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Parameters of podobarography after hip total endoprosthetics at different surgical accesses

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Abstract

Urgency. These days hip endoprosthetics is quite common surgery. Following prosthetics, most of the functional limb disorders were observed in the patients under treatment at the early and long-term periods after surgery. This was associated with uneven loading on the feet when walking. **The objective:** to evaluate the load distribution of patients' feet plantar surface after hip replacement for coxarthrosis, depending on the use of anterior - lateral or posterior - lateral surgical approach. **Materials and methods.** The parameters of podobarography were analyzed in 120 patients before operation, at early and long-term postoperative periods after hip replacement. Herewith 60 patients underwent anterior-lateral and 60 patients - posterior-lateral approach. **Results.** The indices of the load by the zones of the feet plantar surfaces and the ratio of the operated-contralateral limb after endoprosthetics at the stages of functional recovery varied. The imbalance of values under the use of anterior-lateral and posterior-lateral approach can be regarded as a compensatory mechanism for the transfer of the projection of the body's gravity center to the support area due to the redistribution of muscle activity between agonists and antagonists to maintain the joint's stability after implant's positioning.

Key words: hip joint endoprosthetics; podobarography; surgical approach

It is known that in the case of coxarthrosis, especially of its long-term course, biomechanical-geometric parameters of a hip are distorted, which is manifested in the asymmetry of weight loads on the feet, development of asymmetry of steps, decrease of stride length, impaired rhythmic walking, etc. [4]. Despite the fact that nowadays total endoprosthesis has become the main, and often the only possible, method of severe pathological changes of the hip treatment, which allows to restore the hip support ability, achieve sufficient amplitude of movements range, relieve the patient of pain, lameness, return the one to normal life, the number of positive results achieved immediately after surgery in longer observation times [3, 6] is growing less.

The many authors claim that immediately after surgery in most patients, these functional disorders disappear within 6 months, but in some cases they continue to be observed at a more distant time, which may be associated with hypotrophy of the thigh muscles and joint contracture, or joint contractility, errors in the prosthesis positioning; inflammatory phenomena, loosening of the endoprosthesis [2, 5].

The results of the gait biomechanics study indicate that with good results of treatment, the natural patient's pace remains reduced for several years after prosthetics, the load on the operated limb during gait and muscles strength are reduced. Foot transfer duration in patients after surgery on the side of the intervention is significantly greater than on the non-operated foot. The legs uneven loading in patients underwent hip replacement when walking is associated with a deficiency of sensory mechanism around the artificial joint, which in turn leads to overloading of the non-operated leg [8, 9]. Among these reasons of the main symptoms persistence, our task was to investigate the role and degree of impact of various surgical approaches of hip replacement in early and long-term follow-up, which remains the subject of debate and is still unexplained.

The objective: to evaluate the load distribution of feet plantar surface in coxarthrosis stage III patients underwent hip arthroplasty depending on the use of different surgical approaches.

Materials and methods. A biomechanical study was performed at the biomechanics laboratory with the use of podobarography. Parameters of podobarography of 120 preoperative patients in early (3 weeks) and long-term (4 months) postoperative periods after hip replacement were investigated. Of these, 60 patients underwent surgery from the anterior - lateral and 60 - from the posterior - lateral surgery.

Podobarography is used for the functional estimation of the load distribution on the feet plantar surface during double limb stance and intended to objective quantification of the

feet individual characteristics under the conditions of static loading. To estimate the load distribution on the plantar surface of a human's feet [1] a special device was used. It allowed to get data of feet posterior, anterior - external, anterior - median and anterior – internal plantar surface [Fig. 1] was used to estimate the load distribution on the plantar surface of the human foot [1], with the help of which data were obtained on the load of the posterior, anterior-outer, anterior-midline, and anterior-inner plantar surfaces of the feet (Fig. 1).

