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Original Article

Relationship Between Upper Extremity Functions and Balance, Falls, and Functional Status in Patients with Chronic Stroke

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ABSTRACT

Objective: Balance problems that accompany physical mobility limitations are common after stroke. It is aimed to reveal the relationship between the upper extremity functions and balance, fall, and functional status in chronic stroke patients.

Methods: A total of 74 patients who had diagnosed stroke more than 6 months evaluated with Brunstom Recovery Scale for motor recovery, Modified Ashworth Scale for muscle tone, Fugl–Meyer Assessment for upper extremity motor function, Berg Balance Scale for balance, Functional Ambulation Classification for ambulation level, Barthel index for functional state, and Downton index to estimate the risk of falling. The number of patient falls in the last 6 months was recorded.

Results: It has been found that patients who have better upper extremity functions have both higher balance and functional scores ($P < .01$). Besides, the functional scores were found to be higher in patients who have better balance ($P < .01$). Patients' upper extremity functions, balance, and functional scores were not correlated with the number of falls and Downton index scores ($P > .05$).

Conclusion: In chronic stroke patients, we have detected a significant relation between upper extremity function, balance, and functional state. Therefore, upper extremity functions in stroke patients should be evaluated at an early stage, and appropriate rehabilitation methods should be determined.

Keywords: Stroke, balance, falls, upper extremity, functional status

INTRODUCTION

Stroke is the third cause of death after ischemic heart diseases and cancer worldwide and is a major public health concern. The goals of stroke rehabilitation are to maximize functional independence, to facilitate neurological recovery, to minimize disability, to achieve successful reintegration into society, and to restore a fulfilling life.[1]

Most stroke survivors regain some walking ability within the first 6 weeks after stroke, but 40% will have severe motor impairment that limits walking function to domestic ambulation. Walking capacity is limited due to insufficient motor control, impairment of upper extremity functions, and balance and muscle strength deficiencies that occur after stroke.[2]

Balance problems that accompany physical mobility limitations are common after stroke. After the patient is mobilized, complications such as head trauma and bone fractures may occur as a result of repetitive falls due to balance problems. In addition, imbalance may cause fear in patients and reduce willingness to ambulate, and eventually the patient may become dependent on others in many activities of daily living (ADL). For these reasons, balance disorder is one of the parameters that should be targeted specifically in rehabilitation.[3]

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Falls and fractures are among the most common complications after stroke. In the literature, the frequency of falls in chronic stroke patients has been estimated to vary from 23% to 50%.[4,5] It has been reported that stroke patients have a 2-fold higher risk of falling than age- and gender-matched controls.[4] In addition to their high prevalence in stroke patients, falls also represent an important complication with devastating consequences. Falls restrict the activities of the patients by causing the fear of falling again. This may significantly limit the participation of patients in rehabilitation activities. Various additional problems, especially fractures that occur after falls, also hinder rehabilitation. The fear of falling caused by falls and the problems that subsequently occur may cause social isolation.

There is a relationship between balance impairment and lower extremity dysfunction in stroke; however, a limited number of studies reported that upper extremity dysfunction also affects balance significantly. Studies investigating the association between upper limb function and balance have revealed the relation between upper limb dysfunction and risk of falling.[6,7] One study has shown that inadequate arm swing while walking increases the risk of falling.[8] In addition, it has been demonstrated that, aids and orthotic appliances for the upper extremity have positive effects on balance and gait pattern by providing normal arm swing.[8]

The aim of our study was to investigate the association of upper extremity functions with falling, balance, and ADL in chronic hemiplegic post-stroke patients.

METHODS

A total of 74 post-stroke patients (mean age, 60.1 ± 9.4 years) who were followed at an inpatient clinic of a rehabilitation hospital and who met the following inclusion and exclusion criteria were included in this study.

The study inclusion criteria were (i) ischemic brain damage or intracerebral hemorrhage demonstrated by magnetic resonance imaging or computed tomography scans, (ii) hemiplegia after the first stroke, (iii) at least 6 months post-stroke, (iv) ability to stand for more than a minute with or without support, (v) patients with normal cognitive function (Mini-Mental Test (MMDT) score of 24 or higher). The exclusion criteria of the study were (i) the presence of a significant comorbid disease (severe heart disease, Parkinson's disease), (ii) the presence of accompanying lower motor neuron or peripheral nerve lesions, (iii) aphasia and communication disorder, (iv) the presence of movement disorders such as ataxi a-dystonia-dyskinesia, (v) recurrent stroke, (vi) patient with hemiplegia without a definite diagnosis of cerebrovascular accident (CVA) in medical history, (vii) cerebellar stroke. The study protocol was approved by the Institutional Ethics Committee. The patients were informed about the study and signed a written consent form before enrollment in the study.

