling rate, two receiver in square centimeters) platform at the first and control admission by the same researcher. This platform covered with a thin leather surface and mounted on 7x1 meter wooden. Measurements were performed with barefoot and in a normal walking speed. Before coming to the measurement area, participants completed at least three times the normal gait cycle. Measurements were repeated three times for each foot. Assessment values were averaged for each of them by selecting the closest two measurements. A static and two dynamic measurements are made for each feet. Plantar pressures measurements that separates the foot to the four different parts which are called masks. Each region were evaluated in terms of the contact area (cm²), the maximum force (N), the peak pressure (N / cm²), the maximum average pressure (N / cm²), a pressure-time integral of [(N/cm²)*s] and arch index. Recorded pressure images were transferred to Novel ortho (Novel GmbH) software for further analysis (Figure 2).

A method as described by Cavanagh and Rodgers was used to the evaluation of medial longitudinal arch [13]. They have divided

feet into three equal parts as front foot, midfoot, hind foot. Arch index is defined as the ratio of middle foot pressure area to all of the foot pressure area.

In our method, plantar pressures measurements that separates the foot to the four different parts which are called masks (Automask, Novel-ortho, Germany). These masks were divided as front foot, mid foot, hind foot and fingers. Lines were drawn from 50% and 69% of the length of all foot and thus the border of mask areas were identified. The border of fingers and front foot was identified by taking advantage of the difference in pressure in these areas. Abductor function was evaluated by correlating arch index and changes in foot contact time. Postoperative abductor forces in two different approach were evaluated by pedobarographic and plantar pressure changes.

All the parameters were compared as preoperatively and postoperatively at the second year. Trendelenburg's sign is used as an indicator of abduction dysfunction. This test is described by Friedrich Trendelenburg in 1895 [14]. Trendelenburg's sign has been estimated as grade 1 and grade 2 by the method which was described by Hardcastle and Nade [15].

Clinical outcome was measured by comparing Harris Hip Scores pre-operatively and at last clinic visit. All the parameters were compared as preoperatively and postoperatively at the second year. The cases is considered over 100 points according to Harris Hip Score.

Statistical analysis used the SPSS software (IBM corp version 21). Significance level was determined as $p < 0.05$. Mean and standard deviation were calculated for all variables, with frequency values calculated with the same software.

Results

The age ranges of the all patients varied between 30 and 77 years old and the average age for the whole patients was 54.78 years during the time of surgery. In the first group which were operated by classical lateral Hardinge approach; 10 (76%) of the 13 patients were women and 3 (24%) were men, and the average age was 57.62 years; in the second group 11 (73%) of the 15 patients were women and 4 patients (27%) were men and the average age was 52.33 years during the time of surgery. There was no significant difference between two groups in terms of age, gender and operated side ($p > 0.05$).

The load-bearing parts of the foot are divided into three parts, as mask1, mask2 and mask3. Preoperatively, measurements in mask 1, 2, and 3 areas of operated and opposed sides do not differ from group to group ($p > 0.05$).

When the pedobarography results and the first three masks were analysed, we reached that; contact area, peak pressures and total contact time were less at the operation side preoperatively than the healthy side. Also at the second mask; which is the significance of the midstance phase, contact time was again less at the operation side (Table 1).

In both groups after the two years from the surgery; total contact time has increased at the operation side when the results were compared before the surgery at the same side and at the other side after the surgery. Also when we looked at the first and second masks which show the significant part of the stance phase; contact areas

have similarly increased and the changes at the peak pressures were similar as contact areas. (Table 2,3).

