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REVIEW ARTICLE

Outcomes and predictors of prosthetic use, mobility, and survival after below-knee amputation: a literature review

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ABSTRACT

INTRODUCTION: Despite advances in prevention and revascularization, a significant number of patients still require major lower-limb amputation. Below-knee amputation (BKA) is generally associated with better functional outcomes and prosthetic use than more proximal amputations. In recent years, increased access to healthcare has led to a shift in the patient profile undergoing BKA: individuals now tend to undergo amputation later in the disease course and often present with more severe comorbidities and advanced limb ischemia. This literature review aims to re-evaluate the prognostic advantages of BKA and understand how factors such as pre-existing comorbidities and prior surgical interventions affect outcomes after BKA.

METHODS: A search of the PubMed database was conducted using the following query: ("below-knee amputation" OR "transtibial amputation") AND ("prosthetic use" OR "prosthesis" OR "mobility" OR "survival" OR "mortality") AND ("predictors" OR "outcomes").

RESULTS: A total of 230 articles were analyzed, and 10 were included. One-year mortality after BKA ranged from 25% to over 40%, with dementia, dialysis dependence, cerebrovascular disease, and female sex identified as significant predictors of poor survival and prosthetic use. Prosthetic fitting success was reported in 38%–44.5% of patients. Functional outcomes were inversely related to preoperative frailty, comorbidities, and poor limb perfusion ($TcPO_2$ < 40 mm Hg). Reintervention rates—including conversion to above-knee amputation (AKA)—reached up to 20%. Delays in prosthetic fitting and limited actual use further impaired mobility outcomes. Composite success—defined as wound healing, ambulation, and survival—was achieved in just over half of patients in some studies.

CONCLUSION: The emerging patient profile undergoing BKA—older, more comorbid, and further along in disease progression—requires rethinking how success is defined and achieved. Tailored patient selection, frailty assessment, and early involvement of rehabilitation teams may help optimize BKA outcomes.

Keywords: Major lower limb amputation; Below-knee amputation; Prosthetic use.

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INTRODUCTION

Despite advances in the prevention and treatment of peripheral arterial disease (PAD) and growing efforts in surgical and endovascular revascularization, a significant number of patients still progress to the point of requiring major lower-limb amputation.[1,2] In Europe and Australia, between 7 and 41 individuals per 100,000 population undergo major amputations each year due to diabetes and vascular disease.[3]

For patients undergoing major lower-limb amputation, one of the main goals of treatment is to preserve the highest possible quality of life (QoL) by maintaining independence, especially through ambulation.[4] Major lower-limb amputations can typically be performed at one of four anatomical levels: below-knee, through-knee, above-knee, and through-hip. These levels are preferred over more distal amputations because they offer a higher likelihood of prosthesis use, primary wound healing, and rehabilitation potential.[5] Studies show an inverse relationship between amputation level and postoperative QoL — higher amputation levels are generally associated with poorer functional outcomes and decreased patient-reported well-being, as they pose a greater hemodynamic and metabolic challenge.[6,7]

Below-knee amputation (BKA) is widely recognized as yielding better outcomes than more proximal amputations.[8] Patients undergoing BKA are more likely to regain mobility with a prosthesis and report better functional status and quality of life.[1,6]

However, in recent years, the growing use of percutaneous endovascular treatment strategies and greater access to healthcare have led to a reduction in the incidence of major lower-limb amputations. This shift has also resulted in a changing patient profile: individuals now tend to undergo amputation later in the disease course and often present with more severe comorbidities and advanced limb ischemia. Consequently, outcomes after BKA may no longer reflect those observed in earlier patient cohorts.[9]

This literature review aims to re-evaluate the prognostic advantages of BKA with respect to functionality, ambulation, and overall QoL, and to understand how factors such as pre-existing comorbidities and prior surgical interventions—including revascularization procedures (endovascular or open) and minor amputations—affect outcomes after BKA.

