

для однонуклеотидного поліморфізму rs2583988 (C> T) в гені альфа-синуклеїна. Поліморфний нуклеотид був обраний шляхом аналізу біоінформатичних та генетичних досліджень. Ми розробили пару праймерів та умови рестрикційного аналізу для виявлення різних алелів у rs2583988. Як результат, був розроблений простий і доступний метод виявлення однонуклеотидного поліморфізму алелів rs2583988. Очікується, що метод виявиться зручним для клінічних лабораторій, завдяки доступній вартості та обладнанню, а також використовуватиметься в подальших асоціативних дослідженнях.

**Ключові слова:** хвороба Паркінсона, ген альфа-синуклеїна, однонуклеотидний поліморфізм, полімеразна ланцюгова реакція довжин рестрикційних фрагментів.

Стаття надійшла 18.09.2019 р.

однонуклеотидних поліморфізма rs2583988 (C> T) в гені альфа-синуклеїна. Текущий поліморфний варіант був вибран шляхом аналізу біоінформатичних та генетичських досліджень. Мы разработали пару праймеров и условия рестрикционного анализа для выявления различных аллелей в rs2583988. Как результат, был разработан простой и доступный метод выявления однонуклеотидных полиморфизма аллелей rs2583988. Ожидается, что метод окажется удобным для клинических лабораторий, благодаря доступной стоимости и оборудованию, а также использоваться в дальнейших ассоциативных исследованиях.

**Ключевые слова:** болезнь Паркинсона, ген альфа-синуклеїна, однонуклеотидный полиморфизм, полимеразная цепная реакция длин рестрикционных фрагментов.

Рецензент Дельва М.Ю.

DOI 10.26724/2079-8334-2020-3-73-134-139

UDC 616.728.2-089.28:612.76

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## FEATURES OF THE ABDUCTION MECHANISM WORK BEFORE AND AFTER TOTAL HIP JOINT ARTHROPLASTY

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Increased tone of the flexors and adductor muscles of the hip in combination with a decrease in elasticity and contractile function of abductors and protractors of the hip due to contracture of the hip joint leads to imbalance in the muscles of the pelvic girdle, which negatively affects the positional adaptation of endoprosthesis components during the surgery and complicates the postoperative period in patients. The treatment results analysis of 114 patients with diseases of the hip joint showed that in most patients the manifestations of pelvic girdle muscle deficiency after hip arthroplasty decreased, but did not disappear for a long time. The study of vertical posture in patients with normal and reduced size of the total femoral offset after hip arthroplasty showed that the reduction of the abductor shoulder leads to a significant change in the main indices of the stabilogram, namely to increased energy expenditure to maintain vertical posture, therefore energy depletion occurs faster. It is clinically manifested by symptoms of pelvic girdle muscle insufficiency - lameness, positive symptom of Trendelenburg, Duchenne, the need to use additional support, etc.

**Key words:** endoprosthesis, hip joint, vertical posture, statography, femoral offset.

*The work is a fragment of the research project "To study the biomechanical features of the standing and walking function in humans after hip arthroplasty", state registration No. 0118U006950.*

Owing to the classic works by Yanson Kh.A. [2], Kizilova N. [7] it is generally accepted that maintaining the horizontal balance of the pelvis in the frontal plane is achieved by the work of the pelvic girdle muscles, namely the ability to dynamically balance the gravitational, reactive and muscular forces acting on the joint components in the frontal plane in single-support standby.

The main condition for stable single-support standby is the balance (relative to the center of the hip joint rotation) of the abductor muscles force moments and gravitational and reactive forces, which is determined by the so-called abduction mechanism - the work of pelvic girdle muscles, which provide constant dynamic restoration of the pelvis horizontal balance [11]. To counteract the gravity force, muscles must develop significant efforts. This is especially true of dynamic loads, because in these conditions great effort is required to maintain a horizontal balance of the pelvis. Given that the arm of the abductor muscles is by 2.2-2.5 times shorter than the arm of gravity, to ensure the operation of the abduction mechanism, the muscular effort must exceed the body weight by 1.5 to 3 times [2, 5].

This makes it clear what an important factor in the normal functioning of the hip joint is the functional state of the abductor muscles, i.e. the work of the abduction mechanism of the hip joint to ensure the horizontal balance of the pelvis [4].

