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ASSESSMENT OF QUALITY OF LIFE OF PATIENTS AFTER ABOVE AND BELOW KNEE AMPUTATION WITH LOWER LIMB ARTERY OCCLUSION WITH CRITICAL ISCHEMIA

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Abstract

Introduction: Lower limb arterial occlusion often leads to critical ischemia requiring amputation. The level of amputation determines not only the patient's functional capabilities but also their quality of life, which makes it important to study the effect of knee preservation on rehabilitation and subjective perception of health.

Objective: to determine and compare the quality of life of patients after above-knee amputation (AKA) and below-knee amputation (BKA) performed for occlusive disease of the lower limb arteries with critical ischemia.

Research methods: A prospective study of 63 patients (33 BKA, 30 AKA) was conducted. Quality of life was assessed using the SF-36 questionnaire at 1, 6, and 12 months after surgery. The analysis included eight SF-36 scales, as well as comorbidities. Statistical analysis was performed using the χ^2 test and Student's t-test, significance level $p < 0.05$.

Results: BKA patients had higher scores on physical functioning (68.2 ± 12.1 vs. 39.7 ± 10.4 points, $p < 0.001$), role functioning due to physical condition (56.7 ± 11.5 vs. 42.3 ± 9.8, $p < 0.001$), and lower pain severity (63.8 ± 10.9 vs. 49.1 ± 10.2, $p < 0.001$). General health status was also assessed higher in BKA (59.5 ± 9.8 vs. 48.6 ± 8.9, $p < 0.001$). No significant differences were found in the psychoemotional scales, but there was a tendency for better indicators in the BKA group.

Conclusions: The study showed that the level of amputation significantly affects the physical activity and autonomy of patients. Patients with below-knee amputation (BKA) showed higher indicators of physical functioning (68.2 vs. 39.7 points, $p < 0.001$), role activity (56.7 vs. 42.3 points, $p < 0.001$) and less pain severity (63.8 vs. 49.1 points, $p < 0.001$), which positively affected their psychological state and perception of quality of life. Preservation of the knee joint accelerates rehabilitation, while for patients with above-knee amputation (AKA), comprehensive physical and psychological support is especially important.

Key words: *amputation; above- and below-knee amputation; occlusive arterial disease; critical ischemia; lower limbs; quality of life; vascular surgery; rehabilitation; disability; peripheral arterial disease.*

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Резюме

ОЦЕНКА КАЧЕСТВА ЖИЗНИ ПАЦИЕНТОВ ПОСЛЕ АМПУТАЦИИ ВЫШЕ И НИЖЕ КОЛЕННОГО СУСТАВА ПРИ ОККЛЮЗИИ АРТЕРИИ НИЖНИХ КОНЕЧНОСТЕЙ С КРИТИЧЕСКОЙ ИШЕМИЕЙ

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Введение: Окклюзия артерий нижних конечностей нередко приводит к критической ишемии, требующей ампутации. Уровень ампутации определяет не только функциональные возможности пациента, но и его качество жизни, что делает важным изучение влияния сохранения коленного сустава на реабилитацию и субъективное восприятие здоровья.

Цель: определить и сравнить качество жизни пациентов после ампутации выше (above-knee amputation, AKA) и ниже коленного сустава (below-knee amputation, BKA), выполненной по поводу облитилирующие заболеваний артерий нижних конечностей с критической ишемией.

Методы исследования: Проведено проспективное исследование 63 пациентов (33 — BKA, 30 — AKA). Оценка качества жизни выполнялась с помощью опросника SF-36 через 1, 6 и 12 месяцев после операции. Анализ включал восемь шкал SF-36, а также сопутствующую патологию. Статистическая обработка проводилась с использованием χ^2-теста и t-теста Стьюдента, уровень значимости $p < 0,05$.

Результаты: Пациенты BKA имели более высокие показатели физического функционирования (68,2 ± 12,1 против 39,7 ± 10,4 балла, $p < 0,001$), ролевого функционирования, обусловленного физическим состоянием (56,7 ± 11,5 против 42,3 ± 9,8, $p < 0,001$), и меньшую выраженность боли (63,8 ± 10,9 против 49,1 ± 10,2, $p < 0,001$). Общее состояние здоровья также оценивалось выше у BKA (59,5 ± 9,8 против 48,6 ± 8,9, $p < 0,001$). Существенных различий по психоэмоциональным шкалам не выявлено, однако отмечалась тенденция к лучшим показателям в группе BKA.