MAIN POINTS

- Clinicians caring for stroke patients need to inquire about falls, assess for fall risk, and address modifiable risk factors to prevent serious injuries that may occur as a result of falls.
- The upper extremity functions of stroke patients affect balance and functional status.
- In patients who are included in the rehabilitation program due to balance and gait impairment, it should also be aimed to regain upper extremity and hand functions.

Evaluation Parameters

Age, sex, educational status, body mass index (BMI), smoking and alcohol use, marital status, disease duration, etiology, dominant hand, affected side, accompanying pathologies, existing complications, use of a walking aid, fall history, fear of falling, comorbidities, and medication use were questioned. A detailed physical, neurological, and musculoskeletal examination was performed.

The motor control of patients was assessed using several tools. The Brunnstrom Recovery Scale (BRS) was used for the assessment of upper extremity, hand, and lower extremity. Muscle tone was evaluated using the Modified Ashworth Scale (MAS), and upper extremity motor function was assessed using the Fugl–Meyer Motor Rating Scale. The Functional Ambulation Classification (FAC) was used to determine ambulation level and balancing function was evaluated using the Berg Balance Scale (BBS). The Downton index (DI) was used to estimate the risk of falling. The Barthel index (BI) was used to assess physical independence in ADL.

Brunnstrom Recovery Scale

Brunnstrom Recovery Scale is used to evaluate the recovery of motor control in hemiplegic patients. In this scale, the recovery process of the hemiplegic patient is divided into 6 stages, with the lowest stage being stage I (flaccidity, non-voluntary movement stage) and the highest stage being stage VI (isolated joint movement stage). Upper extremity, lower extremity, and hand are evaluated separately.[9]

Modified Ashworth Scale

The MAS is a valid and reliable tool to measure spasticity and the increase in muscle tone. Patients are assigned a

score from 0 to 4 points where 0 denotes no increase in muscle tone and 4 indicates that the extremity is rigid.[10]

Berg Balance Scale

The BBS is a tool developed to measure balance performance. Scores from 0 to 20 indicate imbalance, scores from 21 to 40 indicate acceptable balance, and scores from 41 to 56 indicate good balance performance.[11]

Fugl–Meyer Assessment

The Fugl–Meyer Assessment (FMA) was developed as the first quantitative tool to evaluate sensorimotor recovery after stroke.[12] It consists of 5 parts: motor function (upper and lower extremities), sensory function, balance, range of motion, and joint pain. For the current study, we used the upper extremity (FMA-UE) evaluation part of the FMA. Maximum possible score that can be obtained in the FMA-UE is 66. Scores of 0-19 show severe, scores of 20-46 show moderate, and scores of 47-66 show mild upper extremity motor dysfunction.

Barthel Index

The BI consists of 10 items related to the ADL and mobility. Nutrition, washing, dressing, self-care, bowel and bladder care, sitting on the toilet, transferring from a wheelchair to the bed, walking on a smooth surface, and going up and down stairs are evaluated. Scores of 0-20 indicate that the individual is fully dependent, scores of 21-61 denote high dependence, scores of 62-90 denote moderate dependence, scores of 91-99 denote mild dependence, and a score of 100 indicates that the individual is fully independent.[13]

Functional Ambulation Classification

The FAC was used to determine the ambulation level of the patients. This scale consists of 6 items in which the ambulation level is classified between 0 and 5. Stage 0 indicates the level of nonfunctional ambulation, while stage 5 indicates the level of independent ambulation.[14]

Downton Index

The DI is used in rehabilitation clinics to predict the risk of falls. The DI consists of 5 sections in which the factors that pose a risk for falling are questioned. These sections include previous history of falls, medication use, sensory deficits, mental status, and walking. A value between 0 and 11 is obtained by summing the scores obtained for each risk factor. If the value obtained is greater than 3, the risk of falling is considered to be high.[15]

The NCSS (Number Cruncher Statistical System) 2007 and PASS (Power Analysis and Sample Size) 2008 Statistical Software (Utah, USA) package were used for statistical analysis. Descriptive statistics (mean, SD, median, frequency, ratio, minimum, maximum) were used to summarize the study data. For the quantitative data, the Student's *t*-test was used to compare 2 groups for normally distributed parameters . The Mann–Whitney *U*-test was employed for comparisons of 2 groups for the parameters with a nonnormal distribution.