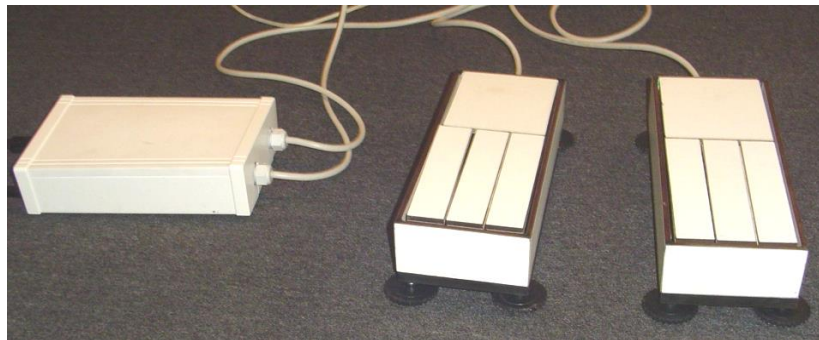


Fig. 1. Device for estimation of load distribution on plantar surface of foot

A computer software system and device with two load cell platforms was used. The construction allows the platforms to be placed individually at different distances, heights and at different angles relative to each other, depending on the individual features of each patient's standing. The patient, with the help of the operator, placed the feet on the surface of load cell platforms, according to the position of the feet, and was in the normal upright position, looking ahead (Fig. 2).



Fig. 2. Position of patient's feet on load cell platforms

Measurements were made within 30 seconds, with subsequent registration of the parameters under study (Fig. 3). The results obtained were exported to the database.

Results. The analysis of load forces values in different segments of the plantar surface of the foot made it possible to carry out an objective assessment of the functional status of coxarthrosis patients at the pre-surgical stage, as well as to monitor pathological changes or restorative processes after postendoprosthesis of hip joints and joints at early and long-term post-operative periods.

Левый			Правый		
Внешн	Средн	Внутр	Внутр	Средн	Внешн
8,92	10,73	1,62	6,64	15,08	9,5
Средн (кг)	Средн (кг)	Средн (кг)	Средн (кг)	Средн (кг)	Средн (кг)
9,01	10,78	1,64	6,65	15,02	9,4
Проц (%)	Проц (%)	Проц (%)	Проц (%)	Проц (%)	Проц (%)
10,35	12,38	1,88	7,63	17,24	10,8
Пятка			Пятка		
11,16			23,34		
Средн (кг)			Средн (кг)		
11,23			23,37		
Проц (%)			Проц (%)		
12,89			26,83		
32,43			54,56		
Средн (кг)			Средн (кг)		
32,66			54,44		
Проц (%)			Проц (%)		
37,5			62,5		
0 коррекция			0 коррекция		
86,99					
Средн (кг) 87,1					

Fig. 3. Indicators of load distribution on the plantar surface of the feet in "Planto" software

The following parameters were determined: 1) symmetry of loading on the affected and intact limb; 2) symmetry of loading on the heel and toe sections separately for the affected and intact foot; 3) the distribution of loads into separate segments of the feet - anterior-medial, anterior-median, anterior-lateral and posterior (heel) separately for each foot; 4) symmetry of loading on separate segments of feet; 5) indicators of loads distribution on separate segments of feet after surgery.

According to podobarography data the changes in the load values across all zones of the plantar surface and the ratio of the operated-contralateral (intact) limb in the stages of postoperative functional recovery (Tables 1, 2) were observed.

Table 1

Dynamics of average values of load on the segments of the feet after hip replacement with the use of posterior-lateral approach

Indexes of load, (% of body mass)							
Part of foot plantar surface	Referen- ce values	Before operation		Early post-operative period		Long-term post- operative period	
		Damaged limb, M±m	Contra lateral limb, M±m	Damaged limb, M±m	Contra lateral limb, M±m	Damaged limb, M±m	Contra lateral limb, M±m
Anterior- external	8,5±0,9	2,8±1,2	8,23±0,5	3,7±0,2	5,87±1,1	5,8±0,7	5,9±1,4
Anterior-medial	9,9±0,8	7,07±1,9	13,3±0,7	7,1±0,9	12,03±1,9	10,3±1,2	12,3±2,1
Anterior-internal	2,4±1,1	5,3±0,3	6,5±1,1	3,9±1,0	7,1±0,9	5,2±1,1	7,0±1,0
Posterior part (heel)	28,0±1,2	19,9±1,1	36,9±3,1	11,83±2,1	71,5±4,7	22,8±2,1	37,0±4,3
Total distribution between limbs	50,0±1,6	25,08±2,4	64,9±2,9	17,85±3,8	82,15±5,0	37,7±3,0	62,1±3,8

Thus, in the group of patients with anterior-lateral access at hip replacement a difference in load between the affected and contralateral limb due to the emphasis of support for intact (conditionally healthy limb) was noted. Compared with the reference values, there was a 17% load decrease on the plantar surface of the foot on the side of the lesion along anterior-outer area.