The work efficiency of the hip joint is determined by two main factors: the anatomical parameters of the joint elements and the condition of the pelvic girdle muscles, which are closely related. Thus, the change in the anatomical parameters of the hip joint: deformation of the femoral head, its protrusion, elongation of the trochanter major, impairment of the proximal femur torsion, which are caused by various orthopedic diseases and injuries, lead to a change in the force arm of abductor muscles, which adversely affects the abduction mechanism's operation and significantly slows down the process of the patient's

rehabilitation after arthroplasty [1]. In the context of the above, the question arises about the causes and mechanism of the abduction mechanism's dysfunction development (which manifestation is an impairment of the patient's standby) after total hip arthroplasty.

Prolonged pain and contracture of the hip joint lead to contractile spasm and reduction in the length of the adductor and flexor muscles of the hip and to the relative overstretching of the abductor muscles, which leads to a decrease in their elasticity and impaired contractility, and subsequently, to structural muscular changes and significant loss of strength of the abductor muscles.

Reducing the length of the flexors and adductor muscles complicates the installation of the endoprosthesis components, which requires in some cases, the performance of adductors myotomy, excision of the joint capsule. Sometimes excessive soft tissue tension causes the installation of endoprosthesis components with a decrease in the total femoral offset - (distance from the center of the femoral head rotation to the line of the abductor muscles action) [10].

Thus, the working concept of the study can be formulated as follows: the presence of long-term flexion- adductor contracture of the hip joint complicates the positional adaptation of the endoprosthesis components reducing the total femoral offset (arm of abductor muscles), which in its turn negatively affects the abduction mechanism and slows down the process of postoperative rehabilitation in patients.

**The purpose** of the study was to determine the cause and mechanism of the abduction mechanism dysfunction development and slow down the recovery process after hip joint arthroplasty.

**Materials and methods.** The study group included 114 patients aged 29 to 76 years (mean age - (56±8) years) with diseases and consequences of the hip joint injuries, who were performed total cementless hip arthroplasty during 2012-2017. The study was performed on the basis of Joint Pathology Clinic and the archive of the Sytenko Institute of Spine and Joint Pathology, NAMS of Ukraine. 47 men (41.2%) and 67 women (58.8%) were examined.

Clinical examination and study of the musculoskeletal system function in patients were performed according to the classical method of the trauma patient's examination.

Functional results of endoprosthetics were assessed in compliance with the Harris rating scale [6], based on clinical trial data and subjective assessment of the patient's condition, the severity of pain was assessed by a visual analog scale (VAS), function of muscles responsible for maintaining postural balance was assessed, according to our improved method [10], the efficacy of maintaining a vertical posture before and after the surgery - using protocol indices of stabilographic study, namely the amplitude and energy parameters of standby for two-support and single-support standing.

The studies comply with the principles and provisions of the Declaration of Helsinki, adopted by the General Assembly of the World Medical Association, on the ethical principles of scientific medical research with human participation (1997-2000).

The study data were processed statistically: descriptive statistics was used with the calculation of the mean (M) and its standard deviation (SD), the range of values. The data analysis for the distribution normality was performed using the Kolmogorov-Smirnov test. Comparisons between groups of patients were performed using the T-test for independent samples. The analysis was performed using the software package IBM SPSS Statistics 20.0. Preliminary data preparation was performed using the Microsoft® Excel® 2013 software package of the Microsoft Office Prof. + 2013.

**Results of the study and their discussion.** Almost all the patients at the time of consultation complained of pain in the hip joint. At the same time, 39 patients (34.5%) noted moderate pain in the compromised joint, 75 (65.8%) - severe.

After surgical treatment, the severity of the pain changed. The complete absence of pain in the operated joint was noted by 104 patients (91.2%), or they noted mild intermittent pain or discomfort. Nine patients (7.9%) reported moderate, often intermittent pain, which was rated at 3-5 points for hip joints. And only in one case (0.9%) the patient complained of severe pain, which he rated as 7 points according to VAS.

Our particular interest was drawn by clinical indices of postural imbalance (in this case we speak about the abduction mechanism of the hip joint, which provides horizontal balance of the pelvis) in the form of lameness, the use of additional support when walking, symptoms of muscle failure, limited movement and contractures in the hip joint. In table 1 clinical signs of limb dysfunction in patients before surgery and 6 months after surgery are presented.