Statistical Analysis

One-way analysis of variance test was used for comparisons of 3 and more normally distributed groups and Tukey's HSD (honestly significant difference) test to identify the group that caused the difference. For the comparison of 3 and more groups with a normal distribution, the Kruskal–Wallis test and the Mann–Whitney *U*-test were used to identify the group that caused the difference. Pearson's chi-squared test and Fisher–Freeman–Halton test were used to compare qualitative data. The relationships among parameters were analyzed using Pearson correlation analysis and Spearman's correlation analysis. Backward stepwise regression analysis was used for multivariate analysis. For FMA assessments, Bonferroni correction was applied and *P*-value was accepted as .017. In other evaluations, significance was set at $P < .01$ and $P < .05$ levels.

RESULTS

The study was conducted at an inpatient clinic of a rehabilitation hospital with a total of 74 patients, of whom 51.4% (n=38) were female and 48.6% (n=36) were male. Demographic characteristics, etiology, hand dominance, and hemiplegic side of the patients are shown in Table 1.

When the muscle tone of the participants were examined, 4.1% (n=3) were flaccid, 37.8% (n=28) were normal, and 58.1% (n=43) were spastic. The mean MAS scores were 2 ± 0.8 for upper extremity and 1.4 ± 0.6 for lower extremity.

The BRS scores of the participants showed that upper extremity stages ranging from 1 to 6, with a mean stage of 3.3 ± 1.4. Lower extremity stages ranged from 2 to 6, with a mean stage of 4 ± 1, and hand stages varied between 1 and 6, with a mean stage of 2.9 ± 1.9.

The mean FAS score of the participants was 4.4 ± 0.5.

The distribution of patients by the use of ambulatory devices is shown in Figure 1. The frequencies for fear of falling and fall history are shown in Table 2. The distribution of FMA-UE, DI, BI, and BBS scores are shown in Table 3.

The results of Spearman correlation analysis for correlations among FMA-UE, DI, BI, BBS, FAC, and BRS are shown in Table 4.

The relationships among FMA-UE, BBS, DI, and BI are shown in Table 5.

Regression Analysis for Fugl–Meyer Assessment—Upper Extremity Levels

There were univariate effects on FMA-UE scores. The effects of BMI, CVA duration, etiology, age and BBS, BI, and upper extremity, lower extremity, and hand BRS scores were evaluated using backward stepwise regression analysis. From the value in the significance column of the Table 6 ($P=.000$), it can be seen that the relationship among the aforementioned variables is statistically significant. The model was found to have a very good explanatory level with a $r^2=0.957$.

Table 1. Demographic Characteristics, Etiology, Hand Dominance, and Hemiplegic Side of the Patients

		Mean ± SD	Minimum–Maximum
Age (years)		60.1 ± 9.4	33-75
Body weight (kg)		75.3 ± 11.7	45-112
Height (cm)		163.7 ± 7.7	150-181
BMI (kg/m^2)		28.1 ± 4.5	17.6-40.7
Duration of education (years)		6.5 ± 2.6	5-16
CVA duration (months)		26.0 ± 33.8	7-180
		n	%
Sex	Female	38	51.4
	Male	36	48.6
Age	<65 years	46	62.2
	≥65 years	28	37.8
Marital status	Single	10	13.5
	Married	64	86.5
Smoking	Yes	8	10.8
	No	66	89.2
Alcohol use	Yes	1	1.4
	No	73	98.6
Etiology	Ischemic	64	86.5
	Hemorrhagic	10	13.5
Dominant side	Right	72	97.3
	Left	2	2.7
Hemiplegic side	Right	33	44.6
	Left	41	55.4

BMI, body mass index; CVA, cerebrovascular accident.

The effects of BBS, CVA duration, Brunnstrom upper extremity, and hand measurements on FMA-UE scores were significant.