Выводы: Проведённое исследование показало, что уровень ампутации существенно влияет на физическую активность и автономность пациентов. У больных с ампутацией ниже коленного сустава (BKA) отмечены более высокие показатели физического функционирования (68,2 против 39,7 балла, $p < 0,001$), ролевой активности (56,7 против 42,3 балла, $p < 0,001$) и меньшая выраженность боли (63,8 против 49,1 балла, $p < 0,001$), что положительно сказывается на их психологическом состоянии и восприятии качества жизни. Сохранение коленного сустава ускоряет реабилитацию, тогда как для пациентов с ампутацией выше колена (AKA) особенно важна комплексная физическая и психологическая поддержка.

Ключевые слова: *ампутация; выше- и нижеколенная ампутация; облитерирующие заболевания артерий; критическая ишемия; нижние конечности; качество жизни; сосудистая хирургия; реабилитация; инвалидизация; периферическая артериальная болезнь.*

Для цитирования:

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Түйіндеме

ТӨМЕНГІ АРТЕРИЯ ОККЛЮЗИЯСЫНДАҒЫ ТІЗЕ БУЫНЫНАН ЖОҒАРЫ ЖӘНЕ ТӨМЕН АМПУТАЦИЯДАН КЕЙІНГІ НАУҚАСТАРДЫҢ ӨМІР СҮРУ САПАСЫН БАҒАЛАУЖӘНЕ КРИТИКАЛЫҚ ИШЕМИЯМЕН

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Кіріспе: төменгі аяқ артерияларының окклюзиясы жиі ампутацияны қажет ететін сыни ишемияға әкеледі. Ампутация деңгейі пациенттің функционалдығын ғана емес, сонымен қатар оның өмір сүру сапасын да анықтайды, бұл тізе буынының сақталуының оңалтуға және денсаулықты субъективті қабылдауға әсерін зерттеуді маңызды етеді.

Мақсаты: жоғарыда (above-knee amputation, AKA) және тізе буынынан төмен (below-knee amputation, BKA) ампутациядан кейінгі пациенттердің өмір сүру сапасын анықтау және салыстыру.төменгі аяқтың артериялық ауруларын сыни ишемиямен облитиляциялау.

Зерттеу әдістері: 63 пациентке перспективалық зерттеу жүргізілді (33 — BKA, 30 — AKA). Өмір сапасын бағалау операциядан кейін 1, 6 және 12 айдан кейін SF-36 сауалнамасы арқылы жүргізілді. Талдау сегіз SF-36 шкаласын, сондай-ақ ілеспе патологияны қамтыды. Статистикалық өңдеу β2-тест пен студенттің t-тестін қолдану арқылы жүргізілді, $p < 0,05$ маңыздылық деңгейі.

Нәтижелер: BKA пациенттерінде физикалық жұмыс көрсеткіштері жоғары болды (68,2 ± 12,1 қарсы 39,7 ± 10,4 балл, $p < 0,001$), физикалық жағдайға байланысты рөлдік жұмыс (56,7 ± 11,5 қарсы 42,3 ± 9,8, $p < 0,001$) және ауырсыну ауырлығы төмен (63,8 ± 10,9 қарсы 49,1 ± 10,2, $p < 0,001$). Жалпы денсаулық BKA-да жоғары бағаланды (59,5 ± 9,8 қарсы 48,6 ± 8,9, $p < 0,001$). Психоэмоционалды шкалалар бойынша айтарлықтай айырмашылықтар анықталған жоқ, бірақ BKA тобындағы ең жақсы көрсеткіштерге бейімділік байқалды.

Қорытындылар: жүргізілген зерттеу ампутация деңгейі пациенттердің физикалық белсенділігі мен автономиясына айтарлықтай әсер ететінін көрсетті. Тізе буынынан төмен ампутациясы бар науқастарда (BKA) физикалық жұмыс көрсеткіштері жоғары (68,2 қарсы 39,7 балл, $p < 0,001$), рөлдік белсенділік (56,7 қарсы 42,3 балл, $p < 0,001$) және ауырсынудың ауырлығы төмен (63,8 қарсы 49,1 балл, $p < 0,001$), бұл олардың психологиялық жұмысына оң әсер етеді өмір сапасын қабылдау және қабылдау. Тізе буынын сақтау оңалтуды тездетеді, ал тізеден жоғары ампутациясы (AKA) бар науқастар үшін кешенді физикалық және психологиялық қолдау әсіресе маңызды.

Түйінді сөздер: *ампутация; жоғары және төменгі тізе ампутациясы; артериялардың облитиляциялық аурулары; критикалық ишемия; төменгі аяқтар; өмір сапасы; тамырлы хирургия; оңалту; мүгедектік; перифериялық артериялық ауру.*

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Introduction

Lower limb amputation is a radical surgical intervention that belongs to the category of highly traumatic operations, accompanied by significant anatomical, functional, psycho-emotional and social-adaptive changes in the patient's condition. According to clinical practice, two main types of such interventions are most often performed: upper-knee amputation (AKA) and lower-knee amputation (BKA) [1].