METHODS

A search was conducted on PubMed and Scopus using the following query: ("below-knee amputation" OR "transtibial amputation") AND ("prosthetic use" OR "prosthesis" OR "mobility" OR "survival" OR "mortality") AND ("predictors" OR "outcomes"). The search was conducted on April 12, 2025. Only studies published in English or Portuguese since 2000. We excluded case reports and conference abstracts. Reference lists were searched for additional publications. A total of 230 articles were retrieved. After abstract analysis, 42 articles were selected for full reading, of which 10 were selected.

RESULTS

We included 10 studies, all in English, with 9 relying on retrospective data from 1996-2019. Patient numbers ranged from 120 to 9303. Survival rates, prosthetic use, need for reamputation, complications, and patient-reported outcomes varied considerably according to comorbidity burden and preoperative physiological status.

Survival

Mortality outcomes after BKA varied considerably across studies. García et al. reported mortality rates of 9% at 1 month, 32% at 1 year, and 64% at 5 years.[10] Similarly, Beyaz et al. observed 30-day and 1-year survival rates of 84% and 64% among diabetic patients, while Wu et al. reported 1-year survival of 75% and 5-year survival of 58%.[13,17] Short-term mortality was consistently low across several studies, with Wu et al., Ciufo et al., and Taylor et al. each reporting 30-day mortality around 5%.[15,17] Registry-based analyses reported even lower rates, with Andersen et al. reporting 3% at 30 days.[18]

Prosthetic fitting and ambulation

Prosthesis fitting and ambulation rates varied widely, often falling below 50%. García et al. reported that 45% of patients were fitted with a prosthesis, although only 41% of the total cohort ultimately achieved ambulation.[18] Similarly, Columbo et al. observed combined healing, prosthesis fitting, and ambulation in 38% of cases.[11] Taylor et al. reported that 51% of patients reached a composite outcome of wound healing, survival beyond six months, and prosthetic ambulation maintained for at least one year.[16] In contrast, registry-based data from Kamrad et al. showed slightly higher rates, with prosthesis fitting achieved in 55% of patients and a median time to first fitting of 69 days.[19]

Reinterventions, re-amputations and complications

Reinterventions, re-amputations, and complications were common across the included studies. Columbo et al. reported a 25% reintervention rate, including 18% conversions to above-knee amputation (AKA).[11] Taylor et al. similarly found that 14% of patients required conversion to AKA, while Wu et al. observed 9% conversions within 30 days.[16,17] In contrast, registry-based data from Andersen et al. documented a lower conversion rate of 4%.[18] Ciufo et al. reported a reoperation rate of 10%.[15] Beyond revision procedures, complications were also frequent in large cohorts: Ciufo et al. identified major complications in 13% of patients, whereas Andersen et al. observed an overall complication rate of 18%.[15,18]

Predictors of poor outcomes

Predictors of poor outcomes consistently included advanced age, female sex, end-stage renal failure (ESRF), dialysis dependence, dementia, and cerebrovascular disease (CeVD). Functional dependence and low preoperative mobility were also strongly associated with failure to achieve long-term ambulation. Conversely, protective factors included prior revascularization procedures and infectious rather than ischemic amputation etiologies.[10-19]

Sambandam et al. reported an "obesity paradox," where Class I and II obesity were associated with lower rates of complications, including anemia requiring transfusion, pneumonia, and mortality, compared with non-obese and Class III obese patients.[14]

On the other hand, Andersen et al. highlighted frailty, assessed by the mFI-5 score, as a significant predictor of adverse outcomes, including postoperative myocardial infarction.[18]

Quality of life and functional outcomes

Alavi et al. highlighted quality of life and functional outcomes, finding that health-related quality of life, measured by the SF-12 Physical Component Score, was the strongest predictor of mobility. This underscores the importance of psychosocial and patient-reported measures in postoperative outcomes[12] Table 1 summarizes the outcomes and predictors across the included studies.