Table 1. Preoperative contact area of operated side according to the groups

	Group	Average (cm ²)	Std. deviation	t	p
Operated side, Preop Mask 1 Area	Hardinge	29.44	4.18	-1.709	0.107
	Modified Hardinge	33.50	5.57		
Operated side, Preop Mask 2 Area	Hardinge	25.69	6.91	-1.177	0.256
	Modified Hardinge	29.10	5.41		
Operated side, Preop Mask 3 Area	Hardinge	49.81	5.76	-0.222	0.827
	Modified Hardinge	50.50	7.09		

Table 2. Postoperative contact area of operated side according to the groups

	Group	Average (cm ²)	Std. deviation	t	p
Non-operated side, Postop Mask 1 Area	Hardinge	32.13	4.47	-1.015	0.325
	Modified Hardinge	34.30	4.55		
Non-operated side, Postop Mask 2 Area	Hardinge	26.19	5.31	-1.445	0.168
	Modified Hardinge	31.40	8.99		
Non-operated side, Postop Mask 3 Area	Hardinge	47.06	10.10	-0.792	0.440
	Modified Hardinge	50.60	8.85		

Table 3. Preoperative and postoperative contact time of each two side according to the groups

	Group	Average (sn)	Std. deviation	t	p
Operated side, Preoperative total time	Hardinge	1120.00	444.55	0.395	0.698
	Modified Hardinge	1041.60	396.98		
Operated side, Postoperative total time	Hardinge	1155.78	540.32	-0.062	0.951
	Modified Hardinge	1171.80	578.29		
Non-operated side, Preoperative total time	Hardinge	1151.50	454.25	0.403	0.692
	Modified Hardinge	1064.00	459.61		
Non-operated side, Postoperative total time	Hardinge	1096.67	539.25	0.144	0.887
	Modified Hardinge	1064.00	450.61		

Before the surgery, Trendelenburg's sign was positive in 3 patients in the first group and 1 patient in the second group; and there were no statistically differences for Trendelenburg's sign between the two groups preoperatively. In the first group at the second year visit, 4 patients had Trendelenburg's sign and 2 of them had also positive results before the surgery. In the second group only 1 new patient had Trendelenburg's sign at the second year visit. After the analyse of the results by chi-square test; no significant differences were seen ($p > 0.05$).

For whole the patients the average preoperative Harris hip score was 41.50 (19-61) points. At the time of the last visit, the average Harris hip score was found as 86.68 (66-100) points. In the first group, the average preoperative Harris hip score was 39.46 (22-

56) points and at the postoperative second year visit, the average Harris Hip Score was found as 84,08 (67-100) points. In the second group, the average preoperative Harris hip score was 43.27 (19-61) points and at the postoperative second year visit, the average Harris Hip Score was found as 88.93 (66-100) points. There were no statistically differences for both groups ($p>0.05$). But, there was a significant difference between preoperative and postoperative Harris hip scores ($p<0.01$) (Figure 1).