A pressing task of modern vascular surgery and rehabilitation remains the study of the influence of the level of amputation on key indicators of treatment outcomes - quality of life, functional capacity, the possibility of returning to independent movement and the success of prosthetics.

Preservation of the knee joint in case of lower leg amputation (BKA) ensures a more biomechanically rational gait pattern, reduces metabolic costs during locomotion and increases the likelihood of full adaptation of the prosthetic-orthotic device. In contrast, amputation of the femur (AKA) is more often performed in case of widespread ischemic and necrotic lesions, which initially predetermines a more complex course of the recovery period and potentially worse functional results.

Despite the introduction of high-tech prosthetic systems that allow partial compensation for lost functions of the musculoskeletal system, the height of amputation continues to be considered as one of the leading prognostic factors determining the effectiveness of rehabilitation measures and the degree of restoration of the patient's quality of life.

Modern areas of vascular surgery and rehabilitation are aimed at a detailed study of the influence of the level of lower limb amputation on clinical outcomes and social adaptation indicators. There is convincing evidence that patients who have undergone below-knee amputation (BKA) demonstrate a higher level of autonomous mobility and adapt to prosthetics more successfully compared to patients after above-knee amputation (AKA) [2–4].

Occlusion of the arteries of the lower extremities complicated by the development of critical limb ischemia (CLI) is the terminal stage of chronic arterial insufficiency, in which a pronounced deficit in the blood supply to the tissues of the distal parts of the limb is formed. The clinical picture of this condition is characterized by the appearance of intense ischemic pain at rest, the formation of trophic ulcers, necrotic changes in soft tissues and an extremely high probability of loss of the affected limb [5]. In those clinical situations when reconstructive or endovascular interventions to restore adequate blood flow are impossible or ineffective, surgical amputation is considered a forced measure aimed at preventing the spread of necrosis and saving the patient's life. However, this operation is associated with serious consequences affecting not only physical health, but also the psychoemotional state, as well as the social adaptation of the patient [6].

According to the World Health Organization, the prevalence of peripheral arterial disease (PAD) globally reaches approximately 202 million people. At the same time, according to experts, about 10-11% of patients have severe clinical forms of the disease, in which the restoration of blood flow requires surgical or endovascular interventions [7].

European statistics show that between 150,000 and 200,000 lower limb amputations are performed on the continent every year, with atherosclerotic occlusion of the main arteries being the main etiological factor in 50–70% of cases [8].

The prognosis for critical limb ischemia remains extremely poor: up to 30% of patients undergo amputation within the first year of diagnosis, and the five-year mortality rate after such surgery exceeds 50% [9]. These data highlight the need for early diagnosis and comprehensive treatment of peripheral arterial disease to reduce the number of amputations and improve long-term outcomes.

The height (level) of amputation has a direct and multifactorial effect on the subsequent functional state of the patient, including physical activity indicators, the amount of energy expenditure when walking, the pace and success of mastering the prosthetic and orthopedic device, as well as the degree of social and everyday adaptation. According to clinical studies, preserving the knee joint during amputation at the level of the lower leg (below-knee amputation, BKA) is associated with higher values of quality of life according to the validated SF-36 scales. In addition, this group shows better results of prosthetics - success reaches up to 88% of cases, while with hip amputation (above-knee amputation, AKA) this figure does not exceed 63% [10, 11].

However, the choice of the optimal level of amputation in clinical practice is often determined by the severity of ischemic disorders and the volume of necrotic damage to soft tissues, which in some cases objectively limits the possibility of preserving the knee joint.

Aim: To determine and compare the quality of life of patients after above-knee amputation (AKA) and below-knee amputation (BKA) performed for lower limb arterial occlusion with critical ischemia.

Materials and Methods: A study was conducted to assess the quality of life of patients after lower limb amputation at different levels due to occlusion of lower limb arteries. Two groups were compared: The main group (BKA) - amputation below the knee joint. The control group (AKA) - amputation above the knee joint. The duration of observation of patients was 12 months after surgery.

The diagnosis of lower extremity artery occlusion in all patients was confirmed using a comprehensive clinical and instrumental examination in accordance with current international and national clinical guidelines. Clinical examination - assessment of the skin condition, the presence of trophic disorders, ulcerative defects, skin color, limb temperature, as well as palpation of the pulse on the main arteries of the lower extremities. Instrumental methods - ultrasound Dopplerography (USDG) and duplex scanning of the arteries of the lower extremities to determine the degree of stenosis and localization of occlusion; if necessary, contrast angiography or CT angiography was performed to clarify the extent of the lesion and the state of collateral blood flow. Laboratory tests — determination of lipid profile (total cholesterol, LDL, HDL, triglycerides), fasting blood glucose level, glycosylated hemoglobin (HbA1c) in patients with suspected or existing diabetes mellitus, as well as inflammation markers (C-reactive protein). Evaluation of ischemia severity - was carried out based on the Fontaine and Rutherford classifications, taking into account the severity of pain syndrome, pain-free walking distance and the presence of necrotic changes.