When the effects of other independent variables in the *B* (unstandardized beta) multiple regression model are kept constant, it shows the change that an increase of 1 unit in any independent variable will cause on the dependent variable of FMA-UE. Accordingly, upper extremity BRS showed the most important effect on FMA-UE, followed by hand BRS, and the effects of BBS and CVA duration were also found to be significant (Table 6).

DISCUSSION

Despite the advances in the prevention and treatment of stroke, it remains an important health problem. With its high incidence and mortality rate, stroke affects a large part of the population and causes disability in survivors. Post-stroke disability reduces the patient's quality of life, affects the lives of patients' families, and causes both socioeconomic and social problems.[16]

In this study, we found a significant association of upper extremity functions with balance and functional status in patients with stroke. Therefore, upper extremity functions should be evaluated early in stroke patients and appropriate rehabilitation methods should be individualized based on patient needs. Exercises that will improve the patient's balance performance should also be included in the rehabilitation program.

In our study, we found that 86.5% of the patients had ischemic stroke and 13.5% had hemorrhagic stroke, in accordance with the literature.[17,18] Consistent with previous reports, 58.1% of our study group patients had spasticity.[19]

Sufficient muscle strength and coordination of the upper extremity and hand are necessary for self-care activities, especially nutrition, dressing, hygiene, and even

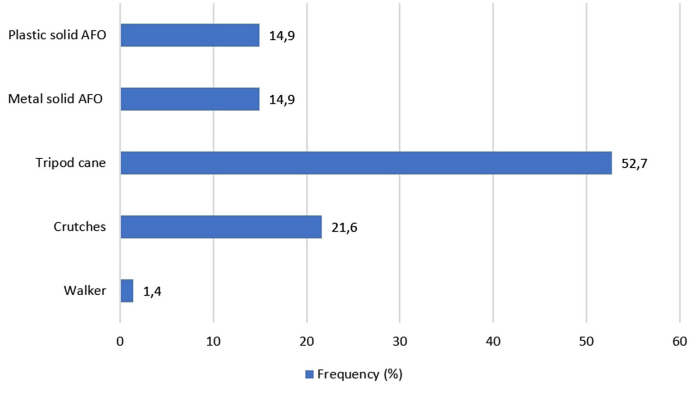

Figure 1. Ambulatory device usage.

Table 2. Fear of Falling and Fall History Frequencies

		n	%
Fear of falling	Yes	62	83.8
	No	12	16.2
Fall history in the previous 6 months	No	40	54.1
	Once	12	16.2
	More than once	22	29.7

self-expression. Individuals whose coordination and cognitive abilities naturally decrease due to advanced age become fully dependent on ADL with further loss of upper extremity and hand motor function after stroke.[7]

Approximately 85% of the patients have motor and sensory impairment in the upper extremity at the beginning of the stroke, and functional recovery is observed in the upper extremities of only 25-45% of these patients.[20]

When we examined the factors affecting the FMA-UE scores using regression analysis, the upper extremity and hand BRS scores were found to have the greatest effect, followed by balance performance and the CVA duration also had an effect on FMA-UE scores.

It is well-known that problems developing in the long term after a stroke lead to serious deficits in the physical, psychological, and social dimensions of life and cause a significant reduction in quality of life. Considering that significant correlations are observed between disability and quality of life scores in both the early and late periods after stroke, it can be predicted that quality of life can be improved by preventing disability in stroke patients.[21,22]

In a study by Pang et al.[23] 63 chronic stroke patients were divided into 2 groups. One group received upper extremity exercises and the other group received lower extremity exercises. More progress was achieved in the quality of life in the group that received exercises for the upper extremity. Oliviera et al[24] investigated the correlation between upper and lower extremity functions and functional status in 20 patients with chronic stroke and found a correlation between FMA total motor score and BI scores.[24] The findings of our study also show that motor disability, including both upper and lower extremities, strongly affects the dependence of stroke patients on ADL, in line with the literature.

In a study by Tyson et al.[26] balance impairment was reported to be the strongest predictor of ADL and mobility, with the second strongest predictor being muscle weakness.[25] Postural control was reported to be the best predictor of achieving independence in ADL and showed the highest correlation ($r=0.70$) with perceived disability after discharge from the hospital.