Thus, after surgery - total hip arthroplasty - the presence of the abduction mechanism insufficiency signs in the form of the pelvis horizontal balance disorder decreased significantly. In particular, the number of patients with pelvic girdle muscles insufficiency, such as lameness and the use of additional support, decreased by approximately 20%, such as the Trendelenburg symptom and the Duchenne symptom - by 50-60%.

**Signs of the hip joint abduction mechanism dysfunction, which ensures the horizontal balance of the pelvis, before surgery and 6 months after surgery**

Signs of the pelvis horizontal balance disorder	Number of observations (n = 114)	
	Before surgery	6 months after surgery
Lameness	85 (74.6 %)	61 (53.5 %)
Use of additional support	37 (32.5 %)	15 (13.1 %)
Trendelenburg's symptom	103 (90.4%)	49 (43.0 %)
Duchenne's symptom	103 (90.4%)	34 (29.8 %)
Contracture	97 (85.1 %)	7 (6.1 %)

Hip-spine syndrome was detected in 47 patients (41.2%), mainly in patients with bilateral coxarthrosis, and mostly these particular patients had signs of incompetence in muscles responsible for the operation of the abduction mechanism in the post-operative period.

In 97 patients before surgery, adduction-flexion contractures of varying severity were identified, in 58 cases (59.8% of the total number of detected contractures) the magnitude of hip flexion exceeding  $20^\circ$ , and the magnitude of adduction  $-10^\circ$ , having clinical manifestations in the form of relative shortening of the diseased limb, pelvic tilt, hyperlordosis, etc. In 28 cases (28.9% of the total number of detected contractures), the amount of hip flexion exceeded  $30^\circ$ , and the amount of adduction  $-15^\circ$ .

Thus, it can be stated that in most patients there was a pronounced adduction-flexion contracture of the hip joint, which was clinically manifested by shortening of the limb on the affected side, pelvic tilt to the "healthy" side and forward, hyperlordosis and concomitant lesions, which together formed "pathological" movement strategy.

These clinical indices are usually associated with functional changes in the muscles and determine the musculoskeletal function disorder in the limb and negatively affect the maintenance of postural balance, lead to the development of new motor strategies (because standing is a dynamic type of posture maintaining).

After hip arthroplasty, almost all the patients showed a marked improvement in musculoskeletal function, in addition, over time, most patients showed positive dynamics of improving the function of the muscles responsible for the pelvis horizontal balance.

Functional results of the patients' treatment were assessed according to the standard Harris method. Before the endoprosthesis surgery by Harris, the condition of each patient was assessed in points. The functional status of the hip joint before surgery averaged  $(32.6 \pm 7.1)$  points. Then the results of treatment for each patient were assessed in points approximately 6 and 12 months after the surgery and, comparing the point scores before the surgery and after the surgery in different terms, determined the dynamics of the recovery process over time.

For further analysis and comparison of treatment results for the study group in total, the mean value and the standard deviation were calculated.

Comparison of mean scores permitted to determine the efficacy of treatment, and comparison of the standard deviation values in the same terms permitted to assess the uniformity of the study group.

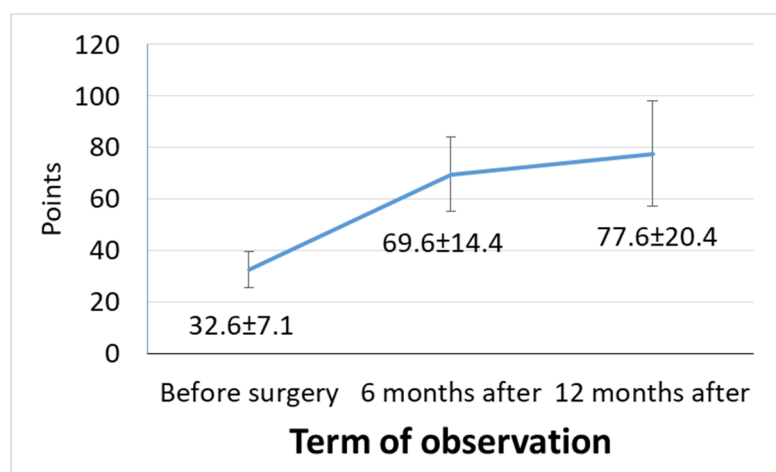


Fig. 1. Diagram of the mean indices' dynamics of the functional state recovery in the operated hip joint and the value of the standard deviation 6 and 12 months after surgery.