All surgical interventions were performed according to uniform standards, taking into account the principles of atraumaticity and formation of an optimal stump for subsequent prosthetics. Below-knee amputation (BKA) was performed with preservation of a functional knee joint and sufficient length of the tibia for prosthetics. When forming the stump, adequate myoplasty and myodesis were ensured to increase stability and reduce the risk of pain. Above-knee amputation (AKA) was performed at the level of the middle third of the thigh with preservation of the maximum length of the femur, allowing the use of modern prostheses. Particular attention was paid to the formation of a conical stump with smooth skin and optimal distribution of soft tissues. Anesthesia - in most cases, spinal or epidural anesthesia was used; in case of contraindications - general endotracheal anesthesia. Postoperative care included prevention of infectious complications, deep vein thrombosis, correction of pain syndrome and early initiation of rehabilitation measures. Early rehabilitation began on the first day after surgery and included breathing exercises, isometric exercises to maintain muscle mass, teaching patients self-care skills, and subsequently preparing the stump for prosthetics.

Inclusion criteria: diagnosis of occlusive disease of the arteries of the lower extremities with critical ischemia (CLI), confirmed by clinical and instrumental methods; amputation performed at the level of the thigh or lower leg; period after surgery ≥ 6 months; age ≥ 18 years; consent to participate.

Exclusion criteria included amputation due to trauma, tumor or infection; bilateral amputation, patients who did not agree to participate in the study for any reason, and incompetent patients.

The study included 63 patients: 33 (52.4%) - BKA and 30 (47.6%) - AKA, treated in the Vascular Surgery Department of the UG NCJSC «SMU» in the period from January 2021 to December 2024.

The mean age of all participants was 62.4 ± 8.9 years (range 41–81 years). In the BKA group, the mean age was 61.3 ± 8.7 years, in the AKA group, 63.6 ± 9.1 years (p = 0.12).

In terms of gender composition, BKA is 12 men (36.4%) and 21 women (63.6%); AKA is 11 men (36.7%) and 19 women (63.3%).

To assess the quality of life of patients, the Short Form-36 Health Survey (SF-36) questionnaire was used, which is an internationally recognized instrument that has undergone a procedure of cultural adaptation and validation in Russian. This questionnaire allows for a comprehensive assessment of the patient's physical, psychological and social well-being, as well as subjective perception of health. SF-36 consists of 36 questions, combined into eight scales:

1. PF (Physical Functioning) — physical functioning, reflects the degree of limitations in performing physical activities.
2. RP (Role-Physical) — role functioning associated with the physical condition.
3. BP (Bodily Pain) — the intensity of the pain syndrome and its impact on activity.
4. GH (General Health) — general perception of health.
5. VT (Vitality) — vitality and energy level.
6. SF (Social Functioning) — social activity and quality of interaction with others.
7. RE (Role-Emotional) — role functioning caused by the emotional state.
8. MH (Mental Health) — mental health, including mood, anxiety and depression levels.

Each scale is rated on a scale from 0 to 100, with higher scores indicating better health or lesser limitations.

Survey procedure: The first stage is 1 month after amputation, in a hospital or outpatient setting. The second stage is 6 months after surgery. The third stage is 12 months after surgery.

The questionnaire was conducted in the form of a personal interview with the patient or independent completion of the questionnaire, depending on the cognitive and motor capabilities of the subject. In case of difficulties, patients received assistance from the researcher, but the wording of the questions and the order of their presentation were strictly preserved, which excluded the influence of external factors on the answers.

Ethical approval.

Before the study, a meeting of the Ethics Committee of the Non-Profit Joint-Stock Company Semey Medical University (NCJSC SMU), Semey, Kazakhstan, "Protocol No. 5" dated January 25, 2022, was held, at which the study protocol, informed consent forms, start and end dates of the scientific study were approved and approval of the Ethics Committee was obtained. The study was conducted in accordance with the institutional guidelines for human research and the principles of the Declaration of Helsinki. The study protocols were approved by the Ethics Committee of NCJSC SMU, Semey and the University Hospital of the Non-Profit Joint-Stock Company Semey Medical University, Semey, Kazakhstan. All patients participating in the study were familiarized with the informed consent. They also signed consent to participate in the scientific work and the patients were given information on full confidentiality and anonymity of the data.