The load on the anterior-medial and anterior-internal foot areas vicer versa increased by 4 and 84% correspondingly. The load on the anterior foot area was increased by 5% and that on the posterior part was within the reference values. Thus, the total load on both feet was uniform, on the side of lesion it corresponded to the values of the contralateral (intact) limb (50% : 50%), that is, the affected limb, unlike intact, occupied an externally rotational position.

In the early postoperative period, the difference in the load indexes on the operated limb, compared with the contralateral, increased.

Table 2

Dynamics of average values of load on the parts of feet after hip replacement with anterior-lateral approach

Load indexes, (% of body mass)							
Part of foot plantar surface	Reference values	Before operation		Early post-operative period		Long-term post-operative period	
		Damaged limb, M±m	Contra lateral limb, M±m	Damaged limb, M±m	Contra lateral limb, M±m	Damaged limb, M±m	Contra lateral limb, M±m
Anterior-external	8,5±0,9	7,5±1,2	2,23±2,0	3,9±1,9	5,9±1,1	4,0±0,3	5,6±2,0
Anterior-medial	9,9±0,8	10,4±0,3	7,77±1,9	8,03±0,7	10,7±1,8	8,4±0,1	9,8±0,1
Anterior-internal	2,4±1,1	4,6±0,1	5,4±0,8	3,96±0,3	3,5±0,6	2,9±1,4	3,0±0,2
Posterior part (heel)	28,0±1,2	27,6±0,7	21,3±0,9	24,16±1,2	40,61±2,7	31,5±2,2	38,7±1,1
Total distribution between limbs	50,0±1,6	50,7±1,3	49,3±2,2	42,8±1,9	57,2±2,3	44,1±2,3	54,2±0,9

Compared with the reference values, there was a decrease in the load indexes on all sections of the plantar surface of the foot on the side of the lesion, except the anterior - inner part, where the index increased by 58%. Front and posterior foot loads were reduced by 26 and 14%, respectively. In this case, the total foot load on the side of lesion was 14% less.

In the long-term postoperative period, after the use of anterior-lateral access, the values of the loads on the operated limb tended to reach the parameters of the contralateral limb, the load difference was leveled. Compared with the reference values, the load indexes on the anterior- external segment of the plantar surface of the foot on the lesion side was lower by 56%, on the anterior-middle one - by 16%. At the same time, the load indexes on the front - inner segment were 16% higher than the reference values. The load on the foot front on the side of the lesion was 19% lower and on the back one - 13% higher than the reference value.

Patients who underwent posterior-lateral approach for hip endoprosthetics also noted the difference in load between the affected and contralateral limbs before surgery, due to the emphasis of the support on intact, conditionally healthy limb. Compared with the reference

values, there was a decrease in the load indexes across all sections of the plantar surface of the foot on the side of the lesion, except for the anterior- inner part, where the values almost doubled. Front and back foot loads were reduced by 29%. In this case, the total load on the foot on the side of lesion was reduced by 49%. Loadings values on the foot plantar surface of contra lateral limb increased accordingly.

In the early postoperative period the difference in the load indexes on the operated limb, compared with the contra lateral one, increased.

Compared with the reference values, there was a decrease in the load indexes on all sections of foot plantar surface on the side of lesion, except for the anterior- inner part, where the values increased by 56%. Front and posterior foot loads were reduced by 33% and 58%, respectively. The total load on the foot on the operated side was 64% less.

In the long-term postoperative period, after the use of posterior - lateral approach, the values of the operated limb loads approached those of the contra lateral limb, the load difference was leveled. Compared with the reference values, the reduction in load indexes across all part of the foot plantar surface on the operated side was insignificant - from 2% (anterior- external part) to 26% (anterior- internal part). Front and back foot part loads were reduced by 1 and 19%, respectively. At the same time, the total load on the foot on the operated side was 25% less.

Thus, in long-term postoperative period, there was a transition of body weight to the intact limb, with unloading of its posterior part. It was associated with the displacement of the body's mass projection forward. Significant imbalance of the load distribution over the feet plantar surface after hip joint endoprosthetics with the use of anterior and posterior approach can be regarded as a compensatory mechanism for the transfer of the body gravity centre projection to the support area due to the redistribution of muscle activity between agonists and antagonists to maintain joint stability after implantation.