Table 1. Summary of Key Outcomes and Predictors after BKA

Study	Year	Study design	N	Inclusion criteria	Outcomes	Outcome predictors
García et al.[10]	2020	Retrospective single-center cohort	209	Consecutive BKA patients (1996-2015)	**Mortality:** 9.2% at 1m; 31.9% at 1y; 63.9% at 5y **Prosthetic fitting:** 44.5% **Ambulation:** 41.1%	**Mortality:** dementia, hemodialysis, hypertension, ischemic etiology and previous contralateral amputation. **Lower Prosthetic Use:** female sex, dementia, previous contralateral amputation and CeVD.
Columbo et al.[11]	2016	Retrospective single-center cohort	120	BKA for PAD (2008-2014	**1-Year freedom from AKA or death:** 60% **Prosthetic fitting and ambulation:** 38% **Re-intervention:** 25% **Conversion to AKA:** 18%	**Mortality/ conversion to AKA at 1-year:** low transcutaneous oximetry TcPO2 <40 mmHg.
Alavi et al.[12]	2024	Cross-sectional observational	168	Nontraumatic, unilateral BKA patients using a prosthetic leg	**Mobility score** (measured by the 12-item Prosthetic Limb Users Survey of Mobility)	**Mobility:** Physical Component Summary score of the SF-12 Health Survey, age and comorbidity.
Beyaz et al.[13]	2017	Retrospective review of prospective data	470	Diabetic patients undergoing BKA (2004-2014)	**Survival:** 90% at 7d; 84% at 30d; 64% at 1y.	**Mortality:** ESRF requiring dialysis, higher blood BUN, longer insulin use, older age and female sex.
Sambandam et al.[14]	2023	Retrospective, matched case-control	9,303	BKA patients from NIS database (2016-2019)	**Inpatient mortality:** 2.8% (N-Ob), 1.4% (Ob-I/II), 2.9% (Ob-III) **LOS**: 13.1 days (N-Ob), 11.8 days (Ob-I/II), 13.5 days (Ob-III)	**"Obesity paradox":** Ob-I/II was found to be protective against some complications (anemia with transfusion need and pneumonia) and death compared to N-Ob and Ob-III patients. **LOS and inpatient costs:** higher in Ob-III patients
Ciufo et al.[15]	2019	Retrospective cohort	4,631	BKA cases from ACS- NSQIP database (2012-2014)	**Re-operation:** 9.6% **Major Complications:** 12.8% **30-Day Mortality:** 5.1%	**Reoperation:** Smoking, bleeding disorder, preoperative ventilator use and transfer from another facility. **30-Day Mortality:** age, underweight BMI (<18.5), functional dependence, preoperative dialysis or ventilator use, sepsis/shock.
Taylor et al.[16]	2008	Retrospective review of prospective data	309	Consecutive unilateral BKA (1998-2004)	**"Successful outcome" (healing, ambulation >1y, survival >6m):** 51.1% **30-day mortality:** 5.2% **Conversion to AKA:** 13.6%	**Failure to achieve" successful outcome":** CAD, CeVD and impaired preoperative ambulatory ability.
Wu et al.[17]	2017	Retrospective, single center cohort	210	BKA for PAD-related causes (2008-2015)	**Conversion to AKA:** 9% **30-Day Mortality:** 5% **Survival:** 75% at 1y, 58% at 5y	**Conversion to AKA:** ESRF and preoperative non-ambulatory status. **Mortality:** ESRF.
Andersen et al.[18]	2020	Retrospective study	2,040	BKA cases from VQI registry (2012-2017)	**Complications:** 17.6% **30-Day Mortality:** 2.6% **Conversion to AKA:** 4.0%	**Mortality/ Post-op MI/ Failure to prosthetic use:** each one-point increase in the mFI-5 score
Kamrad et al.[19]	2020	Descriptive analysis of a retrospective registry study	5,762	BKA patients in SwedeAmp registry (2011-2018)	**1-Year Mortality:** 24% **Prosthetic Fitting:** 55% **Median time to Prosthesis:** 69 days	**NA**

BKA: Below-Knee Amputation; **CeVD:** Cerebrovascular Disease; **PAD:** Peripheral Arterial Disease; **AKA:** Above-Knee Amputation; **$TcPO_2$:** Transcutaneous Oximetry; **SF-12:** 12-Item Short-Form Health Survey; **ESRF:** End-Stage Renal Failure; **BUN:** Blood Urea Nitrogen; **NIS:** Nationwide Inpatient Sample; **N-Ob:** Non-Obese; **Ob-I/II:** Class I/II Obese; **Ob-III:** Class III Obese; **LOS:** Length of hospital stay; **ACS-NSQIP:** American College of Surgeons National Surgical Quality Improvement Program; **BMI:** Body mass index; **CAD:** Coronary Artery Disease; **VQI:** Vascular Quality Initiative; **mFI-5:** 5-Item Modified Frailty Index; **MI:** Myocardial Infarction.