Statistical analysis

Homogeneity between groups was assessed using the chi-square test for categorical variables and independent Student's t-tests for continuous variables. Continuous data were presented as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages (%). A two-sided p-value <0.05 was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics 20.0.

Results

The study included 63 patients with critical lower limb ischemia due to vascular occlusion, who underwent limb amputation at different levels. The main group (BKA) - 33 people (52.4%) and the control group (AKA) - 30 people (47.6%).

The average age of the entire sample was 62.4 ± 8.9 years (from 41 to 81 years). In the BKA group - 61.3 ± 8.7 years, in the AKA group - 63.6 ± 9.1 years (p = 0.12).

By gender: BKA - 12 men (36.4%) and 21 women (63.6%), AKA - 11 men (36.7%) and 19 women (63.3%). The differences in gender are statistically insignificant (p = 0.74).

Table 1.

Concomitant pathology in patients of two groups.

Concomitant disease	BKA (n=33)	AKA (n=30)	p-value
Arterial hypertension	24 (72,7 %)	22 (73,3 %)	0,69
Coronary heart disease	19 (57,6 %)	18 (60,0 %)	0,78
Chronic heart failure	9 (27,3 %)	9 (30,0 %)	0,73
COPD	4 (12,1 %)	3 (10,0 %)	0,82
Chronic renal failure	2 (6,1 %)	2 (6,7 %)	0,94

An analysis of the structure of concomitant diseases in the study sample showed that the largest proportion is made up of chronic non-infectious diseases of the cardiovascular system.

Arterial hypertension was the most common pathology: it was detected in 72.7% of patients in the BKA group and in 73.3% of the AKA group. This indicator reflects the high frequency of hypertension in patients with occlusion of lower extremity vessels and confirms its role as a leading risk factor for the progression of cardiovascular pathology.

Coronary artery disease (CAD) was found in 57.6% of patients in the BKA group and 60.0% in the AKA group. This demonstrates a close relationship between the systemic atherosclerotic process and peripheral arterial disease: patients with occlusion of the lower extremity vessels, as a rule, have severe coronary artery disease.

Chronic heart failure (CHF) was recorded in 27.3% of BKA patients and in 30.0% of AKA patients. The high frequency of CHF is explained by the combination of arterial hypertension and ischemic heart disease, which together form a long-term myocardial overload.

Chronic obstructive pulmonary disease (COPD) was found in 12.1% of BKA patients and 10.0% of AKA patients. This figure is probably related to the age of the patients and the high prevalence of smoking among patients with vascular diseases.

Chronic renal failure (CRF) was observed in 6.1% of patients in the BKA group and 6.7% in the AKA group. This figure reflects a relatively low but stable incidence of this pathology, which often accompanies severe systemic vascular disorders.

In general, the structure of comorbidity indicates that patients with occlusion of lower extremity vessels represent a population with pronounced multifactorial comorbidity, where cardiovascular diseases predominate.

Analysis of data obtained using the SF-36 questionnaire revealed significant differences between patients who had undergone below-knee amputation (BKA) and patients who had undergone above-knee amputation (AKA), primarily in scales reflecting physical status.

Table 2.

SF-36 scale Mean scores in comparison of two groups.

SF-36 scale	BKA (n=33)	AKA (n=30)	p-value
PF — physical functioning	68,2 ± 12,1	39,7 ± 10,4	<0,001
RP — role functioning (physical)	56,7 ± 11,5	42,3 ± 9,8	<0,001
BP — pain intensity	63,8 ± 10,9	49,1 ± 10,2	<0,001
GH — general health	59,5 ± 9,8	48,6 ± 8,9	<0,001
VT — vitality	56,8 ± 9,5	50,1 ± 8,7	0,07
SF — social functioning	65,7 ± 8,9	57,9 ± 8,3	0,08
RE — role functioning (emotional)	62,4 ± 8,7	56,2 ± 7,9	0,09
MH — mental health	61,3 ± 7,8	57,4 ± 8,2	0,10

Physical Functioning (PF): BKA patients had significantly higher physical function scores (68.2 points vs. 39.7 points in AKA, $p < 0.001$). This reflects that preserving the knee joint provides a more rational gait pattern, lower energy expenditure during ambulation, and faster recovery of motor skills.

Role functioning related to physical condition (RP). Role limitations were significantly lower in BKA patients (56.7 points vs. 42.3 points in AKA, $p < 0.001$). This indicates that patients with below-knee amputations are less likely to experience difficulties in performing every day and professional duties.

Pain intensity (BP). BKA patients have lower pain intensity (63.8 vs. 49.1, $p < 0.001$). This is due to the lower trauma of the surgery, preservation of most of the muscle mass and joint complex, and more favorable conditions for prosthetics.