In our study, when we divided the patients with stroke into 3 subgroups according to the BBS scores, and examined the relationship with functional status, BI scores of patients with balance disorder were significantly lower than those with acceptable balance and good balance. The BBS scores of severely dependent patients were significantly lower than those of moderately and mildly dependent patients as well as fully independent patients. These findings show that in addition to upper and lower extremity functions, balance performance of stroke patients affects dependence on ADL in accordance with the literature.

Table 3. FMA-UE, DI, BI, and BBS Scores of the Patients

		n	%	Minimum–Maximum	Mean ± SD
FMA-UE	Severe	39	52.7	0-65	26.2 ± 21.9
	Moderate	15	20.3		
	Mild	20	27.0		
DI	Low risk	30	40.5	0-4	2.7 ± 0.9
	High risk	44	59.5		
BI	Severe dependence	15	20.3	35-100	77.4 ± 16.2
	Moderate dependence	47	63.5		
	Slight dependence	6	8.1		
	Independent	6	8.1		
BBS	Balance impairment	5	6.8	15-54	37 ± 10
	Acceptable balance	34	45.9		
	Good balance	35	47.3		

BBS, Berg Balance Scale; BI, Barthel index; DI, Downton index; FMA-UE, Fugl–Meyer Assessment—Upper Extremity.

Table 4. Spearman Correlation Analysis Results for Correlations Among Brunnstrom Motor Stage, FMA-UE, DI, BI, FAC, History of Falls, and BBS

	Brunnstrom Motor Stage					
	Upper Extremity		Lower Extremity		Hand	
	r	*P*	*r*	*P*	*r*	*P*
BBS	0.330	**.004****	0.328	**.004****	0.268	**.021***
DI	-0.075	.524	-0.135	.253	0.002	.989
BI	0.470	**.001****	0.367	**.001****	0.440	**.001****
FAC	0.127	.280	0.133	.259	0.084	.475
FMA-UE	0.902	**.001****	0.737	**.001****	0.889	**.001****
Number of falls in the last 6 months	0.135	.250	0.035	.765	0.174	.138

**$P < .01$.
*$P < .05$.
BBS, Berg Balance Scale; BI, Barthel index; DI, Downton index; FAC, Functional Ambulation Classification; FMA-UE, Fugl–Meyer Assessment—Upper Extremity; *r*, Spearman's correlation coefficient.

One of the main goals of rehabilitation in stroke patients is to achieve independent walking. Gait disturbances occur in stroke patients, such as poor gait performance, decreased walking speed, and reduced endurance.[27] In the study of Ford et al.[28] it was observed that during the walking training given on the treadmill, the swinging of the arms accompanied by the rhythm of a metronome increased transverse, thoracic, pelvic rotation, and stride length.[28] In the present study, no significant relationship was found between the upper and lower extremity motor functions and the ambulation levels assessed by FAC. The ambulation levels of 73 (98.6%) patients included in our study were stage 4 and 5 according to the FAC. In contrast with the literature, there was no significant relationship between upper and lower extremity motor functions and ambulation levels in the current study.

There are a few studies in the literature examining the relationship between upper extremity functions and balance in stroke patients.[7,29,30] In stroke patients, during the movement of the upper extremity, depending on the weight and dynamics of that arm, some forces and moments may occur on that side. These forces and moments can cause changes on balance by affecting the fixed standing and sitting posture, as well as the ability to change position.[31] In hemiparetic patients, gait speed slows down, stance period and stride length shorten on the paretic side, and double support time is prolonged. In a study by Yavuzer and Ergin, hemiplegic patients wearing an arm sling showed increased walking speed and stance period on the paretic side, increased weight transfer to the paretic side, and reduced double support time of the paretic side in all planes and decreased excursion of the center of gravity in the coronal and transverse planes.