The results presented in the diagram (fig. 1) show that after 6 months from the moment of surgery the mean index of functional recovery was  $(69.6 \pm 14.4)$  points, and up to 12 months. -  $(77.6 \pm 20.4)$  points.

The mean scores indicate that, on average, in the study group most of the patients had good functional outcome of treatment 6 months after surgery. And over time (after 12 months) the number of patients with good results only increases. For example, 6 months. after surgery, the maximum score by the Harris scale was 84.14 points, and a score exceeding 80 points, which corresponds to an excellent result, only four patients had. After 12 months the maximum score by the Harris scale was 86.54 points, and a score exceeding 80 points was recorded in 19 patients.

It should be noted that the increase in the mean score in the study group was insignificant, and the difference was statistically unreliable. However, the value of the standard deviation has significantly increased. An increase in the standard deviation rate by almost a third reflects a greater variation in treatment outcomes in the group as time passed or a decrease in the group uniformity. This means that 12 months after surgery, most of the patients had excellent results compared to those after 6 months, but this does not mean that in all the patients the results became better 12 months after the operation.

The obtained results of treatment in the patients show that the total hip arthroplasty permits to reliably relieve patients of pain and quickly restore normal household activity. However, muscular incompetence of pelvic girdle occurs even 12 months after surgery. This is evidenced by the presence of lameness, a positive symptom of Trendelenburg and Duchenne signs, which are identified in some patients, i.e. indirect signs of abduction mechanism impairment, which provides horizontal balance of the pelvis and is determined by equality of the gravity force moment and the force moment of hip abductor muscles. The force moment of the hip abductor muscles is determined by the product of the size of the arm of force value by the value of muscle power, which depends on the presence of pain, tone and contractility of the muscle.

However, it is not possible to assess the function of the pelvic girdle muscles using the Harris assessment method, as it focuses on the analysis of the quality of life and the household adaptation of the patient. Therefore, we have proposed and tested a technique based on the principle of maintaining the pelvis horizontal balance while standing and walking due to the muscles of the torso and pelvic girdle.

Details and principles of using this technique are given in the literature [9], so we will only focus on the results obtained.

According to our data, before the surgery all the studied patients had an unsatisfactory condition of the muscles, which are responsible for the work of the abduction mechanism, i.e. for maintaining the horizontal balance of the pelvis. Even conservative treatment of coxarthrosis for 6-12 months does not significantly improve the function of the hip abductor muscles, although the tendency to restore the muscle function after surgery is more pronounced in patients who received such preoperative conservative treatment.

Hip arthroplasty improves the function of the abductor muscles by restoring the geometry of the joint, eliminating (or significantly reducing) the contracture, and relieving the patient of pain. Although in most patients the recovery of muscle function occurs within a year after surgery, but in a number of patients the function of the abductor muscles is never completely restored.

What is the reason for the impairments? We have analyzed the causes of such complications and concluded that it is due to a disorder of the hip joint abduction mechanism, which is determined by two indices - the arm of force length and the maximum power of the abductor muscles. The product of these parameters determines the magnitude of the abductor muscles' force moment, which counteracts the moment of gravity. Given this, a very important index is the size of the abductor muscles' arm of force, and the condition of the muscles before and after surgery.

The magnitude of the hip abductor muscles' arm of force after arthroplasty is determined by an index called the total femoral offset. If the value of the total femoral offset after hip arthroplasty is equal to the length of of a healthy joint abductors' arm of force, as it is the case in most patients, the restoration of muscle function occurs in a short time. But in more than 30% of patients according to our data [7, 11] the value of the total femoral offset decreases after surgery.

We have studied the effect of this factor on muscle function by means of stabilographic studies, which are objective evidence of the abduction mechanism dysfunction in clinical settings [11].

According to the archival materials of the laboratory of biomechanics at the SI "Sytenko Institute of Spine and Joint Pathology, NAMS of Ukraine" there were selected stabilogram protocols of 30 patients with coxarthrosis before and after hip arthroplasty, of which 15 had the total femoral offset equal to the arm of force length of abductors on the opposite side, and 15 patients had a lower total femoral offset, according to measurements in radiographs.