General health (GH). Patients with BKA rate their health higher (59.5 vs. 48.6, $p < 0.001$). This indicator integrally reflects general well-being, level of autonomy and subjective perception of their condition.

Vitality (VT): Although the differences did not reach statistical significance, BKA patients had higher vitality and energy scores (56.8 vs. 50.1, $p = 0.07$).

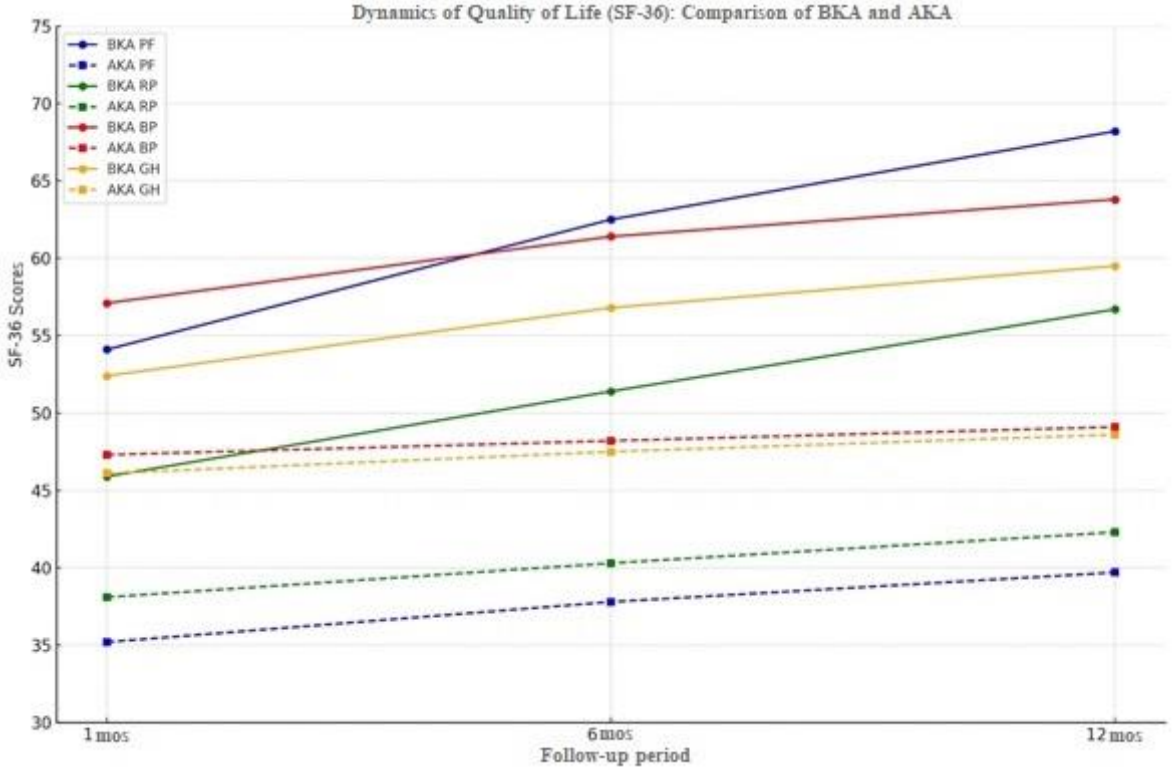
Social functioning (SF): BKA patients demonstrated higher levels of social functioning (65.7 vs. 57.9, $p=0.08$), which may be associated with better mobility and greater independence in daily living.

Role functioning related to the emotional state (RE): BKA patients tended to have better results (62.4 vs. 56.2, $p = 0.09$). This reflects a lower level of emotional limitations related to the disease.

Mental health (MH). Mental health scores were also higher in BKA (61.3 vs. 57.4, $p=0.10$), although the differences did not reach statistical significance. This indicates that preserving the knee joint also has a positive effect on psychological adaptation, but this effect is less pronounced than the physical benefits.

Overall, the results of the table show that the key differences between the groups concern the physical component of quality of life (PF, RP, BP, GH), where the advantages are reliably on the side of BKA. Psychoemotional indicators (VT, SF, RE, MH) demonstrate only a tendency towards better values in the BKA group, but did not reach statistical significance.

The analysis of the dynamics of the quality of life of patients who underwent amputation at different levels was carried out at three time points: 1 month after surgery - early rehabilitation stage. 6 months after surgery - active recovery period. 12 months after surgery - late stage of rehabilitation with maximum stabilization of the condition.