Table 5. Relations of FMA-UE Dysfunction Levels with DI, BI, and BBS scores and History of Falls

		FMA-UE Dysfunction Levels			
		Severe (n = 39)	Moderate (n = 15)	Mild (n = 20)	
		Median ± SD	Median ± SD	Median ± SD	*P*
DI		2.8 ± 0.8	2.4 ± 1	2.6 ± 0.9	*.546*[b]
BI		70.9 ± 15	81.6 ± 16.6	86.7 ± 13	***.001****[,b]
BBS		33.6 ± 10.1	41 ± 9.9	40.6 ± 7.7	***.007****[,a]
		n (%)	n (%)	n (%)	*P*
Number of falls in the last 6 months	No	22 (56.4%)	8 (53.3%)	10 (50.0%)	*.955*[c]
	Once	7 (17.9%)	2 (13.3%)	3 (15.0%)	
	More than once	10 (25.6%)	5 (33.3%)	7 (35.0%)	

[a]One-way analysis of variance test.
[b]Kruskal–Wallis test.
[c]Fisher–Freeman–Halton test.
*$P < .017$.
BBS, Berg Balance Scale; BI, Barthel index; DI, Downton index; FMA-UE, Fugl–Meyer Assessment—Upper Extremity.

Table 6. Regression Model for FMA-UE

	B	SE	Beta	*t*	*P*
BBS	0.165	0.082	0.075	2.015	***.048****
CVA duration	0.047	0.024	0.073	2.010	***.048****
BRS—upper extremity	4.220	1.103	0.284	3.826	***<.001****
BRS—hand	7.406	0.808	0.664	9.167	***<.001****

BBS, Berg Balance Scale; BRS, Brunnstrom Recovery Scale; CVA, cerebrovascular accident; FMA-UE, Fugl–Meyer Assessment—Upper Extremity.

The authors concluded that the use of an arm sling helps postural adaptation with a feedback mechanism.[29] That study lends support to the association of impaired postural reactions with upper extremity dysfunction in patients with stroke. Külcü et al investigated the relationship between upper extremity functions and balance in 50 stroke patients. The Action Research Arm Test detected a highly positive significant correlation between Motor Assessment Scale upper extremity and hand scores of the FMA, BRS upper extremity and hand stages, and BBS scores.[30] In their recent study, Rafsten et al[7] reported that the motor function of the affected arm was significantly associated with impaired postural balance post-stroke, as assessed by BBS and TUG.[7] Similarly, in our study, we found that patients with high FMA-UE scores and higher BRS upper and lower extremity stages had significantly higher BBS scores.

Falls are among the important complications frequently encountered in patients with stroke. Falls restrict the activities of the patients by causing the fear of falling again. This in turn reduces the willingness of stroke patients to ambulate and may significantly prevent the patient from participating in rehabilitation activities. Many other problems, especially fractures, which occur after a fall also hinder the ability to follow a rehabilitation program. Stroke patients tend to fall more frequently than general population. Reported frequency of falls in patients with stroke ranges from 10% to 46%.[32,33] In a study by Kerse et al[33] investigating the frequency of falls in 1104 stroke patients, 37% of the patients reported falling at least once in the last 6 months since stroke.

In the current study, 45.9% of the patients reported that they had fallen at least once in the last 6 months after stroke, with 16.2% of the patients falling once and 29.7% falling more than once. The reasons for the high incidence of falls in our study can be explained by technical shortcomings of the rehabilitation units in Türkiye, the low number of staff, and the inability to properly arrange home environment of the patients to help them continue their daily lives, especially after acute care.

A number of limitations of this study should be noted. First, additional conditions that may affect upper extremity and balance functions were not adequately evaluated. These include the presence of neuropathy in patients with diabetes mellitus, whether the affected side is the dominant hand or not, and factors that can affect both upper extremity functions and balance. Trunk control is necessary to maintain body position, stability in changing positions, and performance in ADL. Trunk performance was not assessed in our study. It would be of value to evaluate these parameters collectively in future studies.

The upper extremity functions of stroke patients affect balance and functional status. As the upper extremity dysfunction increases, the balance disorder also increases. In patients who are included in the rehabilitation program due to balance and gait impairment, not only should we aim to improve balance and lower extremity functions, but we should also provide rehabilitation programs to help patients regain upper extremity and hand functions. Clinicians caring for stroke patients need to inquire about falls, assess for fall risk, and address modifiable risk factors to prevent serious injuries that may occur as a result of falls.

Ethics Committee Approval: Protocol for this research project has been approved by Ethics Committee of Bakirkoy Dr Sadi Konuk Training and Research Hospital (Date: April 24, 2014/ Decision no: 2014/0223).

Informed Consent: Written informed consent was obtained from the patients who participating in this study.

Peer-review: Externally peer-reviewed.

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