Conclusions:

1. Podobarography investigations made after total hip endoprosthetics allow to state that there are certain changes in the load indexes of a lower extremity in the segments of feet plantar surfaces (posterior, anterior- external, anterior- medial and anterior-internal) and the ratio "operated –contralateral (intact) limb" at the stages of postoperative functional recovery.

2. At the early postoperative stage after the use of anterior - lateral approach an increased values' difference was revealed. The load on the anterior and posterior foot areas was decreased by 26 and 14%, correspondingly on the operated side. The increase on the posterior - internal part equaled 58%, and decrease of total loading on the damaged side

constituted 14% compared with reference values. When applying posterior - lateral access, reduction of load on the front (33%) and back (58%) part of the foot, except the anterior - inner segment (56% increase), and reduction of the total load on the foot on the side of surgery (64%) in compared to reference values took place.

3. In the long-term postoperative period under the use of both anterior - lateral and posterior - lateral approach, a tendency for the approximation of the values of the operated limb load to the indexes of the contralateral limb was found. Equalization of the values difference took place.

4. In the long-term postoperative period under the use of anterior-lateral approach load decrease on the anterior- external segment of the foot plantar surface (56%) on the side of surgery was revealed; on the anterior-middle segments it equals 16%; as well 16 % increase on the anterior-internal (16%), total load decrease on the front of the foot was 19% and there was 13% increase on the back part of the foot, compared with the reference values. Under the use of posterior-lateral access decrease in the load on the side of the lesion on the anterior – internal part (26%), anterior- external (2%) and posterior part (19%) was revealed. compartment (19%). The total foot load decreased by 25%.

5. In the long-term postoperative period, the body weight is transferred to the intact limb, with the unloading of the posterior section of the operated limb. This is associated with the displacement of the body mass centre forward.

6. Significant imbalance of load distribution indices on the plantar surface of the feet after hip replacement with the use of anterior-lateral and posterior-lateral accesses can be regarded as a compensatory mechanism for transferring the projection of the body gravity center to the support area due to redistribution muscles activity after their intraoperation damage, between agonists and antagonists, to maintain joint stability after implantation.

References:

1. Pat. 50374 Ukraine, IPC A61B 5/103. A device for estimating the load distribution on the plantar surface of the human foot / IA Lazarev, DI Belous; patent holder State Institution “Institute of Traumatology and Orthopedics of the Academy of Medical Sciences of Ukraine”. - № u200911341; claimed 09.11.2009; publ. 10/06/2010, Bul. № 11.

2. Decreasing length of hospital stay and postoperative complications after primary total hip arthroplasty: a decade analysis from 2006 to 2016 / M. J. Grosso, A. L. Neuwirth, V. Boddapati [et al.] // J.Arthroplasty. - 2019.- Vol. 34, N 3. - P. 422 - 425.

3. How long does a hyperplacement last? A systematic review and meta-analysis of case series and national registry reports with more than 15 years of follow - up / J. T. Evans, J. P. Evans, R. W. Walker [et al.] // *Lancet*. - 2019. - Vol. 393, N 10172. - P. 647 - 654.
4. Hunter D. J. The individual and socio-economic impact of osteoarthritis / D. J. Hunter, D. Schofield, E. Callander // *Nat.Rev.Rheumatol*. - 2014. - Vol. 10, N 7. - P. 437 - 441.
5. Late complications following elective primary total hip and knee arthroplasty: who, when, and how? / J. C. Rozell, P. M. Courtney, J. R. Dattilo [et al.] // *J Arthroplasty*. -2017. - Vol. 32, N 3. 6 P. 719 - 723.
6. Learmonth I. D. The operation of the century: total hip replacement / I. D. Learmonth, C. Young, C. Rorabeck // *Lancet*. - 2007. -Vol. 370, N9597. P. 1508-11519.
7. Postural control in patients with total hip replacement / L. Calò, A. Rabini, P. M. Picciotti [etal.] // *Eur. J.Phys.Rehabil.Med*. - 2009. - Vol. 45, N3. - P. 327- 334.
8. The assessment of static balance in patients after total hip replacement in the period of 2-3 years after surgery / T. Pop, D. Szymczyk, J. Majewska [et al.] // *Biomed.Res.Int*. -2018. "Vol. 2018. -Art. No 3707254.
9. Wareńczak A. Does total hip replacement impact on postural stability? / A. Wareńczak, P. Lisiński // *BMC Musculoskelet.Disord*. - 2019. - Vol. 20, N 1.- Art. No 229.