Physical functioning (PF). BKA patients showed a significant increase in the parameters: from 54.1 ± 11.2 at 1 month to 62.5 ± 10.8 at 6 months (+8.4; $p < 0.01$) and to 68.2 ± 12.1 at 12 months (+14.1 from the outcome; $p < 0.001$). In the AKA group, the increase was minimal: from 35.2 ± 8.7 at 1 month to 37.8 ± 9.3 at 6 months (+2.6; $p = 0.11$) and to 39.7 ± 10.4 at 12 months (+4.5; $p = 0.09$). The rate of PF recovery in BKA was 3.1 times higher than in AKA.

Role functioning related to physical condition (RP). In the BKA group, the indices increased from 45.9 ± 9.4 after 1 month to 51.4 ± 10.2 after 6 months (+5.5; $p < 0.05$) and 56.7 ± 11.5 after 12 months (+10.8; $p < 0.01$). In the AKA group, the dynamics were significantly weaker: from 38.1 ± 8.9 to 40.3 ± 9.1 (+2.2; $p = 0.18$) and to 42.3 ± 9.8 (+4.2; $p = 0.12$).

Pain intensity (BP). In BKA patients, the intensity of pain syndrome decreased more significantly: 57.1 ± 10.2 after 1 month, 61.4 ± 9.8 after 6 months (+4.3; $p < 0.05$) and 63.8 ± 10.9 after 12 months (+6.7; $p < 0.01$). In the AKA group, the increase was minimal: from 47.3 ± 9.6 to 48.2 ± 10.1 (+0.9; $p = 0.44$) and 49.1 ± 10.2 (+1.8; $p = 0.31$). Thus, BKA provided an almost two-fold reduction in pain syndrome compared to AKA.

General health status (GH). GH values in BKA increased from 52.4 ± 9.7 at 1 month to 56.8 ± 9.1 at 6 months (+4.4; $p < 0.05$) and 59.5 ± 9.8 at 12 months (+7.1; $p < 0.01$). In AKA patients, changes were minimal: from 46.1 ± 8.6 to 47.5 ± 8.8 (+1.4; $p = 0.21$) and 48.6 ± 8.9 (+2.5; $p = 0.16$).

Vital activity (VT). In BKA, the values increased from 51.7 ± 8.9 to 54.9 ± 9.1 (+3.2; $p = 0.07$) and 56.8 ± 9.5 (+5.1; $p = 0.06$). In AKA, the dynamics were weakly expressed: from 48.3 ± 8.4 to 49.4 ± 8.6 (+1.1; $p = 0.32$) and 50.1 ± 8.7 (+1.8; $p = 0.27$).

Social functioning (SF). In BKA patients, the scores increased from 59.3 ± 8.1 to 63.5 ± 8.7 (+4.2; $p < 0.05$) and 65.7 ± 8.9 (+6.4; $p < 0.01$). In AKA patients, they increased from 54.6 ± 7.9 to 56.8 ± 8.2 (+2.2; $p = 0.12$) and 57.9 ± 8.3 (+3.3; $p = 0.10$).

Role functioning due to the emotional state (RE). In BKA, the increase was from 56.8 ± 8.3 to 59.4 ± 8.5 (+2.6; $p = 0.09$) and 62.4 ± 8.7 (+5.6; $p = 0.07$). In AKA, the indicators increased only from 53.7 ± 7.8 to 55.1 ± 7.9 (+1.4; $p = 0.18$) and 56.2 ± 7.9 (+2.5; $p = 0.15$).

Mental health (MH). The dynamics in the BKA group were moderate: from 58.4 ± 7.6 to 60.2 ± 7.7 (+1.8; $p = 0.21$) and 61.3 ± 7.8 (+2.9; $p = 0.19$). In the AKA group, the changes were insignificant: from 56.1 ± 7.9 to 56.9 ± 8.1 (+0.8; $p = 0.34$) and 57.4 ± 8.2 (+1.3; $p = 0.28$).

BKA patients demonstrated stable positive dynamics in all physical scales (PF, RP, BP, GH) with an increase from 6.7 to 14.1 points over 12 months. In the AKA group, statistically significant improvements were not noted in most scales, indicating limited possibilities for physical rehabilitation in above-knee amputations. The greatest

difference between the groups remained in the PF scale (28.5 points by the end of the follow-up).

Analysis of the frequency and structure of complications in the postoperative period showed that they occurred in both groups, but their frequency and severity depended on the level of amputation. In patients with above-the-knee amputation (AKA), complications were observed more often (26.7%) compared to the BKA group (18.2%). Although the differences did not reach statistical significance (p = 0.18), the trend indicates a more favorable course of the postoperative period in patients with a preserved knee joint.

Table 3.

Structure of complications depending on the level of amputation.