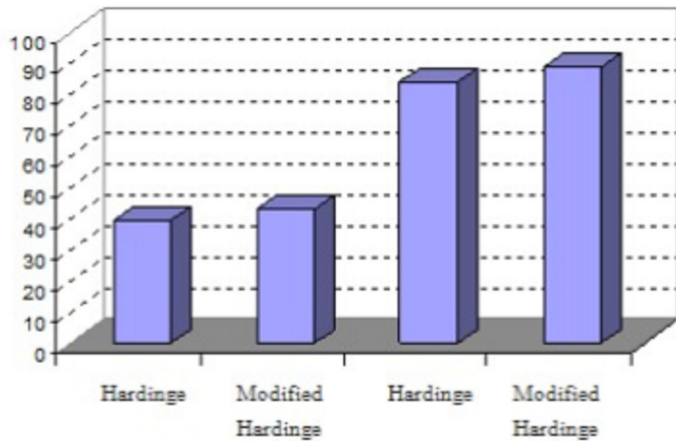


Figure 1. Postoperative increase of Harris Hip Score

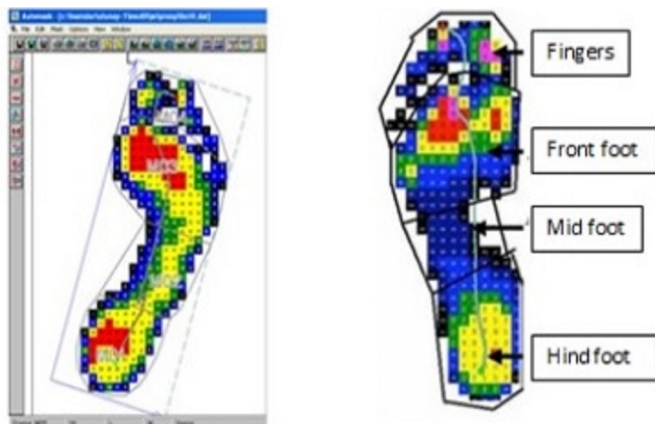


Figure 2. Four-part pressure areas as called "mask" by EMED-SF system

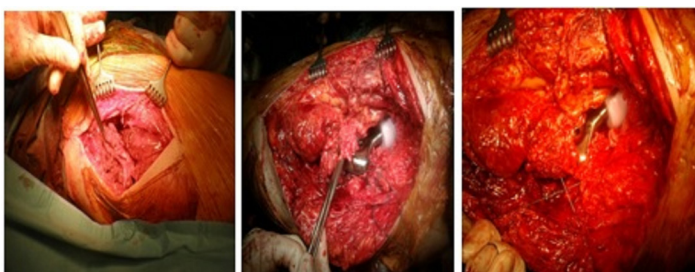


Figure 3. Repair of tendons with 1.0 vicryl after Hardinge approach

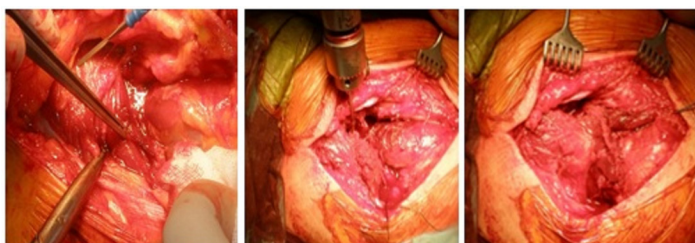


Figure 4. Conjunct tendon repair after modified Hardinge approach

Discussion

Total hip arthroplasty, continues to be the most ideal method for hip surgical treatment of hip degenerative arthritis. In studies with large patient participation; male/female ratio is equal in some series, some series contain higher male/female rates. Male/female rates is 1 in Valle's series, 0.37 in Kim's series, 2.5 in Erdemli's series [16,17]. In our study, there is no statistically significant difference between groups as similar publications. The average age is 57.6 in classic lateral Hardinge approach and 52.3 in modified intermuscular Hardinge approach. The average age of all patients in this study is 54.7. This average is 48.4 in Kim's series [16], 58.0 in Pieringer's series [17], 45.0 in Hellman series [18], 53.0 in Solak series [19]. In our study there were no significant differences between the two groups and similar publications in literature.

Up to now, various approaches used for hip arthroplasty in the literature have been compared with gait analysis. Perron et al. compared posterior and anterolateral approaches [10], Klausmeier et al. compared anterior and anterolateral approaches, and Madsen et al. [20] compared the anterolateral and posterolateral approaches [21]. This is the first study to compare two different lateral approaches by pedobarographic analysis.

The modified Hardinge approach described by Pai shows some differences compared to the direct lateral approach described by Hardinge. In the direct lateral approach described by the Hardinge, approximately 1/2 of the gluteus medius muscle is pulled out from the trochanter major to reach the joint capsule; In Pai's modified Hardinge method, the joint capsule is reached with blunt dissection among the muscle plans, minimal damage to the muscle. Only the front 1/3 of gluteus medius leaves. Another difference, while tendon-tendon repair method is used for repair of tendons removed in the Hardinge approach, gluteus-vastus flap is fixed to trochanter major, as tendon-bone method with nonabsorbable suture in the Hardinge approach modified by Pai.

A variety of qualitative and quantitative methods are defined to evaluate the preoperative and postoperative hip circumference of muscle strength. Mechanical or digital dynamometer, electromyography and Trendelenburg sign in physical examination are some of the main methods [22,23]. In recent years, gait analysis is used for assessment of hip circumference muscle strength as a method that which can give quantitative parameters and kinematic analysis [24]. It is an effective method of evaluation both the results of hip arthroplasty and recognition of the complications as Trendelenburg gait [24-26].

In patients with hip osteoarthritis, limited joint mobility and shortened stance-phase can be seen. Asymmetry is observed in double-step and stance phase in patients with unilateral osteoarthritis [27]. Rantanen et al. have done dynamometric measurements and gait analysis to 75 years old participants who have no active complaints, can do daily work and climb stairs. Although there is no symptoms, the decline in isometric muscle strength have been identified by gait analysis [28].