According to the comparative statographic analysis, there were some differences in the standing characteristics of the patients in whom the size of the abductor muscles' arm after arthroplasty reduced compared to similar indices of the patients in whom changes in the abductor muscle arm's length did not occur. It has been established that after arthroplasty reduction of the abductor muscle arm's length leads to a significant change in the shape and size of the center of mass projection (during single support of standby), namely: to its sagittal size increase and the frontal size reduction in the center of mass displacement projection spot, which indicates a greater amplitude of body oscillations in the sagittal plane. It was also found that reduction in the length of the abductor muscles arm after arthroplasty leads to an increase in the speed and frequency of oscillations in the center of mass projection (table 2).

Under these conditions, energy expenditures significantly (more than by 2 times) increase to maintain a vertical posture. Thus, energy depletion occurs more quickly, which is clinically manifested by the symptoms of pelvic girdle muscle incompetence - lameness, a positive symptom of Trendelenburg, Duchenne, the need to use additional support, etc.

**Analysis of statograms spectral characteristics in patients with reduced (group I) and unchanged (group II) total femoral offset 9-12 months after hip joint arthroplasty**

Test	Group		Before treatment				After treatment			
			F(Hz) (min÷max)	ΣF(Hz) (Mo)	P(W) (min÷max)	ΣP(W) (M, SD)	F(Hz) (min÷max)	ΣF(Hz) (Mo)	P(W) (min÷max)	ΣP(W) (M, SD)
double-support	I n=15	X1	0.1÷0.8	0.2	50÷250	464±101	0.1÷0.5	0.2	25÷75	<b>129±46</b>
		Y1	0.1÷1.1		130÷690		0.13÷0.7		60÷200	
	II n=15	X1	0.1÷1.0	0.2	50÷250	544±104	0.1÷1.0	0.3	20÷50	<b>269±24</b>
		Y1	0.1÷0.9		200÷480		0.2÷0.5		200÷280	
T-test (t, p)		x				t=-1.744 p=0.098	x		t=-8.570 p=0.001	
Injured limb	I n=15	X1	0.1÷0.5	0.5	250÷550	1013±238	0.12÷1.1	0.7	240÷270	<b>1122±29</b>
		Y1	0.1÷1.0		400÷1000		0.2÷1.1		800÷1000	
	II n=15	X1	0.2÷0.6	0.4	180÷240	1041±271	0.2÷0.6	0.5	150÷175	<b>494±10</b>
		Y1	0.1÷0.7		380÷1040		0.1÷0.7		320÷350	
T-test (t, p)		x				t=-0.244 p=0.810	x		t=65.135 p=0.001	
Conditionally healthy limbs	I n=15	X1	0.12÷0.6	0.3	30÷70	150±57	0.1÷0.8	0.3	70÷90	<b>288±16</b>
		Y1	0.3÷0.6		50÷150		0.04÷0.4		160÷220	
	II n=15	X1	0.2÷0.9	0.2	45÷80	145±65	0.2÷0.9	0.3	50÷70	<b>230±10</b>
		Y1	0.3÷0.9		130÷160		0.3÷0.9		100÷240	
T-test (t, p)		x				t=0.169 p=0.867	x		t=3.714 p=0.065	

Hip joint arthroplasty in the long-term course of coxarthrosis permits to effectively relieve the patient of pain, to restore range of motion, significantly improve the quality of life in patients. But there is a study which says about reduction of the hip joint's support and kinematic function, which is observed for a long time after surgery. In particular, according to the performed meta-analysis of the literature, Vissers et al. [12] showed that the strength of the abductors is not restored in the next 6 months after hip arthroplasty. Similar conclusions were made by other authors [3], who studied the postural stability of patients after the above surgeries.

Unfortunately, researchers focus on the muscles condition when assessing the stability of standing in the postoperative period, but almost do not take into account the condition of the muscles before surgery. Experts who study the support and kinematic function of the extremities after hip arthroplasty believe that insufficiently rapid recovery of muscle activity and soft tissue tone is the result of inadequate restorative treatment in the postoperative period [8]. We suggested that the hip joint contracture, in the long-term course of coxarthrosis is one of the important factors influencing the work of the hip joint's abduction mechanism. According to our data, the vast majority of patients with coxarthrosis - more than 85% - had hip contractures, and most of them (almost 60% of all patients with contractures) had a severe degree of contractures.

In our opinion, the presence of flexion-adduction contracture, which is accompanied by retraction of the adductive muscles and flexors and relative overstretching of the abductors with a decrease in their tone and contractility, has a significant impact on positional adaptation of implant components during surgery, namely in more than 30% of patients it reduces the size of the total femoral offset compared to the arm of force length in a healthy joint's abductors.