Type of complication	BKA (n=33)	AKA (n=30)	p-value
Stump infection	2 (6,1 %)	3 (10,0 %)	0,21
Wound edge necrosis	1 (3,0 %)	2 (6,7 %)	0,29
Delayed healing (> 30 days)	1 (3,0 %)	2 (6,7 %)	0,21
Formation of a rough scar	0 (0 %)	1 (3,3 %)	0,28
Stump pain syndrome (chronic)	2 (6,1 %)	3 (10,0 %)	0,23
Total patients with complications	6 (18,2 %)	8 (26,7 %)	0,18

Stump infection was the most common complication in both groups: 6.1% in the BKA group and 10.0% in the AKA group. A higher risk of infection in AKA patients is associated with greater trauma of the intervention, a larger wound surface volume and a longer healing period. Wound edge necrosis was diagnosed in 3.0% of BKA patients and 6.7% of AKA patients. A more frequent development of necrotic changes in patients with femoral amputation is due to severe circulatory disorders and a more aggressive nature of the ischemic process. Delayed wound healing was noted in 3.0% of BKA patients and 6.7% of AKA patients. This indicator was also more common in patients with femoral amputation, which is associated with a larger volume of surgical trauma and concomitant comorbidity. Rough scar formation was observed in only 1 patient in the AKA group (3.3%). This complication was not recorded in BKA patients. Severe scarring may complicate subsequent prosthetic replacement, especially in the case of hip amputation. Stump pain syndrome (chronic) was observed in 6.1% of BKA patients and 10.0% of AKA patients. The higher incidence of pain syndrome in hip amputation is explained by greater damage to nerve trunks and a high probability of phantom pain formation.

Discussion

The results of this study demonstrate that patients with below-knee amputation (BKA) have significantly higher quality of life according to most SF-36 scales than patients with above-knee amputation (AKA). Particularly pronounced differences were noted in physical functioning (PF), role functioning (RP), pain intensity (BP) and general health (GH). These data are consistent with the results of a number of studies, according to which the level of amputation is one of the key predictors of physical and social rehabilitation after surgery.

The revealed difference of 28.5% on the PF scale in favor of BKA is explained by the preservation of the knee joint, which ensures a more physiological and energy-efficient walking pattern. Patients with BKA master the prosthesis faster and use the prosthesis more often in everyday life. According to the literature, preserving the knee joint reduces energy costs during walking by 25-40% compared to AKA, which directly correlates with PF indicators.

In our study, the average adaptation period to the prosthesis was 4.8 months for BKA and 7.3 months for AKA. These periods are comparable with data from foreign studies, which report an average duration of primary rehabilitation of 4–6 months for BKA and 6–9 months for AKA.

According to the BP scale, BKA patients had an average of 14.7% lower pain severity. This is due to a shorter surgical trauma length, less damage to nerve trunks, and better stump stability. In the AKA group, high-intensity phantom pain was more common.

General health (GH) was also higher in BKA patients. Their subjective perception of health improved faster, which was associated with greater autonomy, better exercise tolerance, and less dependence on outside help.

Although no statistically significant differences were found in the scales of vitality (VT), social functioning (SF), role functioning (emotional) (RE) and mental health (MH), a tendency towards higher values was observed in the BKA group. This can be explained by the fact that the level of physical autonomy directly affects social involvement and psychological well-being.

The results of the study are consistent with the findings of large meta-analyses, in which knee joint preservation was associated with higher quality of life, lower incidence of stump complications, and higher rates of rehabilitation.

Conclusions: The study showed that the level of amputation significantly affects the physical activity and autonomy of patients. Patients with below-knee amputation (BKA) showed higher physical functioning (68.2 vs. 39.7 points, $p < 0.001$), role activity (56.7 vs. 42.3 points, $p < 0.001$) and less pain (63.8 vs. 49.1 points, $p < 0.001$), which positively affects their psychological state and perception of quality of life. Preservation of the knee joint accelerates rehabilitation, while for patients with above-knee amputation (AKA), comprehensive physical and psychological support is especially important.

All authors contributed equally to the research and writing of this article. Dyusupov A.A., Sabitov E.T., and Imanbaev M.N. supervised the scientific research and made adjustments. Kozhakhmetov Zh.O., Dyusupov A.A., Sabitov E.T., Toleutaev T.A., Kazymov E.M., Salmenbaev E.A., Imanbaev M.N., Masalov A.E., Abdrakhmanov S.T. carried out a search of literature data and their processing. Kozhakhmetov Zh.O., Sabitov E.T., Toleutaev T.A., Kazymov E.M., Salmenbaev E.A., Imanbaev M.N., carried out a sample of patients and their surgical treatment, and also took part in developing the outline of the article, editing the

text and approving the final version of the article. Masalov A.E., Abdrakhmanov S.T. edited and designed the text of the article. No conflicts of interest declared.

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