Benedict et al., studied 30 patients with osteoarthritis of the hip as pedobarographic. They found that the total contact area, the peak pressure and the contact time during stance-phase decreased on the side of degenerative arthritis and tried to transfer the load

distribution to the non-pathological side, especially during the mid-stance phase [29]. In our study, contact areas (table 1,2), peak pressure and total contact time (table 3) were found to be lower on osteoarthritic side similar to the literature, although it did not differ statistically as to be parallel to previous studies. At the time of the second mask which is thought to reflect the mid-stance phase, was found lower on osteoarthritic side.

There has not formed a consensus in the literature in terms of postoperative follow-up period. Klausmeier et al. emphasized that 6 week period was sufficient for healing and there was no difference between preoperative and postoperative tissue quality at 16th weeks [20]. Bennett et al. argued that the former muscle strength is reached at 6 weeks after hip replacement [30]. Madsen and Nantel defined that the ideal time of healing in terms of muscle strength after surgery was 6 months [31]. Considering these studies, we invited patients to control at the end of 6th months to be sure of soft tissue healing.

Giving as little damage to the muscle plans and distinguishing the boundaries of safe zone on trochanter major are very important to avoid complications and ensure the ideal reconstruction after surgery [32]. Functional insufficiency ve Trandelenburg movement resulted from retracting anterior ½ fibers of gluteus medius fibers and after occurring reconstruction problems, besides of denervation of superior gluteal nerve, involved in literature [22]. For this reason, in lateral approach of their hip, modifications with less complication and hip muscles with better protection have been tried by various researchers

Patients were performed with two different lateral total hip replacement approach have been analysed and no significant differences have been found from the point of pedobarographic and Trandelenburg sign. The most important reasons are thought as paying attention of safe zone for the inferior bundle of superior gluteal nerve during surgery in Hardinge approach applied group, both groups are taken care of proper and careful conjoint tendon repairment and both have been applied same rehabilitation programme of abductor muscle strengthening.

All hips were classified in poor group preoperatively according to the Harris Hip Score. After 6 months follow up, in 28 hip, good and excellent clinical results (78.6%) and good scores with 86.8(on average) were obtained. In Kim and Pal's 118 case series; Preoperative Harris hip score is reported as 48.8, after 9.8 years follow up score is reported as 92 and 112 cases' (95%) results are reported as good and perfect [33]. Bojeskul [34] reported preoperative Harris Hip Score as 32 and postoperative 93; Archibeck [35] reported preoperative Harris Hip Score as 51 and after 10 follow up as 94; Aldinger [36] reported score after 10-15 years follow up as 84. Jerosch and Pal [37] reported that preoperative Harris score is 44, at the end of the third month 84.7, at the end of the first year 90 in 75 patients after lateral approach(early period results). When we compare our results with clinics in the literature, our results are low on the borderline, but seems parallel with literature. It is estimated that as the follow up time lengthen, functional outcomes will improve.

Our procedure for the assessment of gait parameters was adopted based on a compilation of the methods explained in the literature [29]; we analyzed for characteristic changes in weight-bearing in

the special areas of the foot, possibly associated with osteoarthritis of the hip or with the total hip arthroplasty itself. The results did not indicate any unequivocal differences in the characteristics of dynamic weight-bearing in the stance phase among the patients we studied.

Conclusion

In conclusion, pedobarography is not really affective for grade 1 trendelenburg analyze. The functional and clinical early results are similar in both lateral hip approaches for unilateral total hip arthroplasty when superior gluteal nerve protection, conjunt tendon repair and postoperative rehabilitation have done well. The risk of insufficiency of hip abductors is rather low in both approaches. So that, two different surgical methods should be preferred easily. This is the first study to compare two different lateral approaches by pedobarographic analysis, clinical evaluation and functional scoring. We believe that the increased number of patients and prolonged follow-up can be more effective results in this issue.

Competing interests

The authors declare that they have no competing interest

Financial Disclosure

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Ethical approval

Before the study, permissions were obtained from local ethical committee.

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