In recent years, works have begun to appear raising the question of the total femoral offset size effect on the hip abductor muscles strength [9]. However, the authors have only analyzed the muscle strength indices mainly of the operated limb, but did not study the effect of the total femoral offset on the work of the abduction mechanism, namely on the maintenance of the pelvis horizontal balance. Our stabilographic studies have shown that reduction in the size of the total femoral offset leads to certain noticeable impairments of the vertical posture, in particular, an increase in energy expenditure to maintain a vertical posture by more than 2 times. And this in its turn leads to energy depletion of muscles and slows down the process of postoperative rehabilitation in patients.

## Conclusions

1. Contracture of the hip joint in the prolonged course of coxarthrosis negatively affects the positional adaptation of the endoprosthesis components, namely, creates conditions for reducing the size of the total femoral offset.

2. Reduction of the total femoral offset in its turn is a negative factor influencing the hip joint abduction mechanism, namely the horizontal balance of the pelvis, which has clinical manifestations in the form of lameness, lateral tilt of the pelvis and torso, etc. in the postoperative period.

3. Stabilographic studies have objectively proven that reduction of the total femoral offset size has a negative impact on the hip joint abduction mechanism, and slows down the recovery process after hip joint arthroplasty due to increased energy expenditures for maintaining a vertical posture.

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### Реферати

#### ОСОБЛИВОСТІ РОБОТИ АБДУКЦІЙНОГО МЕХАНІЗМУ ДО ТА ПІСЛЯ ТОТАЛЬНОГО ЕНДОПРОТЕЗУВАННЯ КУЛЬШОВОГО СУГЛОБА

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Підвищення тонусу згиначів і привідних м'язів стегна у поєднанні зі зменшенням еластичності та скорочувальної функції абдукторів та розгиначів стегна внаслідок контрактури кульшового суглоба призводить до виникнення дисбалансу у м'язах тазового пояса, що негативно позначається на позиційній адаптації компонентів ендопротезу під час операції та ускладнює післяопераційний період у хворих. Аналіз результатів лікування 114 пацієнтів із захворюваннями кульшового суглоба, показав, що більшості пацієнтів прояви дефіциту м'язів тазового поясу після ендопротезування зменшилися, але не зникли тривалий час. Вивчення вертикальної пози у пацієнтів із нормальним та зменшеним розміром загального стегнового офсету після ендопротезування кульшового суглоба показало, що зменшення плеча абдукторів призводить до значної зміни основних показників стабілограми, а саме до збільшення енергетичних витрат на підтримку вертикальної постави, тому виснаження енергії відбувається швидше, це клінічно проявляється симптомами недостатності м'язів тазового дна - кульгавістю, позитивним симптомом Тренделенбурга, Дюшенна, необхідністю використання додаткової підтримки тощо.

**Ключові слова:** Ендопротезування, кульшовий суглоб, вертикальна поза, статографія, стегновий офсет  
Стаття надійшла 21.08.2019 р.

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Повышение тонуса сгибателей и приводящих мышц бедра в сочетании с уменьшением эластичности и сократительной функции абдукторов и разгибателей бедра вследствие контрактуры тазобедренного сустава приводит к возникновению дисбаланса в мышцах тазового пояса, что отрицательно сказывается на позиционной адаптации компонентов ендопротеза во время операции и затрудняет послеоперационный период у больных. Анализ результатов лечения 114 пациентов с заболеваниями тазобедренного сустава показал, что у большинства пациентов проявления дефицита мышц тазового пояса после эндопротезирования уменьшились, но не исчезли длительное время. Изучение вертикальной позы у пациентов с нормальным и уменьшенным размером общего бедренного офсета после эндопротезирования тазобедренного сустава показало, что уменьшение плеча абдукторов приводит к значительному изменению основных показателей стабилограммы, а именно к увеличению энергетических затрат на поддержание вертикальной осанки, поэтому истощение энергии происходит быстрее, это клинически проявляется симптомами недостаточности мышц тазового дна - хромотой, положительным симптомом Тренделенбурга, Дюшенна, необходимостью использования дополнительной поддержки и тому подобное.

**Ключевые слова:** эндопротезирование, тазобедренный сустав, вертикальная поза, статография, бедренный офсет.

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