DISCUSSION

This literature review highlights key outcomes and predictors associated with BKA. The evidence shows that although BKA remains a cornerstone procedure for preserving functional potential, its outcomes are highly variable and often fall short of traditional expectations. The changing characteristics of contemporary patients - older age, higher comorbidity burden, and advanced disease at presentation - require reassessing what constitutes a "successful" outcome after BKA.

A stark finding is the persistent significant mortality risk despite the limb-preserving intent of the procedure. One-year survival rates were as low as 64% in some cohorts, reflecting the high burden of systemic illness in this population.[10,13] Across all studies, mortality predictors were consistent: ESRF requiring dialysis, dementia, and advanced age were repeatedly identified as markers of systemic frailty that may outweigh the benefits of limb preservation.[10,13,15,17]

Functional recovery is a major limitation to success after BKA. Across several studies, fewer than half of patients were successfully fitted with a prosthesis, and an even smaller percentage achieved functional mobility.[10,11] Although a large registry reported a slightly higher fitting rate of 55%, [19] the composite "successful outcome" defined by Taylor et al.—which included healing, survival, and sustained ambulation—was achieved in only 51% of patients.[16] These data indicate that prosthetic fitting alone may be an inadequate surrogate for functional success. The association between poor mobility outcomes and baseline neurological deficits, such as dementia and prior cerebrovascular events,10,16 reinforces that a patient's preoperative functional and cognitive integrity is a primary determinant of postoperative potential. Importantly, patient-reported quality of life predicted ambulation more reliably than clinical measures alone, supporting the inclusion of psychosocial evaluation in preoperative counseling.[12]

The need for reintervention and conversion to AKA is common and significantly influences the overall risk–benefit profile of BKA. Conversion rates to AKA were substantial in single-center studies, ranging from 9% to 18%,[11,16,17] whereas a large registry study reported 4%.[18] These procedures may reflect a failure of the initial surgical strategy and subject already frail patients to additional morbidity. Identifying objective preoperative risk factors, such as low transcutaneous oximetry11 and systemic markers like frailty scores,18 is therefore crucial. The mFI-5 score, for instance, proved to be an independent predictor of mortality and adverse cardiac events,[18] suggesting that validated frailty indices should become a standard component of preoperative assessment to better inform shared decision-making between BKA and a primary AKA.

Overall, baseline patient characteristics strongly determine outcomes after BKA. Functional dependence, non-ambulatory status before surgery, and frailty consistently predicted poor survival, limited mobility, and higher reoperation rates.15-18 The "obesity paradox" reported by Sambandam et al., in which class I and II obesity appeared protective against certain complications, adds another layer of complexity to risk stratification but does not apply to severely obese patients, who had worse outcomes.[14] These findings suggest that overall success after BKA may depend more on appropriate patient selection than on the surgical procedure itself.

The main limitations of this review are the retrospective design of most studies and the heterogeneity in outcome definitions, particularly for "successful ambulation." Variability in follow-up duration and the lack of standardized patient-reported quality-of-life metrics across studies may also limit direct comparisons.

CONCLUSION

While BKA continues to offer a potential pathway to preserve ambulation and quality of life, the evidence in this review shows that outcomes are far from uniform and are strongly influenced by the patient's baseline status. The emerging patient profile - older, more comorbid, and further along in disease progression - necessitates rethinking how success is defined and achieved. The traditional focus on prosthetic ambulation as the sole determinant of success may no longer be viable for a large segment of this population.

A successful outcome must be redefined through a patient-centered lens, prioritizing individualized goals that may include uncomplicated wound healing, pain resolution, avoidance of re-amputation, and preservation of independence within a patient's functional limits—whether that involves ambulation or optimized assisted mobility. Achieving this requires a commitment to comprehensive preoperative assessment, including objective measures of perfusion and frailty, to support shared decision-making and set realist

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